KEPLER

Users' Manual

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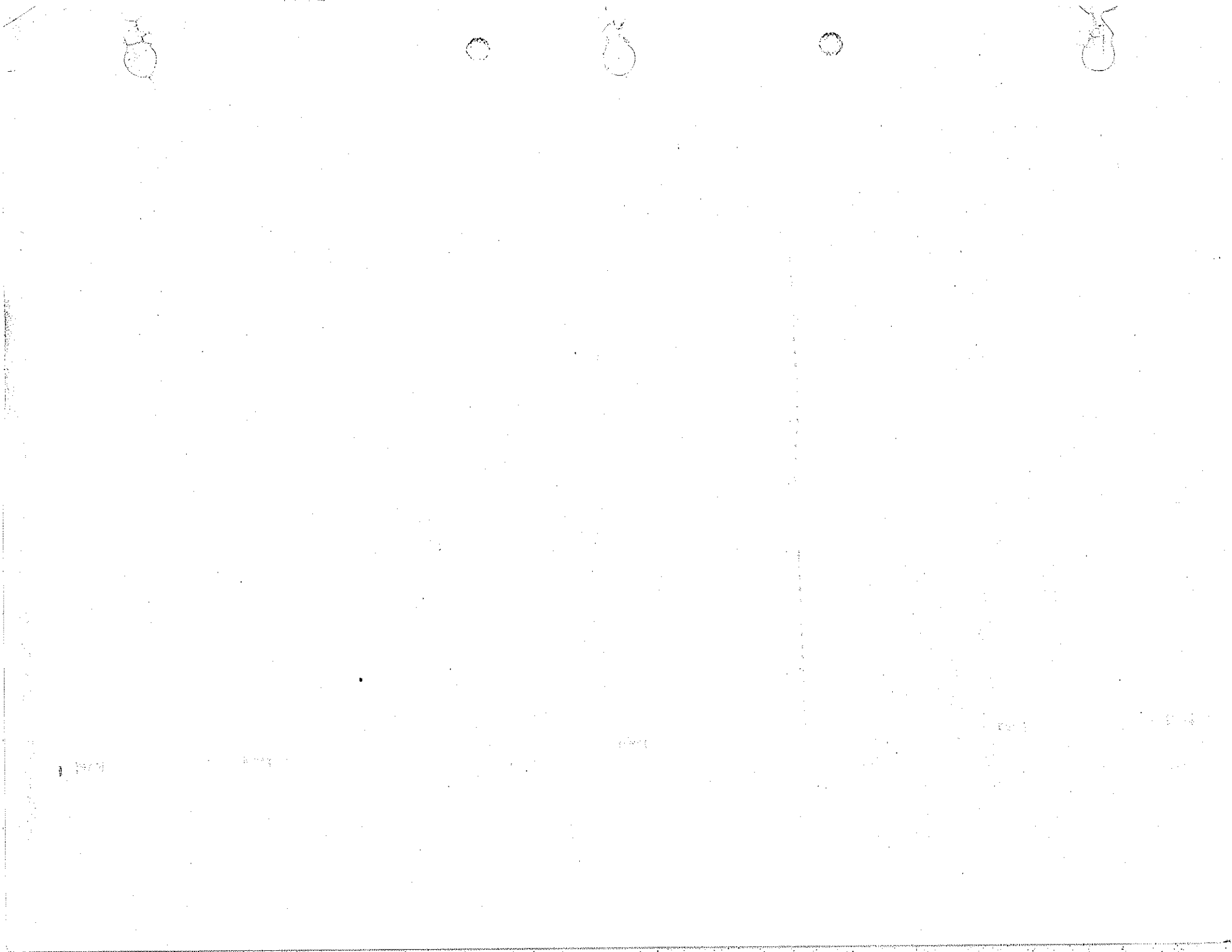

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CHAPTER 1

INTRODUCTION

KEPLER is a general purpose stellar evolution/explosion code that incorporates implicit hydrodynamics and a detailed treatment of nuclear burning processes. It has been used to study the complete evolution of massive and supermassive stars, all major classes of supernovae, hydrostatic and explosive nucleosynthesis, and x- and gamma-ray bursts on neutron stars and white dwarfs. Many aspects of the physics it currently includes has been briefly summarized in Weaver, Zimmerman, and Woosley (1978, *Ap.J. 225*, 1021), Weaver, Woosley, and Fuller (1983, *Proc. of the Conf. on Numerical Astrophysics: A Meeting in Honor of James R. Wilson,* R. Bowers, J. Centralla, J. LeBlanc, and M. LeBlanc, eds. (Science Books, Portola, CA)), and many other papers describing the results of its calculations. Additional documentation is in progress. KEPLER does not currently contain detailed models of neutrino transport and the equation of state of hot matter near nuclear density, but it has the capability to be linked to codes (such as that of Wilson et. al.) that do or to treat these processes in parameterized form.

After more a decade of specialized residence on the CDC 7600, a general (almost standard FORTRAN) version of KEPLER has been developed for use on UNIX super-minicomputers with X-Window graphics (such as P Group's 4D/240VGX computer, **leonardo**), and in a more limited form on CRAY computers. This new version of KEPLER includes calculations of detailed isotopic nucleosynthesis ("BURN coprocessing"), extensive graphics, interactive post-processing, updated nuclear reaction rates, and many other new and/or improved edit and physics capabilities.

The current UNIX version of KEPLER on which this manual is based is **kepler.1may91**. The form of the input files ("generators") needed for KEPLER is discussed in Chapter 2, while a list of the user-changeable KEPLER parameters is given in Chapter 3 by function and in Chapter 4 by number. Chapter 5 describes how to run a KEPLER problem and also the interactive keyboard commands that are available for editing and job-control. Chapter 6 describes the form of the "LINK" input file need to link the results of core collapse calculations

performed by other codes to KEPLER, while Chapter 7 presents a functional list of the zonal edit variables that may be edited, graphed, or stored in post-processor dumps. Chapter 8 lists both the user-unchangeable edit ('Q') parameters and the non-zonal, time-dependent ("time-edit") variables, which can be graphed vs. time. Chapter 9 briefly describes the form of some of the (less obvious) edits that KEPLER produces. Finally, Appendices A, B, and C provide alphabetical reference lists of the terminal commands, the user-changeable parameters, and the zonal edit variables, respectively.

CONVENTIONS

Terminal commands and input file cards are listed according to the following conventions:

COMMAND *REQUIRED-INPUT1 REQUIRED-INPUT2* .... [*OPTIONAL-INPUT1* ....]

Here the words in capital italics are to be replaced by specific input values, and words in brackets are optional parameters. Usually a specific example, shown as a quoted, bold-face character string, is given directly below the command or card to clarify the input format. All specific KEPLER variables, parameters, subroutine names and commands are shown in upper case for clarity (although all communication with the computer must currently be made in lower case and character strings must not be enclosed in quotes). The symbols for edit variables of all kinds are shown in bold-face, lower-case letters.

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CHAPTER 2

GENERATOR INPUT FILES

The initial setup of a KEPLER problem is specified by a series of instructions (known as "cards" for historical reasons) that each occupy one line in an input file termed a "generator" file. (Or sometimes a generator "deck" for the same historical reasons -- backup versions of KEPLER were kept on punch cards until 1978). Running KEPLER always requires the regular KEPLER generator specified in the next section. In addition, a separate BURN generator, specified in the section following, is required if BURN co-processing is specified by the inclusion of a **GENBURN** card in the regular generator. Both files must be in the working directory in which the problem is being run.

A generator card may be up to 120 characters long and contain up to 60 blank, tab, or equal-sign delimited words, each at most 60 characters long. Words are interpreted as being integer, character or floating point depending on their format and must match the type specified for each card or a fatal error message will be sent. Except as noted below, words representing input character variables are truncated to 8 characters, while numerical input is "field-free," except that floating point numbers must be distinguished from integers by a decimal point or exponent.

Card types allowed in the regular KEPLER generator file are listed below. Each card keyword is given in bold capital letters, followed by its arguments, if any, in italic capital letters. For each commands, an example printed in boldface characters and enclosed in quotes is given, which also serves to indicate the expected type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case and that character parameters are never enclosed in quotes.

Except as noted, generator cards may occur in any order, but must always include **NET**, **M**, and **G** cards (and a **BOX** card on the CRAY). BURN generator files must always include **NET**, **M**, and **G** cards of the type separately specified below.

Complete sample KEPLER and BURN generator files are listed in the final sections, along with some useful variants. These are taken directly from recently executed KEPLER jobs.

KEPLER GENERATOR INPUT CARDS

BOX *BOX# [ID-WORD]*

' box v98 weaver '

Identification Card. (Required on CRAY, optional on UNIX systems).

BOX# is the user's output box and must be three characters long. It is used for directing output files on the CRAY.

ID-WORD is an identification word (≤8 characters), usually the user's name.

GENBURN *NAMEBG*

' genburn sol160bg '

Burn Generator Card. (Optional). Inclusion of this card causes KEPLER to read the BURN generator file, *NAMEBG*, immediately after normal problem generation and to initiate BURN co-processing.

NAMEBG can be up to 16 characters long and is not restricted, though by normal convention it ends in the letters **'bg'.**

C *COMMENT*

' c s25s1a -- 25 solar mass star of solar composition '

Comment Card(s). (Optional).

COMMENT is an arbitrary alphanumeric string that is ignored by the code. Note that it must be separated from the ' c ' by at least one space.

NET *NETWORK# IONSYM(1) [IONSYM(2) IONSYM(3) .....]*

' net 1 h1 he3 he4 n14 c12 o16 ne20 mg24 si28 s32
net 1 ar36 ca40 ti44 cr48 fe52 ni56 fe54 pt1 nt1 '

Network Card(s). (Required).

NETWORK# is the identification number of the network being specified. For the current version of KEPLER, the network specified must be the APPROX network given in the example, and the network number must be 1.

ISOTOPE(I) is the symbol for the *Ith* ion in the network. (See the "M" card description given below for how to format these symbols). They can be specified in any order. If there are more than 10 ions in the network, continue on a new "NET" card with the same network number.

ISENET

' isenet '

ISE Network Card. (Optional). This card is a flag that the standard ISE and NSE networks (NETNUM = 2 and 3, respectively) are to be set up for possible later use, in addition to the usual **APPROX network** (NETNUM = 1). Zones should never be specified on a "G" card to initially be **either ISE or NSE, but they should instead be allowed to make the transition** (or not) while the **problem is running depending on the physical conditions encountered and the setting of various control parameters** (see Chapter 3).

M *MIX-NAME MASSFRAC(1) IONSYM(1) [MASSFRAC(2) IONSYM(2)...]*

' m solcomp .70 h1 .28 he4 .02 n14 '

Materials Card(s). (Required).

MIX-NAME is the name of this mixture of ions (≤ 8 characters).

MASSFRAC(I) is the mass-fraction of the *Ith* ion in the mixture.

IONSYM(I) is the symbol for the *Ith* ion in the mixture and consists of an lower case elemental symbol followed by the atomic weight (without a space), e.g. **he4.** Also, each *IONSYM* listed here must be one of the ions in a specific network specified by the "NET" card(s).

Pairs of such mass fractions and ion symbols are listed for each ion in the mixture. Continue if necessary on a new "M" card with the same *MIX-NAME*. After all such cards have been read, the code renormalizes the sum of the mass fractions to insure it equals 1.

G *ZONE# EXTERIOR-MASS NETWORK# MIX-NAME TEMP DENSITY [VELOCITY]*

' g 0 4.e+34 1 solcomp 1.1e+7 0.9 0. '

Grid Cards. (At least 2 required).

ZONE# is the number of the zonal interface being described (J). This should always be 0 for the first "G" card and be equal to the total number of zones desired for the last "G" card. For intermediate "G" cards, J should increase monotonically between these values. Not every interface need be specified, and conditions at intermediate interfaces will be calculated as described below.

EXTERIOR-MASS is the mass (in grams) ***exterior*** to the zonal interface being specified. (YM(J)). Specified values must increase monotonically with zonal interface number (J). Exterior masses for zonal interfaces between those specified will be interpolated from the specified values by minimizing the sum of the squares of the fractional changes in zone mass across each interface (See subroutine ZONIT).

NETWORK# is the number of the nuclear-burning network to be used between this zonal interface and the next one specified. (NETNUM(J)). Currently must be 1 (see **"NET"**).

MIX-NAME is name of the material (as specified by the appropriate "M" cards) that lies between this zonal interface and the next one specified. (IMSEN(J)).

TEMP is the temperature (in degrees K) of the zones that lie between this interface and the next one specified. (TN(J)).

DENSITY is the density (in g/cc) of the zones that lie between this interface and the next one specified. (DN(J)).

VELOCITY is the velocity (in cm/s) of this zonal interface. (UN(J)). If not specified, it is assumed to be 0. Velocities for zonal interfaces between those specified are determined by interpolating linearly with radius.

HSTAT

' hstat '

Hydrostatic Equilibrium Card. (Optional).

Forces the specified initial configuration into hydrostatic equilibrium by adjusting the temperature.

DSTAT

' dstat '

Degenerate Hydrostatic Equilibrium Card. (Optional).

Forces the specified initial configuration into hydrostatic equilibrium by adjusting the density. Useful in very degenerate cases, such as white dwarfs or neutron stars.

P *PARAMETER# PARAMETER-VALUE*

' p 1 1.e-5 '

Parameter Card(s). (Optional -- Parameters are otherwise set to their default values).

PARAMETER# is the number or name of the parameter to be specified. See Chapters 3 and 4 and Appendix B for a list of the changeable parameters in the code and their units and default values.

PARAMETER-VALUE is the value to be assigned to this parameter. Note that fixed point parameters must have fixed pointed values specified , and floating point parameters must be given floating point values ($1 \neq 1.$)

DUMP *DUMPVAR RATZDUMP RATIODEZ RATIOADZ*

'dump convect .1 -1. 0.'

Dump Card(s). (Optional). Add dump variable *DUMPVAR* to the list of variables to be dumped to the qq post-processor dump file and set its dump parameters. *DUMPVAR* may be any zonal edit variable listed in Chapter 7, and in addition it may take the values:

parm -- to dump the values of the changeable ('p') parameters, or

qparm -- to dump the values of the edit ('q') parameters.

The associated dump parameters which must be given for each variable are:

RATZDUMP -- the maximum allowed fractional change between dumps of the specified zonal dump variable.

RATIODEZ -- the minimum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is dezoned.

RATIOADZ -- the maximum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is adzoned.

In the case of **parm** and **qparm** the values of *RATIOADZ* and *RATIODEZ* are ignored but must be given. Note that the **DUMP** command for new variables may also be given interactively from the keyboard while the problem is already running (see Chapter 5).

ZEDIT *IZED NCYCZED EDITVAR1* [*EDITVAR2....EDITVAR10*] [*ZEDMASS1* [*ZEDMASS2*]]

'zedit 1 50 dn tn sige sigi sigr 0. 2.'

Zonal Edit Card(s). (Optional). This card causes a special multiple column ASCII edit of the specified zonal edit variables (*EDITVAR1*, etc.) to be written every *NCYCZED* cycles. A detailed list of the allowed zonal edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. Here *IZED* is an index number (max of NZEDZ, which currently is 30 -- see KEPCOMS) that distinguishes separate **ZEDIT** requests, and *ZEDMASS1* and *ZEDMASS2* specify an optional interior mass range (in SCALEM (P 273) units) to be edited. If only *ZEDMASS1* is specified, a ±1% range around it is edited, and if no masses are specified, an edit of the whole star is made. Previously specified edits can be changed or terminated by overwriting them with a **ZEDIT** command issued from the terminal with the same index number (See Chapter 5). (Note: setting *NCYCZED* = 0 terminates the edit.)

KEPLER GENERATOR RESTRICTIONS

Restrictions corresponding to current FORTRAN parameter settings in include-file KEPCOMS and subroutine GENER are listed below (where the name of the FORTRAN parameter is shown in capital letters). These may be changed by editing and recompiling KEPLER.

NNIZ..... Maximum Number of Networks = 5. (But see "NET" Card discussion).
NHIZ..... Maximum Number of Ion Types per Network = 20.
NMIZ..... Maximum Number of Material Mixtures = 10.
NIMZ..... Maximum Number of Ion Types per Mixture = 20.
NITZ..... Maximum Number of Ion Types Overall = 100.
NDATQZ. Maximum Number of **DUMP** cards = 250.
NZEDZ.... Maximum Number of **ZEDIT** cards = 30.
JMZ..... Maximum Number of Zones = 650.

BURN GENERATOR CARDS

C *COMMENT*

' c sol160bg -- burn generator with solar composition, 160 zones, & 149 BURN isotopes '

Comment Card(s). (Optional).

COMMENT is an arbitrary alphanumeric string that is ignored by the code. Note that it must be separated from the ' **c** ' by at least one space.

NET *NETWORK# ISOTOPE(1) [ISOTOPE(2) ISOTOPE(3) .....]*

' net 1 nt1 h1 h2 h3 he3 he4 li7 be7 b10 b11 '

Network Card(s). (Required).

NETWORK# is the identification number of the network being specified. For the current version of KEPLER, only one network may be specified, and its BURN network number (NETNUMB) must be 1 .

ISOTOPE(I) is the symbol for the *Ith* isotope in the network. (See the "M" card description given below for how to format these symbols). They can be specified in any order. If there are more than 10 isotopes in the network, continue on a new "NET" card with the same BURN network number. The limits and contents of the network depends of the information currently available in the BDAT nuclear data deck stored in **/usr/local/bin/bdat** (see Chapter 5).

M *MIX-NAME MASSFRAC(1) ISOSYM(1) [MASSFRAC(2) ISOSYM(2)...]*

' m solcomp 7.057e-1 h1 4.801e-5 h2 2.929e-5 he3 '

Materials Card(s) (Required).

MIX-NAME is the name of this mixture of isotopes (≤ 8 characters).

MASSFRAC(I) is the mass-fraction of the *Ith* isotope in the mixture.

ISOSYM(I) is the symbol for the *Ith* isotope in the mixture and consists of an elemental symbol followed by the atomic weight (without a space), e.g. **he4.** Also, each *ISOSYM* listed here must be one of the isotopes in the specific BURN network specified by the "NET" card(s).

Pairs of such mass fractions and isotope symbols are listed for each isotope in the mixture. Continue if necessary on a new "M" card with the same *MIX-NAME*. After all such cards have been read, the code renormalizes the sum of the mass fractions to insure it equals 1.

G *ZONE# NETWORK# MIX-NAME*

'g 0 1 solcomp'

Grid Cards. (At least 2 required).

ZONE# is the number of the zonal interface being described (J). This should always be 0 for the first "G" card and be equal to the total number of zones desired for the last "G" card. For intermediate "G" cards, J should increase monotonically between these values. Not every interface need be specified, and conditions at intermediate interfaces will be calculated as described below. Normally, the total number of zones should be the same as specified in the regular KEPLER generator file.

NETWORK# is the number of the BURN nuclear-burning network to be used between this zonal interface and the next one specified. (NETNUMB(J)). Currently it must be 1 (see "NET").

MIX-NAME is name of the material (as specified by the appropriate "M" cards) that lies

P *PARAMETER# PARAMETER-VALUE*

'p 1 1.e-5'

Parameter Card(s). (Optional -- Parameters are otherwise set to their default values).

PARAMETER# is the number or name of the parameter to be specified. See Chapters 3 and 4 and Appendix B for a list of the changeable parameters in the code and their units and default values.

PARAMETER-VALUE is the value to be assigned to this parameter. Note that fixed point parameters must have fixed pointed values specified , and floating point parameters must be given floating point values (1 ≠ 1.)

BURN GENERATOR RESTRICTIONS

Restrictions corresponding to current FORTRAN parameter settings in include-file KEPCOMS and subroutine GENBURN are listed below (where the name of the FORTRAN parameter is shown in capital letters). These may be changed by editing and recompiling KEPLER.

NNIZB..... Maximum Number of BURN Networks = 1. (See "NET" Card discussion).
NHIZB..... Maximum Number of Isotope Types per BURN Network = 300, if NBURN is changed.
NBURN... 'Actual' Number of Isotopes in the BURN Network = 150. (vs. 149 specified?)
NMIZB.... Maximum Number of BURN Material Mixtures = 2.
NIMZB.... Maximum Number of BURN Isotope Types per Mixture = 150.
NITZB.....Maximum Number of BURN Isotope Types Overall = 300.
JMZB..... Maximum Number of BURN Zones = JMZ (Maximum number of KEPLER zones).

SAMPLE KEPLER GENERATOR

```
c s25sha--25 solar mass star of solar composition
c abundances from anders and grevesse (geochem et cosmochem 1988)
c semi-convection and convective overshoot mixing turned on everywhere
c outer region of the star (abar.ge.abarsemi (p324) =  4.)
c note drmult (p24) = 0.1;   woversht (p148) = 0.01
c note drmultlo (p325) = 0.1;  woverslo (p326) = 0.01
c note c12(ag) rate is 0.5 times the cf88 current value
c
c box and id information:
box v98 weaver
c
c specify burn-generator-file name to turn on isotopic co-processing
genburn sol160bg
c
c input for approx network (network #1):
net 1  h1    he3   he4   n14   c12   o16   ne20  mg24  si28  s32
net 1  ar36  ca40  ti44  cr48  fe52  ni56  fe54  pn1   nt1
c
c include ise and nse networks (networks #2 and #3)
isenet
c
c solar abundances (weight %):
m  sol     70.57 h1     2.929e-3 he3       27.52 he4    0.3069  c12
m  sol    0.1109 n14      0.9618 o16      0.1753 ne20   0.06935 mg24
m  sol  7.688e-2 si28   4.259e-2 s32    9.619e-3 ar36
m  sol  6.571e-3 ca40   2.947e-4 cr48   1.813e-3 fe52
m  sol    0.1285 fe54
c
c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g    0  5.0e+34     1  sol  6.0e+6  1.e-1
g    1  4.9996e+34  1  sol  5.e+6   8.e-2
g    2  4.9990e+34  1  sol  5.e+6   8.e-2
g    3  4.9980e+34  1  sol  5.e+6   8.e-2
g    4  4.9962e+34  1  sol  5.e+6   8.e-2
g    5  4.9930e+34  1  sol  5.e+6   8.e-2
g    6  4.9900e+34  1  sol  5.e+6   8.e-2
g    7  4.9850e+34  1  sol  5.e+6   8.e-2
g   20  4.9e+34     1  sol  1.e+6   7.e-2
g   30  4.8e+34     1  sol  1.e+6   6.e-2
g   45  4.5e+34     1  sol  1.e+6   5.e-2
g   65  4.0e+34     1  sol  1.e+6   4.e-2
g   85  3.0e+34     1  sol  3.e+5   3.5e-2
g  115  1.0e+34     1  sol  1.e+5   3.e-2
g  130  1.0e+33     1  sol  1.e+4   2.e-2
g  140  1.0e+32     1  sol  1.e+4   1.e-2
g  150  1.e+31      1  sol  1.e+4   6.e-3
g  160  0.0         1  sol  5.e+3   1.e-3
c
c adjust initial temperature to yield hydrostatic equilibrium
hstat
```

Sample KEPLER Generator (Cont.)

```
c reset default parameter values:
c
c time-step and back-up controls
p 6 .07
p 7 .05
p 8 .15
p 9 .07
p 46 .15
p 47 1.e-3
c
c problem termination criteria
p 158 999999
p 306 9.e+7
p 307 .05
c
c linear artificial viscosity coefficient (reset to 0.1 at zero-age ms)
p 13 1000.
c
c edit and dump  controls
p 16 20
p 18 10
p 156 25
p 268 53
c
c semiconvection and overshoot mixing coefficients
p 24 0.1
p 148 0.01
p 324 4.
p 325 0.1
p 326 0.01
c
c graphics parameters
p 42 10240750
p 64 50
p 113 31
c
c minimum nuclear burning temperature (K)
p 65 1.e+7
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-4
p 86 0
p 87 1
p 138 .15
p 139 .5
p 150 .008
p 151 .01
p 152 .02
p 193 .1
p 195 .005
```

Sample KEPLER Generator (Cont.)

```
c ise control parameters
p 185 1.5e+9
p 185 .04
p 203 1.e+5
c
c c12(a,g) rate multipliers
p 227 0.5
p 228 0.5
c
c post-processor-dump control parameters
p 303 0.5
c
c set the time at which to make zero-age-main-sequence parameter changes
p 308 1.e+12
c
c turn on rezoner at the zero-age main sequence by reseting p 86
c to the value of p 309
p 309 1
c
c turn down the linear artificial viscosity at the zero-age main
c sequence by reseting p 13 to the value of p 310
p 310 .1
c
c set the core temperature at which to make pre-carbon-burning
c parameter changes
p 311 5.e+8
c
c raise floor on abundances considered in calculating the time-step
c just before carbon ignition by reseting p47 to the value of p312
p 312 .003
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by reseting p195 to the value of p313 and p150 to the value of p314
p 313 .0015
p 314 .004

c
c list of dump  variables (name, dump  ratio, dezone ratio, adzone ratio):
c
c thermodynamic quantities
dump  rn       .01   .01   .025
dump  tn       .01   .01   .025
dump  dn       .03   .03   .1
dump  un       .03   .03   .1
dump  pn       .03   .03   .1
dump  sgain    .05   .05   .15
dump  sloss    .05   .05   .15
dump  sneut    .05   .05   .15
c
c convection sentinels
dump  convect  .1   -1.  0.
```

Sample KEPLER Generator (Cont.)

```
c entropies
dump  sig      .01   .01   .025
dump  sigi     .01   .01   .025
dump  sige     .01   .01   .025
dump  sigr     .01   .01   .025
dump  sigp     .01   .01   .025
dump  sigion   .01   .01   .025
c
c approx and ise ions
dump  ionnt1   .02   .02   .06
dump  ionh1    .02   .02   .06
dump  ionpn1   .02   .02   .06
dump  ionhe3   .02   .02   .06
dump  ionhe4   .02   .02   .06
dump  ionc12   .02   .02   .06
dump  ionn14   .02   .02   .06
dump  iono16   .02   .02   .06
dump  ionne20  .02   .02   .06
dump  ionmg24  .02   .02   .06
dump  ionsi28  .02   .02   .06
dump  ions32   .02   .02   .06
dump  ionar36  .02   .02   .06
dump  ionca40  .02   .02   .06
dump  ionti44  .02   .02   .06
dump  ioncr48  .02   .02   .06
dump  ionfe52  .02   .02   .06
dump  ionfe54  .02   .02   .06
dump  ionni56  .02   .02   .06
dump  ionfe56  .02   .02   .06
dump  ion'fe'  .02   .02   .06
dump  ionye    .001  .001  .0025
dump  ionyq    .003  .003  .01
dump  ioneb0   .001  .001  .0025
dump  ionyf    .003  .003  .01
c
c parameters
dump  qparm    1.    1.    1.
dump  parm     1.    1.    1.
c
c misc. zonal edit quantities
dump  netnum   .1    .1    .3
dump  en       .03   .03   .1
dump  zn       .03   .03   .1
dump  etan     .01   .01   .025
dump  abar     .01   .01   .025
dump  zbar     .01   .01   .025
dump  xkn      .02   .02   .06
dump  gamma    .001  .001  .0025
dump  xln      .03   .03   .1
dump  taumix   .05   .05   .15
dump  mixlen   .05   .05   .15
```

Sample KEPLER Generator (Cont.)

```
c weak rates and neutrino losses
dump  wrate     .05    .05    .15
dump  rectot    .05    .05    .15
dump  rpdtot    .05    .05    .15
dump  redtot    .05    .05    .15
dump  snuw      .05    .05    .15
dump  snubps    .05    .05    .15
c
c burn variables
dump  yeburn    .001   .001   .0025
dump  sburn     .05    .05    .15
c
c burn isotopes
dump  isont1    .02    .02    .06
dump  isoh1     .02    .02    .06
dump  isoh2     .02    .02    .06
dump  isohe3    .02    .02    .06
dump  isohe4    .02    .02    .06
dump  isoli7    .02    .02    .06
dump  isobe7    .02    .02    .06
dump  isoc12    .02    .02    .06
dump  isoc13    .02    .02    .06
dump  ison14    .02    .02    .06
dump  isoo16    .02    .02    .06
dump  isoo18    .02    .02    .06
dump  isone20   .02    .02    .06
dump  isone22   .02    .02    .06
dump  isona22   .02    .02    .06
dump  isomg24   .02    .02    .06
dump  isoal26   .02    .02    .06
dump  isosi28   .02    .02    .06
dump  isosi30   .02    .02    .06
dump  isos32    .02    .02    .06
dump  isos34    .02    .02    .06
dump  isoar36   .02    .02    .06
dump  isoca40   .02    .02    .06
dump  isoti44   .02    .02    .06
dump  isofe52   .02    .02    .06
dump  isofe54   .02    .02    .06
dump  isofe56   .02    .02    .06
dump  isofe58   .02    .02    .06
dump  isoni56   .02    .02    .06
dump  isoni58   .02    .02    .06
c
c
c
```

Sample KEPLER Generator (Cont.)

```
c special ascii edit requests:
c zedit 1 10 sig sige sigi sigr sigion sigp
c
c
c parameter changes before silicon ignition:
c (when o16.lt. 5 wt.% and tn(1).gt.tqselim (p184) -- use p307)
c
c tighten up time-step controls on radius, temp, and density changes
c p 6 .02
c p 7 .02
c p 8 .02
c
c relax convergence criteria for radius and temperature
c p 11 1.e-5
c p 12 1.e-5
c
c tolerate more convergence error in temperature and density
c before backing up
c p 54 10.
c p 55 10.
c
c make code insensitive to convergence errors in luminosity
c p 70 1.d+99
c p 73 1.d+99
c
c tolerate larger abundance changes before backing up
c p 206 3.e-3
c
c turn off stop at oxygen depletion
c p 307 -1.e+99
c
c zero the problem time to achieve more precision
c zerotime
```

SAMPLE KEPLER GENERATOR VARIATIONS

Listed below are typical variations in the sample generator given above. Only (non-comment) cards, or sets of cards, that differ from the original generator are listed.

LMC Abundances

```
c lmc abundances (weight %):
m  lmc     74.60 h1     2.929e-3 he3       25.00 he4    0.0522  c12
m  lmc    0.0122 n14      0.2500 o16      0.0561 ne20   0.0354  mg24
m  lmc  4.300e-2 si28   1.830e-2 s32    5.290e-3 ar36
m  lmc  3.020e-3 ca40   1.240e-4 cr48   7.610e-4 fe52
m  lmc    0.0797 fe54
```

Restricted Semiconvection

```
c semiconvection and overshoot mixing coefficients
p 24 1.e-4
p 148 0.0
p 324 4.
p 325 1.e-4
p 326 0.0
```

Nominal deJager Mass Loss Rate

```
c mass loss parameters
p 220 1.
p 225 .01
```

Sample KEPLER Generator Variations (Cont.)

8 Solar Mass Star

```
c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g    0  1.6e+34     1  sol  6.0e+6  1.e-1
g    1  1.5996e+34  1  sol  5.e+6   8.e-2
g    2  1.5990e+34  1  sol  5.e+6   8.e-2
g    3  1.5980e+34  1  sol  5.e+6   8.e-2
g    4  1.5962e+34  1  sol  5.e+6   8.e-2
g    5  1.5930e+34  1  sol  5.e+6   8.e-2
g    6  1.5900e+34  1  sol  5.e+6   8.e-2
g    7  1.5850e+34  1  sol  5.e+6   8.e-2
g   20  1.5e+34     1  sol  1.e+6   7.e-2
g   30  1.4e+34     1  sol  1.e+6   6.e-2
g   50  1.2e+34     1  sol  1.e+6   5.e-2
g   70  1.0e+34     1  sol  1.e+6   4.e-2
g  100  5.0e+33     1  sol  1.e+5   3.e-2
g  130  1.0e+33     1  sol  1.e+4   2.e-2
g  140  1.0e+32     1  sol  1.e+4   1.e-2
g  150  1.e+31      1  sol  1.e+4   6.e-3
g  160  0.0         1  sol  5.e+3   1.e-3
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-4
p 86 0
p 87 1
p 138 .4
p 139 .5
p 150 .008
p 151 .01
p 152 .02
p 193 .27
p 195 .005
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by reseting p195 to the value of p313 and p150 to the value of p314
p 313 .003
p 314 .007
```

Sample KEPLER Generator Variations (Cont.)

15 Solar Mass Star

```
c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g    0  3.0e+34     1  sol  6.0e+6  1.e-1
g    1  2.9996e+34  1  sol  5.e+6   8.e-2
g    2  2.9990e+34  1  sol  5.e+6   8.e-2
g    3  2.9980e+34  1  sol  5.e+6   8.e-2
g    4  2.9962e+34  1  sol  5.e+6   8.e-2
g    5  2.9930e+34  1  sol  5.e+6   8.e-2
g    6  2.9900e+34  1  sol  5.e+6   8.e-2
g    7  2.9850e+34  1  sol  5.e+6   8.e-2
g   20  2.9e+34     1  sol  1.e+6   7.e-2
g   30  2.8e+34     1  sol  1.e+6   6.e-2
g   45  2.5e+34     1  sol  1.e+6   5.e-2
g   70  2.0e+34     1  sol  1.e+6   4.e-2
g  115  1.0e+34     1  sol  1.e+5   3.e-2
g  130  1.0e+33     1  sol  1.e+4   2.e-2
g  140  1.0e+32     1  sol  1.e+4   1.e-2
g  150  1.e+31      1  sol  1.e+4   6.e-3
g  160  0.0         1  sol  5.e+3   1.e-3
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-3
p 86 0
p 87 1
p 138 .24
p 139 .5
p 150 .008
p 151 .01
p 152 .02
p 193 .16
p 195 .005
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by reseting p195 to the value of p313 and p150 to the value of p314
p 313 .002
p 314 .005
```

Sample KEPLER Generator Variations (Cont.)

40 Solar Mass Star

```
c initial grid (zone #, exterior mass(g), network #, temp(K), rho(g/cc)):
g    0  8.0e+34      1  sol  6.0e+6  1.e-1
g    1  7.9996e+34   1  sol  5.e+6   8.e-2
g    2  7.9990e+34   1  sol  5.e+6   8.e-2
g    3  7.9980e+34   1  sol  5.e+6   8.e-2
g    4  7.9962e+34   1  sol  5.e+6   8.e-2
g    5  7.9930e+34   1  sol  5.e+6   8.e-2
g    6  7.9900e+34   1  sol  5.e+6   8.e-2
g    7  7.9850e+34   1  sol  5.e+6   8.e-2
g   20  7.9e+34      1  sol  1.e+6   7.e-2
g   30  7.8e+34      1  sol  1.e+6   6.e-2
g   45  7.5e+34      1  sol  1.e+6   5.e-2
g   57  7.0e+34      1  sol  1.e+6   4.e-2
g   70  6.0e+34      1  sol  1.e+6   4.e-2
g  115  1.0e+34      1  sol  1.e+5   3.e-2
g  130  1.0e+33      1  sol  1.e+4   2.e-2
g  140  1.0e+32      1  sol  1.e+4   1.e-2
g  150  1.e+31       1  sol  1.e+4   6.e-3
g  160  0.0          1  sol  5.e+3   1.e-3
c
c set very small surface boundary pressure to discourage mass loss
p 69 3.
c
c rezoning criteria
p 83 1.e+4
p 84 1.e-4
p 86 0
p 87 1
p 138 .1
p 139 .5
p 150 .005
p 151 .01
p 152 .02
p 193 .065
p 195 .003
c
c finely zone the central 2-4 solar masses just before carbon ignition
c by reseting p195 to the value of p313 and p150 to the value of p314
p 313 .00085
p 314 .00225
```

SAMPLE BURN GENERATOR (SOLAR ABUNDANCES)

```
c sol160bg -- burn generator deck with standard 149 isotope burn network,
c             solar composition (anders and grevesse, geochem et
c             cosmochem 1988) and 160 initial zones.
c
c standard 149 isotope burn network:
net 1    nt1    h1    h2    h3    he3   he4   li7   be7   b10   b11
net 1    c11    c12   c13   c14   n13   n14   n15   o15   o16   o17
net 1    o18    f17   f18   f19   ne19  ne20  ne21  ne22  ne23  na22
net 1   na23   na24  mg23  mg24  mg25  mg26  mg27  al26  al27  al28
net 1   si27   si28  si29  si30  si31   p30   p31   p32   p33   s31
net 1    s32    s33   s34   s35   s36   s37  cl35  cl36  cl37  cl38
net 1   ar36   ar37  ar38  ar39  ar40  ar41   k39   k40   k41   k42
net 1   ca40   ca41  ca42  ca43  ca44  ca45  ca46  ca47  sc43  sc44
net 1   sc45   sc46  sc47  ti44  ti45  ti46  ti47  ti48  ti49  ti50
net 1   ti51    v47   v48   v49   v50   v51   v52  cr48  cr49  cr50
net 1   cr51   cr52  cr53  cr54  cr55  mn51  mn52  mn53  mn54  mn55
net 1   mn56   fe52  fe53  fe54  fe55  fe56  fe57  fe58  fe59  fe60
net 1   fe61   co55  co56  co57  co58  co59  co60  co61  ni56  ni57
net 1   ni58   ni59  ni60  ni61  ni62  ni63  ni64  ni65  cu59  cu60
net 1   cu61   cu62  cu63  cu64  zn60  zn61  zn62  zn63  zn64
c
c define solar composition (anders and grevesse, geochem et cosmochem 1988):
m  solcomp   7.057e-1   h1   4.801e-5   h2   2.929e-5  he3
m  solcomp   2.752e-1  he4   9.349e-9  li7   1.067e-9  b10
m  solcomp   4.730e-9  b11   3.032e-3  c12   3.650e-5  c13
m  solcomp   1.105e-3  n14   4.363e-6  n15   9.592e-3  o16
m  solcomp   3.887e-6  o17   2.167e-5  o18   4.051e-7  f19
m  solcomp   1.619e-3 ne20   4.127e-6 ne21   1.302e-4 ne22
m  solcomp   3.339e-5 na23   5.148e-4 mg24   6.766e-5 mg25
m  solcomp   7.760e-5 mg26   5.805e-5 al27   6.530e-4 si28
m  solcomp   3.426e-5 si29   2.352e-5 si30   8.155e-6  p31
m  solcomp   3.958e-4  s32   3.222e-6  s33   1.866e-5  s34
m  solcomp   9.379e-8  s36   2.532e-6 cl35   8.545e-7 cl37
m  solcomp   7.740e-5 ar36   1.538e-5 ar38   2.529e-8 ar40
m  solcomp   3.472e-6  k39   5.545e-9  k40   2.634e-7  k41
m  solcomp   5.990e-5 ca40   4.196e-7 ca42   8.973e-8 ca43
m  solcomp   1.425e-6 ca44   2.793e-9 ca46   3.893e-8 sc45
m  solcomp   2.234e-7 ti46   2.081e-7 ti47   2.149e-6 ti48
m  solcomp   1.636e-7 ti49   1.644e-7 ti50   9.258e-10 v50
m  solcomp   3.767e-7  v51   7.424e-7 cr50   1.486e-5 cr52
m  solcomp   1.716e-6 cr53   4.357e-7 cr54   1.329e-5 mn55
m  solcomp   7.130e-5 fe54   1.169e-3 fe56   2.855e-5 fe57
m  solcomp   3.697e-6 fe58   3.358e-6 co59   4.944e-5 ni58
m  solcomp   1.958e-5 ni60   8.594e-7 ni61   2.776e-6 ni62
m  solcomp   7.269e-7 ni64   5.753e-7 cu63   9.924e-7 zn64
c
c specify grid composition (for 160 zone problem):
g    0  1  solcomp
g  160  1  solcomp
```

SAMPLE BURN GENERATOR (LMC ABUNDANCES)

```
c lmc160bg -- burn generator deck with standard 149 isotope burn network,
c               lmc composition (isotopes scaled to anders and
c               grevesse, 1988) and 160 initial zones.
c
c standard 149 isotope burn network:
net 1    nt1    h1    h2    h3   he3   he4   li7   be7   b10   b11
net 1    c11   c12   c13   c14   n13   n14   n15   o15   o16   o17
net 1    o18   f17   f18   f19  ne19  ne20  ne21  ne22  ne23  na22
net 1   na23  na24  mg23  mg24  mg25  mg26  mg27  al26  al27  al28
net 1   si27  si28  si29  si30  si31   p30   p31   p32   p33   s31
net 1    s32   s33   s34   s35   s36   s37  cl35  cl36  cl37  cl38
net 1   ar36  ar37  ar38  ar39  ar40  ar41   k39   k40   k41   k42
net 1   ca40  ca41  ca42  ca43  ca44  ca45  ca46  ca47  sc43  sc44
net 1   sc45  sc46  sc47  ti44  ti45  ti46  ti47  ti48  ti49  ti50
net 1   ti51   v47   v48   v49   v50   v51   v52  cr48  cr49  cr50
net 1   cr51  cr52  cr53  cr54  cr55  mn51  mn52  mn53  mn54  mn55
net 1   mn56  fe52  fe53  fe54  fe55  fe56  fe57  fe58  fe59  fe60
net 1   fe61  co55  co56  co57  co58  co59  co60  co61  ni56  ni57
net 1   ni58  ni59  ni60  ni61  ni62  ni63  ni64  ni65  cu59  cu60
net 1   cu61  cu62  cu63  cu64  zn60  zn61  zn62  zn63  zn64
c
c define lmc composition:
m  lmcomp   7.460e-1   h1   4.801e-5   h2   2.929e-5  he3
m  lmcomp   2.500e-1  he4   9.349e-9  li7   1.067e-9  b10
m  lmcomp   4.730e-9  b11   5.150e-4  c12   6.210e-6  c13
m  lmcomp   1.210e-4  n14   4.800e-7  n15   2.490e-3  o16
m  lmcomp   1.010e-6  o17   5.630e-6  o18   1.050e-7  f19
m  lmcomp   5.180e-4 ne20   1.320e-6 ne21   4.170e-5 ne22
m  lmcomp   1.070e-5 na23   2.630e-4 mg24   3.450e-5 mg25
m  lmcomp   3.960e-5 mg26   1.510e-5 al27   3.660e-4 si28
m  lmcomp   1.920e-5 si29   1.320e-5 si30   4.570e-6  p31
m  lmcomp   1.700e-4  s32   1.390e-6  s33   8.020e-6  s34
m  lmcomp   4.030e-8  s36   8.600e-7 cl35   2.910e-7 cl37
m  lmcomp   4.260e-5 ar36   8.460e-6 ar38   1.390e-8 ar40
m  lmcomp   1.740e-6  k39   2.770e-9  k40   1.320e-7  k41
m  lmcomp   2.760e-5 ca40   1.930e-7 ca42   4.130e-8 ca43
m  lmcomp   6.660e-7 ca44   1.280e-9 ca46   2.490e-8 sc45
m  lmcomp   5.140e-8 ti46   4.790e-8 ti47   4.940e-7 ti48
m  lmcomp   3.760e-8 ti49   3.780e-8 ti50   4.440e-10 v50
m  lmcomp   1.810e-7  v51   3.560e-7 cr50   7.130e-6 cr52
m  lmcomp   8.240e-7 cr53   2.090e-7 cr54   6.650e-6 mn55
m  lmcomp   4.420e-5 fe54   7.250e-4 fe56   1.770e-5 fe57
m  lmcomp   2.290e-6 fe58   1.680e-6 co59   2.770e-5 ni58
m  lmcomp   1.100e-5 ni60   4.810e-7 ni61   1.550e-6 ni62
m  lmcomp   4.070e-7 ni64   2.780e-7 cu63   4.960e-7 zn64
c
c specify grid composition (for 160 zone problem):
g    0  1  lmcomp
g  160  1  lmcomp
```

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CHAPTER 3

PARAMETER LIST BY FUNCTION

This chapter lists by functional grouping the 330 changeable ('P') parameters in KEPLER that may be edited changed before or during execution. A reference list of these parameters arranged in numerical order is given in Chapter 4. Initial values for these parameters may be specified by **P** cards in the problem generator file (see Chapter 2). If no explicit such specification is made, their values are initially set equal to the default values listed below.

These parameters may also be edited or changed during program execution by the following set of keyboard commands (also described in Chapter 5):

P *N*

Display the value of parameter name or number *N:* **' p 113 '** or **' p time '**

P *N VALUE*

Change the value of parameter name or number *N* to *VALUE:* **' p 113 31'**

P *N DELTA* **ADD**

Add *DELTA* to the value of parameter name or number *N:* **' p 1 -1.e+14 add'**

Note that, although printed in capital letters for clarity, the parameter names listed below must be given as unquoted, **lowercase** character strings when communicating with KEPLER. The mode of the parameters (fixed or floating point) follows the normal FORTRAN convention.

The current values of the parameters are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with DTNEW) and their ASCII names and types are listed respectively in the **nameparm** and **iptype** arrays loaded in data block KEPDAT. Newly added parameters are initialized in subroutine subroutine RESTART (see Chapter 5).

TIME AND STATUS PARAMETERS

#	Name	Default	Description
2	TIME	0.	Initial or current time (sec).
315	TOFFSET	0.	Cumulative amount of time by which the problem time has been offset by ZEROTIME commands (sec). In other words, TOFFSET should be added to the current problem time to get the actual time since the beginning of the problem. Normally, TOFFSET is reset internally when the ZEROTIME command is issued and should **not** be reset by the user.
157	NITERBAR	1	Total number of cycles used to compute ITERBAR, the average number of iterations per cycle. (Internally set.)

PARAMETER-CHANGE PARAMETERS

308	TIMEZMS	1.E+99	Time at which to make the zero-age-main-sequence parameter changes and restart dump (typically 1.E+12). (sec).
309	IZONEZMS	1	Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).
310	Q1FACZMS	0.1	Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).
311	TEMPCIG	1.E+99	Central temperature at which to make the pre-carbon-ignition parameter changes and restart dump (typically 5.E+8). (K).
312	YFLRXCIG	0.003	Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
313	FMAXMCIG	1.	Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
314	FMAX0CIG	1.	Reset the value of FMAX0 (P 150) to FMAX0CIG when the central temperature specified by TEMPCIG (P 311) is reached.

PROBLEM TERMINATION PARAMETERS

14	NSTOP	100000	Maximum number of cycles.
15	TSTOP	1.E+30	Stop time (sec).
158	ITERBARM	100	Maximum allowed value of NITERBAR without terminating the problem.
304	TEMPSTOP	1.E+99	Terminate the problem when the central temperature reaches TEMPSTOP (K).
305	DENSTOP	1.E+99	Terminate the problem when the central density reaches DENSTOP (g/cc).
306	VINSTOP	1.E+99	Terminate the problem when the infall velocity exceeds VINSTOP (cm/sec). Note that positive values of VINSTOP correspond to negative (infalling) velocities.
307	O16STOP	-1.	Terminate the problem when the O16 mass-fraction drops below O16STOP provided the central temperature exceeds TQSELIM (P 184). Basically this corresponds to a time near the end of core oxygen burning for values of O16STOP about 0.05.

SPECIAL COMMAND EXECUTION AND DUMP PARAMETERS

331	TEMPCDEP	1.E+99	If the central temperature is ≥ TEMPCDEP, then make a restart dump labeled '#cdep', execute the alias-defined "cdep" command, and reset TEMPCDEP to 1.E+99. Normally, this parameter is used to reset certain parameter values following carbon depletion.
332	O16ODEP	-1.E+99	If the central oxygen abundance is ≤ O16ODEP *and* the central temperature is ≥ TQSELIM (P 184), then make a restart dump labeled '#odep', execute the alias-defined "odep" command, and reset O16ODEP to -1.E+99. Normally, this parameter is used to reset certain parameter values at oxygen depletion.
333	TEMPCHAR	1.E+99	If the central temperature is ≥ TEMPCHAR, then make a restart dump labeled with '#tn' and the current cycle number, reset TEMPCHAR to 1.E+99, and *finally* execute the alias-defined

"tnchar" command.
Note that the user -defined "tnchar" command can change the value of TEMPCHAR in such a way as to cause the "tnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

334 DENCHAR 1.E+99 If the central density is ≥ DENCHAR, then make a restart dump labeled with '#dn' and the current cycle number, reset DENCHAR to 1.E+99, and *finally* execute the alias-defined "dnchar" command.
Note that the user -defined "dnchar" command can change the value of DENCHAR in such a way as to cause the "dnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

335 ABARCHAR 1.E+99 If the central mean atomic weight (ABAR) is ≥ ABARCHAR, then make a restart dump labeled with '#ab' and the current cycle number, reset ABARCHAR to 1.E+99, and *finally* execute the alias-defined "abchar" command.
Note that the user -defined "abchar" command can change the value of ABARCHAR in such a way as to cause the "abchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

343 TSHOCK 1.E+99 If the problem time is ≥ TSHOCK, then make a restart dump labeled '#shock', reset TSHOCK to 1.E+99, and *finally* execute the alias-defined "tshock" command.
Normally, this command is used to reset certain parameter values and/or make edits at the time of the piston-induced bounce of the collapsing iron core that creates an out-going shock wave.

344 TNUCLEO 1.E+99 If the problem time is ≥ TNUCLEO, then make a restart dump labeled '#nucleo', reset TNUCLEO to 1.E+99, and *finally* execute the alias-defined "tnucleo" command.
Normally, this command is used to reset certain parameter values and/or make edits at a time just after explosive nucleosynthesis is complete.

345 TENVEL 1.E+99 If the problem time is ≥ TENVEL, then make a restart dump labeled '#envel', reset TENVEL to 1.E+99, and *finally* execute the alias-defined "tenvel" command.
Normally, this command is used to reset certain parameter values and/or make edits just before the supernova shock wave breaks through the surface of the presupernova star.

OTHER EXECUTION CONTROL PARAMETERS

159	IAUTOOUT	0	Send out two copies of the ASCII output if IAUTOOUT>1. Also send out two copies of the graphics output if IAUTOOUT>2. Note: No output files are destroyed. (CRAY only! -- this is an obsolescent parameter that should not be used on UNIX machines without recasting.)
161	FRACCORE	1.1	The effective number of zones used in REGESS (JMCALC) shall be the minimum needed to contain the inner FRACCORE mass-fraction of the initial mass of the star.
162	JMCALC	JM	Effective number of zones used in subroutine REGESS. JMCALC is internally calculated from FRACCORE and should not be changed.
192	JPAUSE	-1	Pause the code at the end of the calculation for zone J = JPAUSE in REGESS ("PAUSE 1") and in UPDATE ("PAUSE 2"). Do not pause if JPAUSE < 0. Type a carriage return to continue.

GENERAL EDIT CONTROL PARAMETERS

16	NEDIT	20	Number of cycles between ASCII edits.
17	DTEDIT	0.	Time between ASCII edits (0. = ∞) (sec).
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
197	NNEWOUTF	2000	Start a new labeled ASCII output file every NNEWOUTF cycles.
268	NPAGE	53	Number of lines printed per "page" of ASCII output. The value 53 causes zone lists to be printed in 50-zone blocks.
273	SCALEM	1.9892E+33	Mass unit used for the mass coordinate employed in making ASCII and terminal edits (g).
274	NEDITZ1	10	Make an ascii edit of primary zonal quantities every NEDITZ1*NEDIT (P 16) cycles.
275	NEDITZ2	20	Make an ascii edit of secondary zonal quantities every NEDITZ2*NEDIT (P 16) cycles.
243	NEDITA	10	Make an elemental abundance edit every NEDITA*NEDIT (P 16) cycles.
278	NEDITP	50	Make an ascii edit of all changeable parameters every NEDITP*NEDIT (P 16) cycles.
276	MEDIT	0	Flag determining the minimum amount of information printed in an ascii cycle edit regardless of the settings of other edit parameters: ≤ 0 means minimum is a 1 page "short" edit; ≥ 1 means minimum includes a primary zonal edit; ≥ 2 means minimum includes a secondary zonal edit; ≥ 3 means minimum includes an ion abundance edit; ≥ 4 means minimum includes an ISE abundance edit; ≥ 5 means minimum includes a BURN isotope edit; ≥ 6 means minimum includes a BURN isotope edit for all

zones;
≥ 7 means minimum includes a parameter edit.

277	MEDITFIN	7	Effective value of MEDIT (P 276) used in determining the scope of the final edit made when the problem is finished.

ISE EDIT PARAMETERS

168	NJEDITQ	5	Make a ISE edit every NJEDITQ zones.
180	NEDITQ	20	Make a detailed edit of the ISE zones every NEDITQ general numerical edits.
183	XTHRES	1.E-4	Edit only those ISE isotopes with mass fractions exceeding XTHRES.
198	NEDITQ1	5	Make an ISE edit for the central zone every NEDITQ1 * NEDIT (P 16) cycles.

BURN EDIT PARAMETERS

241	NEDITB	5	Make a BURN isotopic abundance edit every NEDITB*NEDIT (P 16) KEPLER cycles.
244	JMEDITB	1	Edit only zones whose zone number is ≤ JMEDITB during normal BURN isotopic abundance edits.
245	NEDITALL	100	Make a BURN isotopic abundance edit for all zones every NEDITALL*NEDIT (P 16) cycles regardless of the value of NEDITB (P 241).
272	ABUNLIMB	1.E-5	Edit only those BURN isotope mass-fractions whose values exceed ABUNLIMB in making terminal edits (including isotopic mass-fraction sums over zones).
250	NCOMP	999999	Make a complete ASCII edit of the nuclear processes in all zones considered by the BURN coprocessor every NCOMP cycles.
251	NCENT	999999	Make an ASCII edit of the nuclear processes in the central zone considered by the BURN coprocessor every NCENT cycles.
252	NEDT	999999	Make an ASCII edit of the nuclear processes involved every nedt BURN coprocessor matrix inversions (debugging only).

RESTART-DUMP CONTROL PARAMETERS

18	NDUMP	10	Number of cycles between restart dumps.
156	NSDUMP	10	Save every NSDUMP restart dumps.
269	NSAVEZ	24	Total number of nonBURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with YM and numbering NZONEI + NZONEC in total. NSAVEZ must be at least 14 and no greater than NZONEI + NZONEC. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
270	NSAVEB	10	Total number of BURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with NETNUMB and numbering NZONEB in total. NSAVEB must be at least 6 and no greater than NZONEB. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
308	TIMEZMS	1.E+99	Time at which to make the zero-age-main-sequence parameter changes and restart dump (typically 1.E+12). (sec).
311	TEMPCIG	1.E+99	Central temperature at which to make the pre-carbon-ignition parameter changes and restart dump (typically 5.E+8). (K).

POST-PROCESSOR-DUMP CONTROL PARAMETERS

299	NCYCQQ	5	Number of KEPLER cycles between post-processor dump cycles (i.e.. calls to DUMPQ).
44	LENQMAX	3000000	Maximum length of a post-processor dump file (bytes).
164	NIONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all 'ions' specified as dump variables.
165	NISODUMP	400	Number of dump cycles between forced dumps of all dump-grid points of all 'BURN 'isotopes' specified as dump variables.
166	NZONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all arrays specified as dump variables except 'ions' and 'isotopes.'
297	DSCALEM	1.9892E+33	Mass units used for the internal mass coordinate, YMASS, used for dumping purposes (g). -- See subroutine DUMPQ.
298	NGRIDMIN	10	Minimum number of points allowed in a dump grid. See DUMPQ.
300	LENTRACK	16384	Length of the track(s) assigned to each dump variable in the post-processor dump(s) (bytes). See DUMPQ.
303	BACKFACQ	0.5	If the fractional change in a dump variable since the last dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also dump the old value of that variable at the previous (dump cycle) time point, where RATZDUMP(IDAT) is the (previously specified) maximum allowed fractional change between dumps of this zonal dump variable (indexed by IDAT). See Chapter 2 on Generator Input.
346	NFIRSTQ	0	Default value of the first cycle to be read or plotted in making post-processor edits, time plots, or timemaps. Note that this parameter is reset by the NEWDUMPS command to the current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ) so that KEPLER will not try to read old dumps.

TIMESTEP CONTROL PARAMETERS

1	DTNEW	1.	Initial or current timestep (sec).
25	DTMAX	1.E+99	Maximum timestep allowed (sec).
6	DTCR	0.05	Maximum desired fractional change in radius per step.
7	DTCT	0.05	Maximum desired fractional change in temperature per step.
8	DTCD	0.10	Maximum desired fractional change in density per step.
9	DTCQ	0.05	Maximum desired fractional linear contraction per step.
10	DTCDT	0.99	Maximum fractional change in the timestep per step.
72	DTCL	1.E+99	Maximum desired fractional change in luminosity per step.
46	DTCP	0.1	Maximum desired fractional change in abundances per step.
47	YFLOORX	1.E-3	Minimum elemental mass fraction that effects the timestep.
312	YFLRXCIG	0.003	Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.
39	DYEMULT	200.	If IYTSFLAG≥1, increase the timestep sensitivity to changes in YE by a factor of DYEMULT.
40	DYQMULT	2.5	IF IYTSFLAG≥1, increase the timestep sensitivity to changes in YQ by a factor of DYQMULT.
67	IYTSFLAG	1	Consider only changes in YE, YQ, YF, YSI, and Y56 in ISE zones when computing the timestep if IYTSFLAG ≥ 1.

EXTRAPOLATION CONTROL PARAMETERS

3	EXTRAP	1.	Extrapolation Parameter used in guessing new R, T, and L values. 0. gives old values; 1. gives linear extrapolation.
26	FCREXT	10.	Factor used to reduce noise in radius extrapolation. (See subroutine GESS)
27	FCTEXT	10.	Factor used to reduce noise in temperature extrapolation.
71	FCLEXT	1.E-5	Factor used to reduce noise in luminosity extrapolation.

CONVERGENCE CONTROL PARAMETERS

11	FCRMAX	1.E-6	Maximum allowed relative convergence error in radius.
12	FCTMAX	1.E-6	Maximum allowed relative convergence error in temperature.
70	FCLMAX	1.	Maximum allowed relative convergence error in luminosity.
51	THICKFAC	1.E-3	If the timestep is greater than the thermal timescale for a zone by a factor $\geq$ 0.5*THICKFAC, then consider the zone to be in thermal steady-state and deal with any residual non-convergence in the solution of the energy equation by recalculating the luminosity in terms of the final iterated value of the internal energy. Otherwise, recalculate the internal energy in terms of the final iterated luminosity. (See subroutine UPDATE).
213	DENCONV	1.E-7	Allowed fractional convergence error in density when calculating a hydrostatic initial stellar configuration in the generator using the DSTAT option. (See GENER).

BACKUP CONTROL PARAMETERS

5	MAXIT	40	Maximum number of times subroutine REGESS is called to iterate R, T, and L estimates before the timestep is reduced by DTCUT and the step repeated (termed a "backup").
52	MAXBAK	5	Maximum number of times a given step is redone before the code quits.
53	DTCUT	0.1	Fractional timestep reduction when a step is redone.

BACKUP CONTROL PARAMETERS (Cont.)

22	FCRBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in radius is still greater than FCRBU after MAXIT iterations.
23	FCTBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in temperature is still greater than FCTBU after MAXIT iterations.
73	FCLBU	1.	Reduce timestep by DTCUT and redo step if convergence error in luminosity is still greater than FCLBU after MAXIT iterations.
54	TFCRBU	2.	If the maximum fractional change in radius during a timestep exceeds TFCRBU*DTCR then redo step.
55	TFCTBU	2.	If the maximum fractional change in temperature during a timestep exceeds TFCTBU*DTCT then redo step.
74	TFCLBU	1.E+99	If the maximum fractional change in luminosity during a timestep exceeds TFCLBU*DTCL then redo step.
205	TFCYBU	0.5	Maximim allowed fractional change in abundance before an abundance backup is made. (See P 204).
204	ABUNMINX	-1.E-5	Force a backup after a call to subroutine BURN from subroutine SDOT if a calculated elemental mass fraction change would cause the resulting mass fraction to be less than ABUNMINX or to change by a fractional amount greater than TFCYBU. Such backups are made only if the elemental mass fractions involved are greater than YFLOORBX .
206	YFLOORBX	0.001	Elemental mass fraction floor for making abundance backups. (See P 204).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG ≥ 1, or to terminate if IQERRFLG < 1.
224	XMRATBAK	0.2	Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.

BOUNDARY CONDITION PARAMETERS

60	RADIUS0	0.	Radius of inner boundary (cm).
61	SUMM0	0.	Mass inside inner boundary (g).
62	XLUM0	0.	Luminosity emerging from inner surface (erg/s).
68	TBOUND	0.	Temperature at outer boundary (K).
69	PBOUND	0.	Pressure at outer boundary (erg/cc).
271	VLOSS	1.E+99	Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).

ACCRETION PARAMETERS

211	ACCRATE	0.	Mean rate at which mass in the form of new zones is added to the surface of the star (solar masses per year). The accumulated mass is stored in XMACRETE (P 212) until it is large enough to be added as a whole zone. The surface boundary pressure is gradually increased at a rate proportional to ACCRATE until a mass (in XMACRETE) equal to that in the current outer zone is reached. Then a new zone, the mirror image of the old outer zone, is added. Accretion composition is set by the COMPSURF command in TTYCOM. This prescription will work best for coarse and roughly equal surface zoning.
212	XMACRETE	0.	Mass of phantom outer zone used to mediate mass accretion (g). (See P 211).

MASS-LOSS PARAMETERS

220	XMLOSSM	0.	Multiplier on the de Jager mass-loss rate. (See CYCLE and *Ann. Rev. Astron.Astrophys.* **24**, 336 (1986)).
221	XMLOSS0	0.	Nominal mass loss rate from the surface of the star (solar masses/year). This constant mass loss rate is added to whatever de Jager-prescription mass loss may have been specified by XMLOSSM (P 220).
222	TOTM0	0.	The original total mass of the star (g). This is set during generation and is used in interpreting edit, dump, and rezoning parameters involving stellar mass fractions rather than the current mass of the star (TOTM) which may change due to mass loss, accretion, etc. Normally, the internally set value of TOTM0 should not be changed by the user.
223	FRACDEZ	0.5	Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.
224	XMRATBAK	0.2	Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.
225	XFRACML	0.01	Subtract any "surface" mass loss specified by XMLOSSM (P 220) or XMLOSS0 (P 221) from the zone closest to the surface that still has more than XFRACML*TOTM0 (P 222) grams of material overlying it. This should be set so that mass is not extracted from zones too near the surface in order to avoid excessive dezoning, small timesteps, and luminosity fluctuations.
217	NSURFZ	-10	If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface. Otherwise, NSURFZ has no effect. (See REZONE.) This is an **obsolescent** parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
218	FRACSZ0	1.	Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an **obsolescent** parameter

MASS-LOSS PARAMETERS (Cont.)

			involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
219	FRACSZ1	1.	Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an **obsolescent** parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
348	BINM10	TOTM0	The initial mass of the star being evolved (primary) in solar masses that is used in calculating the possibility of mass loss to a binary companion, following the formalism of Podsiadlowski, Joss, and Hsu, ApJ, 391, 246, (1992). The star loses mass when its radius exceeds its Roche radius, with a power-law cutoff to avoid numerical discontinuities. The formalism also involves parameters 349 - 354, defined below. See subroutine CYCLE.
349	BINM20	0.	The initial mass of the binary companion star (in solar masses) used in calculating the possibility of binary mass transfer. No mass transfer is performed if BINM20 $\leq$ 0. See P 348.
350	BINALP	1.	PJH's alpha parameter, related to the angular momentum of the mass lost in binary transfer. See P 348.
351	BINBET	1.	PJH's beta parameter. Fraction of the total mass spilling over from the Roche lobe of the primary that is transferred to the secondary rather than being lost from the system. BINBET equals 1. for conservative binary mass transfer.
352	BINA0	2.	Initial binary separation in AU used in calculating the possibility of binary mass transfer. See P 348.
353	BINMDT	1.E-3	Mass loss rate due to binary mass transfer assumed when the primary stars exceeds its Roche radius (solar masses per year). See P 348.
354	ROCHER	1.E+99	Current Roche radius (cm). This is a calculated quantity and should normally not be changed by the user. See P 348.

ARTIFICIAL VISCOSITY PARAMETERS

4	Q2FAC	4.	Quadratic artificial viscosity (Q) factor. Shock transitions are spread over about 2*SQRT(Q2FAC) zones. (see WZW78)
13	Q1FAC	0.1	Linear artificial viscosity factor. Helps damp sound waves during hydrostatic evolution. Should be set to 0. during hydrodynamic phases. Normally set to 1000. in the generator until the star settles down onto the zero-age main sequence (from an initially rather arbitrary configuration), at which point it is reset to 0.1.
107	ARTV1	1.	Multiply Q1FAC by ARTV1 in zone J if JARTV1≤J<JARTV2.
108	ARTV2	1.	Multiply Q1FAC by ARTV2 in zone J if JARTV2≤J<JM-JARTV3.
109	ARTV3	1.	Multiply Q1FAC by ARTV3 in zone J if J≥MAX(JARTV1,JARTV2,JM-JARTV3)
110	JARTV1	1000	(See P 107-109).
111	JARTV2	1000	(See P 107-109).
112	JARTV3	1000	(See P 107-109).
310	Q1FACZMS	0.1	Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).

EQUATION-OF-STATE PARAMETERS

34	PIMULT	1.	Ion energy and pressure multiplier.
35	PRMULT	1.	Radiation energy and pressure multiplier.
36	PEMULT	1.	Electron energy and pressure multiplier.
56	XIPOT	13.6053	Ionization potential (eV) --see subtoutine ES.
57	DZERO	0.1	Characteristic density for pressure ionization (g/cc).
58	NPFLAG	1	Pairs are included in EOS calculation only if NPFLAG>0.
92	ETACONV	1.E-5	Relative convergence required in calculating the electron Fermi degeneracy parameter, ETA.
149	XMIMULT	1.	The mass used in calculating ion degeneracy is XMIMULT times the mass of a neutron.
196	EIONMULT	1.	Multiplier on the contribution of ionization potential energy to the equation of state. (See subroutine ES).
199	WILSONMT	-1.	Multiplier on the Wilson-based nuclear EOS (except for the thermal ion component) if it is ≥0. Otherwise, the old non-relativistic, partial degeneracy model for the ion EOS is used. WARNING...setting this parameter ≥ 0 appears to cause anomalous contributions to the pressure and energy at densities far below nuclear density and probably should not be used without revision. (See subroutine ES).
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
215	COULMULT	1.	Multiplier on the Wigner-Seitz Coulomb corrections to the ion energy and pressure (See Clayton, p. 152, and ES).

EQUATION-OF-STATE PARAMETERS (Cont.)

337	ICALCNE	0	Calculate more accurate electron densities in partially ionized regions if ICALCNE > 0 using Lisa Ensman's multiple-ion, Saha equilibrium subroutine, CALCNE. Generally this more accurate, but very time-consuming routine is turned on just before shock-breakout while doing supernova light-curve calculations.
338	XNECONV	1.E-05	Maximum allowable fractional convergence error in the electron density calculated by subroutine CALCNE (see P 337).
339	IONFLAG	0	If IONFLAG ≤ 0 and the density and temperature have changed by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154), respectively, since the last iteration, then extrapolate the value of the electron density from its partial derivatives with respect to density and temperature instead of calling CALCNE (when ICALCNE > 0 -- see p 337), unless this is the first iteration. Otherwise call CALCNE all the time, provided ICALCNE > 0.
340	XNEMIN	1.E-05	Minimum mass fraction for which an element is included in the calculation of Saha ionization equilibrium done in subroutine CALCNE (see P 337).

HEAT DIFFUSION PARAMETERS

37	TRANSM	1.	Multiplier on diffusive heat transport.
49	T7PEEK	1.E+50	Opacity will be no larger than XKMIN+T7PEEK*D*T7**4. (cgs units, except T7=T/(10**7 K)
50	XKMIN	1.E-10	Least upper opacity bound (cm**2/g). (see P 49 and KAPPA)
91	ZBOUND	0.1	Mass fraction of heavy elements above which IBEN1 opacities are used.
29	XK1MT	1.	Multiplier on IBEN1 opacity.
30	XK2MT	1.	Multiplier on IBEN2 opacity.
31	XK3MT	1.	Multiplier on Christy opacity.
32	XK4MT	1.	Multiplier on Compton opacity.
33	RXKCMT	1.	Multiplier on conductive opacity.

CONVECTION PARAMETERS

19	XMLEN	1.	Ratio of the convective mixing length to the pressure scale height.
20	FUDGC	0.01	Fudge factor for convection (about 0.01). Reduces convective efficiency for very small departures from adiabatic gradients and thus makes the numerical onset of convection less abrupt and unstable. (see subroutines REGESS and UPDATE)
21	DIFIM	1.	Multiplier for the rate of convective mixing.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or ","). (see subroutine UPDATE)
146	FRCSOUND	0.1	Don't do convection if the absolute value of the zone velocity exceeds FRCSOUND times the local sound speed.
147	CONVLIM	1.	Limit the convective velocity to a fraction CONVLIM of the local sound speed.
209	XLTAUCON	0.	Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAUCON*TAUCONV)) in one timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).
210	NOQSECON	0	Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you *really* understand what you're doing.

SEMICONVECTION AND OVERSHOOT PARAMETERS

24	DRMULT	0.1	Semi-convective mixing will be slower than thermal transport by at least DRMULT (about 0.1) in zones with mean atomic weight, ABAR, is ≥ ABARSEMI (P 324). (See sub.UPDATE) (Also see DRMULTLO (P 325), WOVERSHT (P 148), and WOVERSLO (P 326)).
75	DTSMULT	1.E+99	The fractional amount of semiconvective mixing that can occur in one timestep is limited to approximately DTSMULT.
148	WOVERSHT	0.01	The semiconvective test parameter, W, is taken to be W=WOVERSHT*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR ≥ ABARSEMI (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSHT=0 no overshoot mixing is done. (Also see WOVERSLO -- P 326).
324	ABARSEMI	4.	Value of the zonal mean atomic weight, ABAR, used to divide the star into two regions with separately specifiable values of the semiconvective mixing rate and the overshoot mixing coefficient (g/mole). (See the definitions of DRMULT (P 24), WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)).
325	DRMULTLO	DRMULT	Semiconvective mixing will be slower than thermal transport by at least DRMULTLO (about 0.1) in zones where the mean atomic weight, ABAR, is below ABARSEMI (P 324). (See UPDATE and discussion of DRMULT (P 24), WOVERSHT (P 148), and WOVERSLO (P 326)).
326	WOVERSLO	WOVERSHT	The semiconvective test parameter, W, is taken to be W=WOVERSLO*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR < ABARSEMI (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but is limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSLO=0 no overshoot mixing is done. (Also see WOVERSHT -- P 148).

NUCLEAR REACTION PARAMETERS

101	SNEUTMT	1.	Neutrino energy loss rate multiplier (APPROX only).
102	SNUCMT	1.	Non-neutrino nuclear energy generation rate multiplier (APPROX only).
208	C12AGMLT	1.	Multiplier on the **overall** C12(a,g) rate (APPROX only). This parameter is **obsolescent.** It is better to use E1MLTC12 P 227) and E2MLTC12 (P 228).
227	E1MLTC12	1.	Multiplier on the E1 part of the C12(a,g) cross-section (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
228	E2MLTC12	1.	Multiplier on the E2 part of the C12(a,g) cross-section. (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)
65	TNUCMIN	0.	Don't calculate nuclear burning in APPROX if the temperature is less than TNUCMIN (K). Note that unless the hydrogen burning rate is significant, no APPROX network calculations will be done below 1.E+7 K, even if TNUCMIN < 1.E+7 K. (See P 89).
89	DYPMIN	1.E-10	Minimum amount of potential hydrogen burn in the present timestep needed to trigger the use of any reaction network (moles/g). (APPROX only).
90	DYMGMIN	1.E-10	Minimum amount of Mg24 production required in the last timestep to trigger the use of the full reaction network (moles/g). (APPROX only).
28	IPUP	1	Abundance update parameter. Update abundances only if IPUP≠0.
38	TIMEX0	-1.E+99	Time at which any Ni56 present in low temperature regions (as determined by P 89 and P 65) of the star is assumed to have been produced and begun to decay, first to Co56 and then to Fe56 (sec). If TIMEX0 ≥ -1.E+50 and the zonal Ni56

			abundance, YNI, ≥ 3.E-5, then the nuclear energy generation is take equal to that generated by an initial Ni56 abundance YNI after having decayed for a time interval TIME (P 2) -TIMEX0. Note that the value of YNI in the abundance array is not changed by this "decay", and always represents the initial amount produced. DO NOT set TIMEX0 > TIME (P 2).
341	XKAPGAM	0.054	Assumed effective opacity (cm^2/g) for the deposition of gamma ray energy from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38).
342	EGAMP	0.60	Dimensionless correction factor used in calculating the escape of gamma rays from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38). See subroutine SDOT for details.
63	IRNET	0	If IRNET=0, use APPROX network. If IRNET=1, use SDOT1 (H and He burning network). Otherwise use SDOT2 (NOVA network). Note that SDOT1 and SDOT2 are replaced by dummy routines in the current version of KEPLER and an error message will result if they are entered. The old routines would have to be extensively updated before being used again.
103	DSNUM	1.E-6	Fractional density and temperature perturbations used to get nuclear energy generation rate derivatives (APPROX only).
153	DDSFRAC	0.01	Maximum fractional change in density since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
154	DTSFRAC	0.001	Maximum fractional change in temperature since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
155	IUDFLAG	0	Extrapolate energy generation rates and ABAR changes in cases of small temperature and density change only if IUDFLAG is also ≤0.

NUCLEAR REACTION PARAMETERS (Cont.)

163	IUPDFLAG	1	Don't calculate derivatives in subroutine SDOT when called from subroutine UPDATE if IUPDFLAG ≥ 0 (APPROX only).
160	IFLGABAR	0	The mean atomic weight, ABAR, calculated in subroutine SDOT is implicitly coupled to the ion equation of state only if IFLGABAR≠0 and the normal APPROX network (IN=1) is being used. (This is an **obsolescent** parameter and the coding should be carefully rechecked if it is set ≠0).

CARBON DEFLAGRATION PARAMETERS

209 XLTAUCON 0.

Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAUCON*TAUCONV)) in one timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).

214 FLAMERAD 0.

Characteristic flame radius for carbon deflagration studies (cm). If XLTAUCON > 0 and FLAMERAD > 0, multiply the convective timescale, TAUCON, used to calculate the maximum allowed rate that the convective luminosity can increase (see P 209) by an additional factor of FLAMERAD/RFLAME, where RFLAME is the maximum radius at which a temperature above 2.E+9 K exists. This parameter effectively varies the velocity at which a deflagration can propagate and should be used *only* when studying carbon detonations. Note that larger values of FLAMERAD imply slower deflagration speeds, and that the relationship is not linear.

279 FLAMVA 0.

If FLAMVA ≠ 0., the current problem is a study of a carbon deflagration in a white dwarf. The current radius of the deflagration flame is taken as the radius of the outermost zone where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283) by KEPLER. The outward speed of the flame is controlled by adjusting the opacity for heat conduction between zones JFLAM and JFLAM + 1 up or down by a factor, XKAPFLAM (P 284), between 0. and 1. Such "gating" is performed in KAPPA and UPDATE and sets the velocity of advance of the 2.E+9 K temperature front to a comoving value that averages:

VFLAME =

VCOND * (RFLAME / XLAMBMIN)**(FLAMVB - 2.),

where: XLAMBMIN = 4π * VCOND**2 / GEFF and VCOND is FLAMVC (P 281) times the heat conduction velocity, RFLAME is the current radius of the flame front, and GEFF is FLAMVA times the acceleration of gravity at the flame front. The calculated flame velocity is bounded below by VCOND and above by FLAMVD (P 282) times the speed of sound behind the flame front.

Basically the flame front wrinkles as it propagates in a fractal manner and the extra area it thus enjoys causes the flame to

burn the entrained material more rapidly. See CYCLE for more details.

FLAMVA would typically be set to a value about 0.2 corresponding to a 20% delta-rho/rho across the burning front to study "plausible" carbon deflagrations using this model.

280 FLAMVB 2.6 Fractal exponent helping determine the relationship between the velocity of heat conduction and the velocity of the carbon deflagration flame based on its degree of "wrinkling." FLAMVB is equivalent to the fractal dimension of the burning front which is 2. for a smooth surface, 2.7 corresponds to fully developed turbulence, and 3. corresponds to filled space.

281 FLAMVC 50. Multiplier on the heat conduction velocity used to calculate the velocity of the carbon deflagration front. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. The default value of 50 corresponds to the laminar flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc.

282 FLAMVD 1. The velocity of the carbon deflagration flame front is limited to FLAMVD times the local sound speed. (See the discussion for FLAMVA (P 279)).

283 JFLAM 0 The zone where the carbon deflagration flame is currently located. This parameter is internally set by KEPLER to be the outermost zone whose temperature exceeds 2.E+9 K and its value should not be changed by the user.

284 XKAPFLAM 0.001 Carbon deflagation opacity gating factor. Must be > 0. and <1. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use.

285 XMFLAM 0. The mass in the current carbon deflagration flame-front zone JFLAM (P 283) that has already been burned (g). This parameter is set internally by KEPLER and should not be changed. When the entire mass of zone JFLAM (P 283) has been burned the opacity coupling it to zone JFLAM + 1 is changed from being divided by XKAPFLAM (P 284) to being multiplied by it. This causes the flame front to advance to the next zone. See the discussion given for FLAMVA (P 279).

347 FLAMVE 0.805 Density power dependence of the heat conduction velocity used in calculating the velocity of nuclear deflagrations in Type I supernovae. (0.805 for C/O, 1.06 for Ne/O)
See P 279-285 and subroutine CYCLE for details.

ISE NETWORK TRANSITION PARAMETERS

184	TQSELIM	1.5E+9	A sufficient condition to change a zone from the APPROX to ISE network is if its temperature exceeds TQSELIM, its O16 mass fraction is less than O16LIM, its iron peak mass fraction exceeds QN56LIM, and its density exceeds DQSELIM.
185	O16LIM	0.04	(See P 184).
186	QN56LIM	0.	(See P 184).
189	SIQSELIM	1.E-3	A sufficient condition to change a zone from the ISE to the NSE network is for the sum of the silicon and sulfur "group" elemental mass fractions to be less than or equal to SIQSELIM.
203	DQSELIM	1.E+5	Nominal minimum density for changing a zone from the APPROX to the ISE network (g/cc). (See P 184).
210	NOQSECON	0	Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you *really* understand what you're doing.
290	NOILAND	1	If NOILAND > 0, prevent separated islands of zones employing the ISE network from developing by not letting zone J go to ISE unless zone J - 1 has already done so.
106	JQSE	0	Change all APPROX network zones with J<JQSE to the ISE network.
188	JNSE	0	Change all ISE zones with J<JNSE to the NSE network.

ISE NETWORK PHYSICS PARAMETERS

201	Y56GESSM	1.E-4	Initial guess made in SDOT for the Y56 abundance when initializing a new ISE zone (moles/g). If Y56GESSM is within 1.E-3 of 1., the temperature is greater than TQSEMIN, *and* J > 1, then the initial guesses for the proton, neutron, and Fe56 abundances used in the ISE iteration are taken equal to their values in the next innermost zone (which typically is already in ISE).
323	YEMAX	0.498	Maximum value of Ye allowed when initializing a new ISE zone (moles/g). This simulates the small amount of neutronization that usually occurs before the end of oxygen burning.
41	YEMIN	0.02	No further changes in YE are allowed for YE < YEMIN (moles/g).
105	TQSEMIN	2.E+9	Floor on the temperature used in the ISE calculation (K).
187	SNUWMULT	1.	Multiplier on neutrino energy losses from weak processes on nuclei and nucleons. (ISE only)
137	BETHEMT	0.	Multiplier on fudged Co63 electron decay rate as suggested by Gerry Brown and Hans Bethe (11/89).
171	IEXCITEH	1	Include excited states in ISE calculations only if IEXCITEH>0.
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
202	ISI30BRN	1	Neutron-rich-silicon-burning flows are included in the ISE network if ISI30BRN ≥ 1. (See subroutine SDOTQ)
167	IFLAGYE	1	The electron EOS is implicitly coupled to nuclear-burning-induced changes in the electron abundance, YE, provided IFLAGYE≠0 and the ISE or NSE network is being used.

ISE NETWORK CONVERGENCE PARAMETERS

172	ITERQMH	1000	Maximum number of iterations allowed in ISE calculation.
173	YPCONVH	1.E-8	Allowed relative convergence error in the proton abundance in the ISE calculation.
174	YNCONVH	1.E-8	Allowed relative convergence error in the neutron abundance in the ISE calculation.
175	YSICONVH	1.E-8	Allowed relative convergence error in the Si28 abundance in the ISE calculation.
176	CNSEH	1.	Increment the proton, neutron, and Si28 abundances by a fraction CNSEH of that calculated by the Newton-Raphson method for an ISE iteration.
177	FYPH	0.05	Maximum allowed relative change in proton abundance during an ISE iteration.
178	FYNH	0.05	Maximum allowed relative change in neutron abundance during an ISE iteration.
179	FYSIH	0.15	Maximum allowed relative change in Si28 abundance during an ISE iteration.
181	XITER1QE	0.5	If the relative change of the proton, neutron, or Si28 abundance is opposite in sign and more than XITER1QE in magnitude with respect to the corresponding change during the previous ISE iteration cycle, then cut the current step size in half if more than ITER1NSE iterations have been done.
182	ITER1QE	10	(See P 181).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG ≥ 1, or to terminate if IQERRFLG < 1.
169	DTQNUM	1.E-4	Relative temperature change used in calculating numerical derivatives in SDOTQ.
170	DDQNUM	1.E-4	Relative density change used in calculating numerical derivatives in SDOTQ.

BURN COPROCESSING CONTROL PARAMETERS

267	INBURN	0	BURN coprocessing and related edits are done only if INBURN > 0. Note that INBURN is set to 1 by subroutine GENBURN if a BURN generator deck has been specified in the regular generator deck or by command GENBURN. It is an internal flag and should not be changed by the user, except to permanently turn off BURN coprocessing in a problem.
230	DTFRAC	0.01	When BURN coprocessing is initiated (or when the ZEROTIME or RESET commands are given), (re)set the zonal timesteps used by the BURN coprocessor to DTFRAC*DTNEW (P 1).
240	NETMAX	1	BURN coprocessing is skipped if a zones's network number, NETNUM, is greater than NETMAX.
231	BMASSMIN	-1.	BURN coprocessing is skipped if a zone's **exterior** mass coordinate is less than BMASSMIN (g).
232	BMASSMAX	1.E+99	BURN coprocessing is skipped if a zone's **exterior** mass coordinate is greater than BMASSMAX (g).
233	BTEMPMIN	1.E+6	BURN coprocessing is skipped if a zone's temperature is less than BTEMPMIN (K).
234	BTEMPMAX	1.E+99	BURN coprocessing is skipped if a zone's temperature is greater than BTEMPMAX (K).
235	SNUCMIN	~~1.E-99~~ -1.E99	BURN coprocessing is skipped if the absolute value of a zone's normal nuclear energy generation rate (SNN) is less than SNUCMIN (erg/g/s).
236	BDENMIN	1.E-99	BURN coprocessing is skipped if a zone's density is less than BDENMIN (g/cc).
237	BDENMAX	1.E+99	BURN coprocessing is skipped if a zone's density is greater than BDENMAX (g/cc).
229	NUPDATE	100	Do a forced update of BURN isotopic abundances in every zone every NUPDATE cycles.

BURN COPROCESSING CONTROL PARAMETERS (Cont.)

238	TCHANGE	.02	Force a zone to be updated by the BURN coprocessor if its fractional temperature change since its last BURN processing exceeds TCHANGE.
239	DCHANGE	.05	Force a zone to be updated by the BURN coprocessor if its fractional density change since its last BURN processing exceeds DCHANGE.
264	NSUBCYCM	1	Number of coupled BURN coprocessing / BURN isotope convection subcycles per KEPLER cycle.

BURN COPROCESSING PHYSICS PARAMETERS

265	MAZFUL	1	Use Fuller et. al.'s weak rates in the BURN coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek and Hansen.
286	TAUNU	0.	Time scale for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (sec).
287	ENU53	3.	Total energy (in units of 10**53 ergs) for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse.
288	TMUNU	8.	Temperature of the mu and tau neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
289	TENU	4.	Temperature of the electron neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).

BURN COPROCESSING ZONAL BURN CONTROL PARAMETERS

258	IRATSTOP	-1	Pause while updating zone IRATSTOP if IRATSTOP > 0. Type return to continue.
247	DELCHI	.15	Maximum desired fractional change of an isotopic abundance used in determining the zonal timestep used in the BURN coprocessor.
246	CHIMIN	1.E-6	Minimum isotopic abundance that affects the calculation of the zonal timestep in the BURN coprocessor (moles/g).
266	AL26MULT	100.	Decrease the abundance threshold for Al26 to affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to CHIMIN/AL26MULT.
248	FDTN	2.	Maximum factor by which the zonal timestep in the BURN coprocessor can be increased in one zonal cycle.
253	NZRO	1	Set newly calculated negative BURN isotope abundances to 0. if NZRO not equal to 0.
254	AMAGLIM	0.	Minimum absolute magnitude of a BURN matrix element for which Gauss-Jordan elimination is carried out in solving for changes in isotopic abundances.
255	NINV	0	Total number of BURN-coprocessor matrix inversions so far (internally incremented).
249	DTBKUP	.5	Back up to the previous zonal cycle in the BURN coprocessor if the new zonal timestep is less than DTBKUP times the previous timestep.
261	BKUPMASS	1.E-13	Minimum absolute magnitude of a negative isotopic abundance (except of protons) that can cause a zonal backup in the BURN coprocessor (moles/g).
260	BKUPDIV	10.	Factor by which to reduce the BURN coprocessor zonal timestep when a negative isotopic abundance backup occurs.
262	BKUPMP	1.E-19	Minimum absolute magnitude of a negative proton abundance that can cause a zonal backup in the BURN coprocessor (moles/g).

BURN COPROCESSING ZONAL BURN CONTROL PARAMETERS (Cont.)

263	NBKUPMAX	10	Maximum number of consecutive negative isotopic abundance backups allowed in the BURN coprocessor before quitting.
256	NBKUP	0	Total number of BURN-coprocessor backups so far (internally incremented).
259	NEGBKUP	0	Cumulative number of BURN coprocessor backups due to encountering negative isotopic abundances (incremented internally).
257	NTTY	6	FORTRAN I/O unit number for ZBURN messages sent to the user's terminal.

NEUTRINO DEPOSITION PARAMETERS

93	JSHELL0	1	Innermost zone in which there is neutrino deposition.
94	JSHELL1	1000	Outermost zone in which there is neutrino deposition.
95	EEXPLODE	0.	Total neutrino deposition energy (erg).
96	TEXPLODE	1.E+99	Time of neutrino deposition (sec).
97	TAUEXP	1.E-2	Time scale for neutrino deposition (sec).
98	P0CORE	0.	Artificial neutrino core pressure is given by: PCORE = P0CORE*D**D0POWER*EXP(-D0CORE/D), where D is the density in g/cc, PCORE is in erg/cc, and P0CORE is in appropriate cgs units.
99	D0CORE	3.E+11	Core density cutoff (g/cc) -- (see P 98).
100	D0POWER	1.	Core pressure density dependence exponent. (See P 98).

GENERAL REZONING PARAMETERS

86	IZONEF	1	Rezoning Flag: ≤0 means no rezoning (including dezoning); =1 means normal rezoning; =2 means rezoning with before and after edits; =3 means stop after hydrostatic adzoning.
87	IDZONEF	1	Dezoning Flag: ≤0 means no dezoning; =1 means normal dezoning; =2 means dezoning with before and after edits; =3 means dezone, edit, then stop.
309	IZONEZMS	1	Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).
85	JMMIN	10	Minimum number of zones allowed after dezoning.
216	IRZOPT	0	Rezoning Option Flag. IRZOPT = 1 or ≥ 3: Modify the density gradient considered in adzoning by the factor (ZBAR+1)/ABAR in order to suppress runaway adzoning of the density discontinuities that sometimes form at composition interfaces (esp. H/He). Note that for a nondegenerate, perfect gas this is equivalent to considering the gradient in the matter pressure instead of in the density when adzoning. Dezoning is not affected. IRZOPT ≥ 2: Don't adzone across the boundaries of fully convective regions. IRZOPT ≤ 0. Normal rezoning. (See REZONE).
190	JLCALC	0	Remove the inner JLCALC zones from the problem and reset the inner boundary conditions on radius (RADIUS0 (P 60)) and mass (SUMM0 (P 61)), but don't change the central luminosity (XLUM0 (P 62) -- note default is 0.).
136	ETACUT	10.	Electron degeneracy parameter, ETA, above which to use temperature interpolation in ADZONE.

PHYSCIAL REZONING PARAMETERS

76	RNRATMAX	0.25	Maximum fractional radius change allowed between zones before adzoning.
77	RNRATMIN	0.1	Minimum fractional radius change allowed between zones before dezoning.
78	TNRATMAX	0.25	Maximum fractional temperature change allowed between zones before adzoning.
79	TNRATMIN	0.1	Minimum fractional temperature change allowed between zones before dezoning.
80	DNRATMAX	0.25	Maximum fractional density change allowed between zones before adzoning.
81	DNRATMIN	0.1	Minimum fractional density change allowed between zones before dezoning.
82	RNMIN	1.E-99	Minimum radius for which adzoning is considered (cm).
88	RNMAX	1.E+99	Maximum radius for which rezoning is considered (cm).
83	TNMIN	1.	Minimum temperature for which adzoning is considered (K).
84	DNMIN	1.E-99	Minimum density for which adzoning is considered (g/cc).

MASS-FRACTION-BASED REZONING PARAMETERS

193	FRACRZ0	-1.	(See P 138 and P 150).
138	FRACRZ1	1.	The effective values of the density, temperature, and radius gradients used to determine the necessity for adzoning or dezoning are multiplied by: RZMULTM if FRACM ≤ FRACRZ0, RZMULT0 if FRACRZ0 < FRACM ≤ FRACRZ1, RZMULT1 if FRACRZ1 < FRACM ≤ FRACRZ2, and RZMULT2 if FRACM > FRACRZ2, where FRACM is the cumulative mass fraction measured from the center of the star. (See also P 104 and P 150).
139	FRACRZ2	1.	(See P 138 and P 150).
194	RZMULTM	1.	(See P 138).
140	RZMULT0	1.	(See P 138).
141	RZMULT1	1.	(See P 138).
142	RZMULT2	1.	(See P 138).
195	FMAXM	1.	(See P 150).
150	FMAX0	1.	Always adzone if the total mass fraction of any pair of zones exceeds: FMAXM if FRACM ≤ FRACRZ0, FMAX0 if FRACRZ0 < FRACM ≤ FRACRZ1, FMAX1 if FRACRZ1 < FRACM ≤ FRACRZ2, and FMAX2 if FRACM > FRACRZ2, where FRACM is the cumulative mass fraction measured from the center of the star.
151	FMAX1	1.	(See P 150).
152	FMAX2	1.	(See P 150).
336	ZONEMMIN	1.E-99	ZONEMMIN is the minimum mass (g) that a zone may have and still be allowed to be adzoned (as part of a zone pair).

MASS-FRACTION-BASED REZONING PARAMETERS (Cont.)

313 FMAXMCIG 1. Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.

314 FMAX0CIG 1. Reset the value of FMAX0 (P 150) to FMAX0CIG when the central temperature specified by TEMPCIG (P 311) is reached.

143 ABARRAT0 2. The effective values of the density, radius, and temperature gradients used for adzoning are formed by multiplying the actual gradients by the factor:
(1.+ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT));
and for dezoning by the factor:
(1.+1.5*ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT),
where ABARRAT is the average relative ABAR change between adjacent zones.
Do this for adzoning only if the sum of the masses in the involved zones divided by the total mass of the star exceeds FRACMLIM.

144 ABARRATM 1.3 (See P 143).

145 FRACMLIM 0.01 (See P 143).

104 TCOREFAC 1. Increase the rezoner's sensitivity to temperature gradients by a factor of TCOREFAC in the region where FRACM, the culmulative mass fraction measured from the center of the star, is less than or equal FRACRZ1.

MASS-LOSS-CONNECTED REZONING PARAMETERS

271	VLOSS	1.E+99	Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).
217	NSURFZ	-10	If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface. Otherwise, NSURFZ has no effect. (See REZONE.) This is an **obsolescent** parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
218	FRACSZ0	1.	Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an **obsolescent** parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
219	FRACSZ1	1.	Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an **obsolescent** parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.
223	FRACDEZ	0.5	Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.

MISCELLANEOUS PARAMETERS

43	HSTATM	1.	Multiplier on the inertial terms in the momentum balance equation. Nominally forces hydrostatic equilibrium for for HSTATM = 0., but may result in convergence and consistency problems. This parameter should be kept set to 1. (normal hydrodynamics) unless the user is prepared to make a very careful study of its actual effects (see subroutines REGESS and UPDATE).
48	CENU	1.0	Velocity centering parameter (Range: 0.5,1.): 0.5 gives exact energy conservation; 1.0 gives greatest stability. Actually, KEPLER only behaves reasonably if CENU=1, so the user should **NOT** change the default value without careful study and a willingness to bear full responsibility for whatever nonsense may result.
66	SETPARM	XK+1.	Initialize new parameters in RESTART if SETPARM ≤ XK. XK represents a floating point number used in RESTART as an index for the version of KEPLER is which the last set new parameters has been introduced. After such a new parameter update is made SETPARM is reset to XK+1. This allows restart dumps written by older versions of KEPLER with fewer parameters to be used by any later version of the code.

OBSOLETE PARAMETERS

117	IGRIDM	498	Obsolete.
118	IGRIDV	496	Obsolete.
129	IVPLOT	1	Obsolete.
226	MLCOMPF	0	Obsolete.
242	EDMASSL	1.E-4	Obsolete.
295	WIDTHTD	60.	Obsolete.

DEVICE-CONTROL GRAPHICS PARAMETERS

127	ITVSTART	0	Graphics device control parameter. = 0 means no graphics processes are active. = 1 means start an X-window graphics display and reset ITVSTART to 2. = -1 means stop the X-window graphics display and reset ITVSTART to 0. = 2 means keep the X-window display open and display graphs and timeplots as requested. (This value is internally set). = 3 means initialize a portrait-orientation Postscript File and reset ITVSTART to 5. = 4 means initialize a landscape-orientation Postscript File and reset ITVSTART to 5. = 5 means keep the postscript file open for further input (under development). Note that ITVSTART is reset to zero when a problem is restarted.
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
42	IWINSIZE	10240750	Size of graphics window to be created in the form *xxxxyyyy*, where *xxxx* is the number of pixels wide to make the window and *yyyy* is the number of pixels wide it should be. Be sure to include leading zeros if *yyyy* is less than 4 digits.
45	IWINLOC	0	Location of the upper-left-hand corner of the graphics window given in the form *xxxxyyyy*, where *yyyy* is the number of pixels below the top of the screen this corner should be, and *xxxx* is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if *yyyy* is less than 4 digits.
296	IBACKGND	-1	Graphics window background color is white if IBACKGND ≥ 0 and black if IBACKGND < 0. The foreground color is always the inverse of the background color.

PLOT-TYPE GRAPHICS PARAMETER

113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the **SETISO** command first to determine the ions to be displayed). =7 thru 9: only header info is displayed. =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.

'RADIAL'-COORDINATE-CONTROL GRAPHICS PARAMETERS

132	IRTYPE	3	Use the interior mass fraction as the independent coordinate in all graphs if IRTYPE =2; use the interior mass in solar mass units if IRTYPE=3; Otherwise use the radius (in cm).
116	IGRIDT	370	Grid choice for the radial coordinate: If IRTYPE = 1, then the radial coordinate will be log10 (radius) if IGRIDT > 10 and linear in radius otherwise. If IRTYPE ≠ 1, IGRIDT has no effect.
119	JP0	1	Innermost zone to plot. (See P 121).
120	JP1	0	Outermost zone to plot is JM (outermost zone) - JP1. (See P 122)
121	RPMIN0	1.E+7	Minimum radius plotted when JP0 < 0 (cm).
122	RPMAX0	1.E+14	Maximum radius plotted when JP1 < 0 (cm).
134	YPLOTMIN	0.	Minimum mass coordinate plotted (fraction of total mass).
135	YPLOTMAX	1.	Maximum mass coordinate plotted (fraction of total mass).

THERMODYNAMICS-GRAPH PARAMETERS

123	YMINTD	1.	Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
124	YMAXTD	1.E+8	Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
125	SSCALEM	1.E-3	Energy generation rate graph scale multiplier in the TD graph.
126	PSCALEM	1.E-1	Pressure graph scale multiplier in the TD graph.
130	VSCALEM	1.E-5	Velocity graph scale multiplier in the TD graph.
131	RSCALEM	1.E-5	Radius graph scale multiplier in the TD graph.
115	TSCALEM	1.E+7	Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K). Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
133	CONVORD	3.	Ordinate value at which to plot convection sentinels in the TD graph (nominally g/cc).

VELOCITY AND ABUNDANCE GRAPH PARAMETERS

191	VLIMSET	-1.	The ordinate bounds of the velocity graph are ±VLIMSET if VLIMSET > 0. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
316	ABUNMINB	1.E-4	Lower mass-fraction limit of the isotopic abundance plot.
317	ABUNMAXB	1.	Upper mass-fraction limit of the isotopic abundance plot.
318	NUMISO	0	Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.

GRAPHICS LABELING PARAMETERS

291	CHARSIZG	1.0	Graphics character size for grid labels (relative to MONGO's default character size).
292	CHARSIZC	0.85	Graphics character size for curve labels (relative to MONGO's default character size).
293	CHARSIZZ	0.85	Graphics character size for zone sentinels (relative to MONGO's default character size).
294	CHARSIZH	1.0	Graphics character size for header info (relative to MONGO's default character size).
114	NPLOTSYM	8	Label each curve with NPLOTSYM character symbols.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE)

POST-PROCESSOR GRAPHICS PARAMETERS

301 IDTMAXL 40

Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME.
In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used:
if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT).
if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances).
if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables).

302 IDTLOOK 10

Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.

328 VMINMAP 1.E+99

Minimum value of the timemap variable to be mapped.
If VMINMAP > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by VRATMAP (P 330), below.

329 VMAXMAP -1.E+99

Maximum value of the timemap variable to be mapped. If VMAXMAP < -1.d+98, then the actual maximum value of the current variable is used as the map limit.

330 VRATMAP 1.E-99

Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.

TIME-COORDINATE GRAPHICS PARAMETERS

327	MAPTIME	2	Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP): 0 => use cycle number; 1 => use linear time (sec); 2 => use negative logarithmic time (-log (sec)). 3 => use positive logarithmic time (log (sec)). Note that the time coordinate is calculated relative to TIMEREF (P 319) + TOSETREF (P 320).
321	TIMECMIN	0.	Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
322	TIMECMAX	0.	Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
319	TIMEREF	-1.E+99	Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
320	TOSETREF	0.	Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.

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CHAPTER 4

PARAMETER LIST BY NUMBER

This chapter lists in numerical order the 354 changeable ('P') parameters in KEPLER that may be edited changed before or during execution. A list of these parameters grouped by function was given in Chapter 3. Initial values for these parameters may be specified by **P** cards in the problem generator file (see Chapter 2). If no explicit such specification is made their, values are initially set equal to the default values listed below.

These parameters may also be edited or changed during program execution by they following set of keyboard commands (also described in Chapter 5):

P *N*

Display the value of parameter name or number *N:* **'p 113'** or **'p time'**

P *N VALUE*

Change the value of parameter name or number *N* to *VALUE:* **'p 113 31'**

P *N DELTA* **ADD**

Add *DELTA* to the value of parameter name or number *N:* **'p 1 -1.e+14 add'**

Note that, although printed in capital letters for clarity, the parameter names listed below must be given as unquoted, **lowercase** character strings when communicating with KEPLER. The mode of the parameters (fixed or floating point) follows the normal FORTRAN convention.

The current values of the parameters are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with DTNEW) and their ASCII names and types are listed respectively in the **nameparm** and **iptype** arrays loaded in data block KEPDAT. Newly added parameters are initialized in subroutine subroutine RESTART (see Chapter 5).

#	Name	Default	Description
1	DTNEW	1.	Initial or current timestep (sec).

2	TIME	0.	Initial or current time (sec).
3	EXTRAP	1.	Extrapolation Parameter used in guessing new R, T, and L values. 0. gives old values; 1. gives linear extrapolation.
4	Q2FAC	4.	Quadratic artificial viscosity (Q) factor. Shock transitions are spread over about 2*SQRT(Q2FAC) zones. (see WZW78)
5	MAXIT	40	Maximum number of times subroutine REGESS is called to iterate R, T, and L estimates before the timestep is reduced by DTCUT and the step repeated (termed a "backup").
6	DTCR	0.05	Maximum desired fractional change in radius per step.
7	DTCT	0.05	Maximum desired fractional change in temperature per step.
8	DTCD	0.10	Maximum desired fractional change in density per step.
9	DTCQ	0.05	Maximum desired fractional linear contraction per step.
10	DTCDT	0.99	Maximum fractional change in the timestep per step.
11	FCRMAX	1.E-6	Maximum allowed relative convergence error in radius.
12	FCTMAX	1.E-6	Maximum allowed relative convergence error in temperature.
13	Q1FAC	0.1	Linear artificial viscosity factor. Helps damp sound waves during hydrostatic evolution. Should be set to 0. during hydrodynamic phases. Normally set to 1000. in the generator until the star settles down onto the zero-age main sequence (from an initially rather arbitrary configuration), at which point it is reset to 0.1.
14	NSTOP	100000	Maximum number of cycles.
15	TSTOP	1.E+30	Stop time (sec). Before terminating the problem, make a restart dump labeled '#final' and execute the alias-defined "tfinal" command. Normally this command is used to make final plots and edits.
16	NEDIT	20	Number of cycles between edits.
17	DTEDIT	0.	Time between edits (0. = ∞) (sec).

18	NDUMP	10	Number of cycles between restart dumps.
19	XMLEN	1.	Ratio of the convective mixing length to the pressure scale height.
20	FUDGC	0.01	Fudge factor for convection (about 0.01). Reduces convective efficiency for very small departures from adiabatic gradients and thus makes the numerical onset of convection less abrupt and unstable. (see subroutines REGESS and UPDATE)
21	DIFIM	1.	Multiplier for the rate of convective mixing.
22	FCRBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in radius is still greater than FCRBU after MAXIT iterations.
23	FCTBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in temperature is still greater than FCTBU after MAXIT iterations.
24	DRMULT	0.1	Semi-convective mixing will be slower than thermal transport by at least DRMULT (about 0.1) in zones with mean atomic weight, ABAR, is ≥ ABARSEMI (P 324). (See sub.UPDATE) (Also see DRMULTLO (P 325), WOVERSHT (P 148), and WOVERSLO (P 326)).
25	DTMAX	1.E+99	Maximum timestep allowed (sec).
26	FCREXT	10.	Factor used to reduce noise in radius extrapolation. (See subroutine GESS)
27	FCTEXT	10.	Factor used to reduce noise in temperature extrapolation.
28	IPUP	1	Abundance update parameter. Update abundances only if IPUP≠0.
29	XK1MT	1.	Multiplier on IBEN1 opacity.
30	XK2MT	1.	Multiplier on IBEN2 opacity.
31	XK3MT	1.	Multiplier on Christy opacity.
32	XK4MT	1.	Multiplier on Compton opacity.

33	RXKCMT	1.	Multiplier on conductive opacity.
34	PIMULT	1.	Ion energy and pressure multiplier.
35	PRMULT	1.	Radiation energy and pressure multiplier.
36	PEMULT	1.	Electron energy and pressure multiplier.
37	TRANSM	1.	Multiplier on diffusive heat transport.
38	TIMEX0	-1.E+99	Time at which any Ni56 present in low temperature regions (as determined by P 89 and P 65) of the star is assumed to have been produced and begun to decay, first to Co56 and then to Fe56 (sec). If TIMEX0 ≥ -1.E+50 and the zonal Ni56 abundance, YNI, ≥ 3.E-5, then the nuclear energy generation is take equal to that generated by an initial Ni56 abundance YNI after having decayed for a time interval TIME (P 2) -TIMEX0. Note that the value of YNI in the abundance array is not changed by this "decay", and always represents the initial amount produced. DO NOT set TIMEX0 > TIME (P 2).
39	DYEMULT	200.	If IYTSFLAG≥1, increase the timestep sensitivity to changes in YE by a factor of DYEMULT.
40	DYQMULT	2.5	IF IYTSFLAG≥1, increase the timestep sensitivity to changes in YQ by a factor of DYQMULT.
41	YEMIN	0.02	No further changes in YE are allowed for YE < YEMIN (moles/g).
42	IWINSIZE	10240750	Size of graphics window to be created in the form *xxxxyyyy*, where *xxxx* is the number of pixels wide to make the window and *yyyy* is the number of pixels wide it should be. Be sure to include leading zeros if *yyyy* is less than 4 digits.
43	HSTATM	1.	Multiplier on the inertial terms in the momentum balance equation. Nominally forces hydrostatic equilibrium for for HSTATM = 0., but may result in convergence and consistency problems. This parameter should be kept set to 1. (normal hydrodynamics) unless the user is prepared to make a very careful study of its actual effects (see subroutines REGESS and UPDATE).

44	LENQMAX	3000000	Maximum length of a post-processor file (bytes).
45	IWINLOC	0	Location of the upper-left-hand corner of the graphics window given in the form *xxxxyyyy*, where *yyyy* is the number of pixels below the top of the screen this corner should be, and *xxxx* is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if *yyyy* is less than 4 digits.
46	DTCP	0.1	Maximum desired fractional change in abundances per step.
47	YFLOORX	1.E-3	Minimum elemental mass fraction that effects the timestep.
48	CENU	1.0	Velocity centering parameter (Range: 0.5,1.): 0.5 gives exact energy conservation; 1.0 gives greatest stability. Actually, KEPLER only behaves reasonably if CENU=1, so the user should **NOT** change the default value without careful study and a willingness to bear full responsibility for whatever nonsense may result.
49	T7PEEK	1.E+50	Opacity will be no larger than XKMIN+T7PEEK*D*T7**4. (cgs units, except T7=T/(10**7 K)
50	XKMIN	1.E-10	Least upper opacity bound (cm**2/g). (see P 49 and KAPPA)
51	THICKFAC	1.E-3	If the timestep is greater than the thermal timescale for a zone by a factor $\geq$ 0.5*THICKFAC, then consider the zone to be in thermal steady-state and deal with any residual non-convergence in the solution of the energy equation by recalculating the luminosity in terms of the final iterated value of the internal energy. Otherwise, recalculate the internal energy in terms of the final iterated luminosity. (See UPDATE).
52	MAXBAK	5	Maximum number of times a given step is redone before the code quits.
53	DTCUT	0.1	Fractional timestep reduction when a step is redone.
54	TFCRBU	2.	If the maximum fractional change in radius during a timestep exceeds TFCRBU*DTCR then redo step.
55	TFCTBU	2.	If the maximum fractional change in temperature during a timestep exceeds TFCTBU*DTCT then redo step.

56	XIPOT	13.6053	Ionization potential (eV) --see subtoutine ES.
57	DZERO	0.1	Characteristic density for pressure ionization (g/cc).
58	NPFLAG	1	Pairs are included in EOS calculation only if NPFLAG>0.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE)
60	RADIUS0	0.	Radius of inner boundary (cm).
61	SUMM0	0.	Mass inside inner boundary (g).
62	XLUM0	0.	Luminosity emerging from inner surface (erg/s).
63	IRNET	0	If IRNET=0, use APPROX network. If IRNET=1, use SDOT1 (H and He burning network). Otherwise use SDOT2 (NOVA network). Note that SDOT1 and SDOT2 are replaced by dummy routines in the current version of KEPLER and an error message will result if they are entered. The old routines would have to be extensively updated before being used again.
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
65	TNUCMIN	0.	Don't calculate nuclear burning in APPROX if the temperature is less than TNUCMIN (K). Note that unless the hydrogen burning rate is significant, no APPROX network calculations will be done below 1.E+7 K, even if TNUCMIN < 1.E+7 K. (See P 89).
66	SETPARM	XK+1.	Initialize new parameters in RESTART if SETPARM ≤ XK. XK represents a floating point number used in RESTART as an index for the version of KEPLER is which the last set new parameters has been introduced. After such a new parameter update is made SETPARM is reset to XK+1. This allows restart dumps written by older versions of KEPLER with fewer parameters to be used by any later version of the code.

85	JMMIN	10	Minimum number of zones allowed after dezoning.
86	IZONEF	1	Rezoning Flag: ≤0 means no rezoning (including dezoning); =1 means normal rezoning; =2 means rezoning with before and after edits; =3 means stop after hydrostatic adzoning.
87	IDZONEF	1	Dezoning Flag: ≤0 means no dezoning; =1 means normal dezoning; =2 means dezoning with before and after edits; =3 means dezone, edit, then stop.
88	RNMAX	1.E+99	Maximum radius for which rezoning is considered (cm).
89	DYPMIN	1.E-10	Minimum amount of potential hydrogen burn in the present timestep needed to trigger the use of any reaction network (moles/g). (APPROX only).
90	DYMGMIN	1.E-10	Minimum amount of Mg24 production required in the last timestep to trigger the use of the full reaction network (moles/g). (APPROX only).
91	ZBOUND	0.1	Mass fraction of heavy elements above which IBEN1 opacities are used.
92	ETACONV	1.E-5	Relative convergence required in calculating the electron Fermi degeneracy parameter, ETA.
93	JSHELL0	1	Innermost zone in which there is neutrino deposition.
94	JSHELL1	1000	Outermost zone in which there is neutrino deposition.
95	EEXPLODE	0.	Total neutrino deposition energy (erg).
96	TEXPLODE	1.E+99	Time of neutrino deposition (sec).
97	TAUEXP	1.E-2	Time scale for neutrino deposition (sec).
98	P0CORE	0.	Artificial neutrino core pressure is given by: PCORE = P0CORE*D**D0POWER*EXP(-D0CORE/D), where D is the density in g/cc, PCORE is in erg/cc, and P0CORE is in appropriate cgs units.

67	IYTSFLAG	1	Consider only changes in YE, YQ, YF, YSI, and Y56 in ISE zones when computing the timestep if IYTSFLAG ≥ 1.
68	TBOUND	0.	Temperature at outer boundary (K).
69	PBOUND	0.	Pressure at outer boundary (erg/cc).
70	FCLMAX	1.	Maximum allowed relative convergence error in luminosity.
71	FCLEXT	1.E-5	Factor used to reduce noise in luminosity extrapolation.
72	DTCL	1.E+99	Maximum desired fractional change in luminosity per step.
73	FCLBU	1.	Reduce timestep by DTCUT and redo step if convergence error in luminosity is still greater than FCLBU after MAXIT iterations.
74	TFCLBU	1.E+99	If the maximum fractional change in luminosity during a timestep exceeds TFCLBU*DTCL then redo step.
75	DTSMULT	1.E+99	The fractional amount of semiconvective mixing that can occur in one timestep is limited to approximately DTSMULT.
76	RNRATMAX	0.25	Maximum fractional radius change allowed between zones before adzoning.
77	RNRATMIN	0.1	Minimum fractional radius change allowed between zones before dezoning.
78	TNRATMAX	0.25	Maximum fractional temperature change allowed between zones before adzoning.
79	TNRATMIN	0.1	Minimum fractional temperature change allowed between zones before dezoning.
80	DNRATMAX	0.25	Maximum fractional density change allowed between zones before adzoning.
81	DNRATMIN	0.1	Minimum fractional density change allowed between zones before dezoning.
82	RNMIN	1.E-99	Minimum radius for which adzoning is considered (cm).
83	TNMIN	1.	Minimum temperature for which adzoning is considered (K).
84	DNMIN	1.E-99	Minimum density for which adzoning is considered (g/cc).

99	D0CORE	3.E+11	Core density cutoff (g/cc) -- (see P 98).
100	D0POWER	1.	Core pressure density dependence exponent. (See P 98).
101	SNEUTMT	1.	Neutrino energy loss rate multiplier (APPROX only).
102	SNUCMT	1.	Non-neutrino nuclear energy generation rate multiplier (APPROX only).
103	DSNUM	1.E-6	Fractional density and temperature perturbations used to get nuclear energy generation rate derivatives (APPROX only).
104	TCOREFAC	1.	Increase the rezoner's sensitivity to temperature gradients by a factor of TCOREFAC in the region where FRACM, the culmulative mass fraction measured from the center of the star, is less than or equal FRACRZ1.
105	TQSEMIN	2.E+9	Floor on the temperature used in the ISE calculation (K).
106	JQSE	0	Change all APPROX network zones with J<JQSE to the ISE network.
107	ARTV1	1.	Multiply Q1FAC by ARTV1 in zone J if JARTV1≤J<JARTV2.
108	ARTV2	1.	Multiply Q1FAC by ARTV2 in zone J if JARTV2≤J<JM-JARTV3.
109	ARTV3	1.	Multiply Q1FAC by ARTV3 in zone J if J≥MAX(JARTV1,JARTV2,JM-JARTV3)
110	JARTV1	1000	(See P 107-109).
111	JARTV2	1000	(See P 107-109).
112	JARTV3	1000	(See P 107-109).
113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the **SETISO** command

			first to determine the ions to be displayed). =7 thru 9: only header info is displayed. =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.
114	NPLOTSYM	8	Label each curve with NPLOTSYM character symbols.
115	TSCALEM	1.E+7	Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K). Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
116	IGRIDT	370	Grid choice for the radial coordinate: If IRTYPE = 1, then the radial coordinate will be log10(radius) if IGRIDT > 10 and linear in radius otherwise. If IRTYPE ≠ 1, IGRIDT has no effect.
117	IGRIDM	498	Obsolete.
118	IGRIDV	496	Obsolete.
119	JP0	1	Innermost zone to plot. (See P 121).
120	JP1	0	Outermost zone to plot is JM (outermost zone) - JP1. (See P 122)
121	RPMIN0	1.E+7	Minimum radius plotted when JP0 < 0 (cm).
122	RPMAX0	1.E+14	Maximum radius plotted when JP1 < 0 (cm).
123	YMINTD	1.	Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
124	YMAXTD	1.E+8	Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
125	SSCALEM	1.E-3	Energy generation rate graph scale multiplier in the TD graph.
126	PSCALEM	1.E-1	Pressure graph scale multiplier in the TD graph.
127	ITVSTART	0	Graphics device control parameter. = 0 means no graphics processes are active. = 1 means start an X-window graphics display and reset

ITVSTART to 2.
= -1 means stop the X-window graphics display and reset ITVSTART to 0.
= 2 means keep the X-window display open and display graphs and timeplots as requested. (This value is internally set).
= 3 means initialize a portrait-orientation Postscript File and reset ITVSTART to 5.
= 4 means initialize a landscape-orientation Postscript File and reset ITVSTART to 5.
= 5 means keep the postscript file open for further input (under development).
Note that ITVSTART is reset to zero when a problem is restarted.

128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
129	IVPLOT	1	Obsolete.
130	VSCALEM	1.E-5	Velocity graph scale multiplier in the TD graph.
131	RSCALEM	1.E-5	Radius graph scale multiplier in the TD graph.
132	IRTYPE	3	Use the interior mass fraction as the independent coordinate in all graphs if IRTYPE =2; use the interior mass in solar mass units if IRTYPE=3; Otherwise use the radius (in cm).
133	CONVORD	3.	Ordinate value at which to plot convection sentinels in the TD graph (nominally g/cc).
134	YPLOTMIN	0.	Minimum mass coordinate plotted (fraction of total mass).
135	YPLOTMAX	1.	Maximum mass coordinate plotted (fraction of total mass).
136	ETACUT	10.	Electron degeneracy parameter, ETA, above which to use temperature interpolation in ADZONE.
137	BETHEMT	0.	Multiplier on fudged Co63 electron decay rate as suggested by Gerry Brown and Hans Bethe (11/89).
138	FRACRZ1	1.	The effective values of the density, temperature, and radius gradients used to determine the necessity for adzoning or dezoning are multiplied by: RZMULTM if FRACM ≤ FRACRZ0,

RZMULT0 if FRACRZ0 < FRACM ≤ FRACRZ1,
RZMULT1 if FRACRZ1 < FRACM ≤ FRACRZ2, and
RZMULT2 if FRACM > FRACRZ2,
where FRACM is the cumulative mass fraction measured from the center of the star. (See also P 104 and P 150).

139 FRACRZ2 1. (See P 138 and P 150).

140 RZMULT0 1. (See P 138).

141 RZMULT1 1. (See P 138).

142 RZMULT2 1. (See P 138).

143 ABARRAT0 2. The effective values of the density, radius, and temperature gradients used for adzoning are formed by multiplying the actual gradients by the factor:
(1.+ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT));
and for dezoning by the factor:
(1.+1.5*ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT),
where ABARRAT is the average relative ABAR change between adjacent zones.
Do this for adzoning only if the sum of the masses in the involved zones divided by the total mass of the star exceeds FRACMLIM.

144 ABARRATM 1.3 (See P 143).

145 FRACMLIM 0.01 (See P 143).

146 FRCSOUND 0.1 Don't do convection if the absolute value of the zone velocity exceeds FRCSOUND times the local sound speed.

147 CONVLIM 1. Limit the convective velocity to a fraction CONVLIM of the local sound speed.

148 WOVERSHT 0.01 The semiconvective test parameter, W, is taken to be W=WOVERSHT*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR ≥ ABARSEMI (P 324).
Overshoot mixing occurs at a rate calculated from this value of W, but limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE &

			WZW78). If WOVERSHT=0 no overshoot mixing is done. (Also see WOVERSLO -- P 326).
149	XMIMULT	1.	The mass used in calculating ion degeneracy is XMIMULT times the mass of a neutron.
150	FMAX0	1.	Always adzone if the total mass fraction of any pair of zones exceeds: FMAXM if FRACM ≤ FRACRZ0, FMAX0 if FRACRZ0 < FRACM ≤ FRACRZ1, FMAX1 if FRACRZ1 < FRACM ≤ FRACRZ2, and FMAX2 if FRACM > FRACRZ2, where FRACM is the cumulative mass fraction measured from the center of the star.
151	FMAX1	1.	(See P 150).
152	FMAX2	1.	(See P 150).
153	DDSFRAC	0.01	Maximum fractional change in density since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
154	DTSFRAC	0.001	Maximum fractional change in temperature since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
155	IUDFLAG	0	Extrapolate energy generation rates and ABAR changes in cases of small temperature and density change only if IUDFLAG is also ≤0.
156	NSDUMP	10	Save every NSDUMP restart dumps.
157	NITERBAR	1	Total number of cycles used to compute ITERBAR, the average number of iterations per cycle. (Internally set.)
158	ITERBARM	100	Maximum allowed value of NITERBAR without terminating the problem.
159	IAUTOOUT	0	Send out two copies of the ASCII output if IAUTOOUT>1. Also send out two copies of the graphics output if IAUTOOUT>2. Note: No output files are destroyed. (CRAY only! -- this is an obsolescent parameter that should

			not be used on UNIX machines without recasting.)
160	IFLGABAR	0	The mean atomic weight, ABAR, calculated in subroutine SDOT is implicitly coupled to the ion equation of state only if IFLGABAR≠0 and the normal APPROX network (IN=1) is being used. (This is an obsolescent parameter and the coding should be carefully rechecked if it is set ≠0).
161	FRACCORE	1.1	The effective number of zones used in REGESS (JMCALC) shall be the minimum needed to contain the inner FRACCORE mass-fraction of the initial mass of the star.
162	JMCALC	JM	Effective number of zones used in subroutine REGESS. JMCALC is internally calculated from FRACCORE and should not be changed.
163	IUPDFLAG	1	Don't calculate derivatives in subroutine SDOT when called from subroutine UPDATE if IUPDFLAG ≥ 0 (APPROX only).
164	NIONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all 'ions' specified as dump variables.
165	NISODUMP	400	Number of dump cycles between forced dumps of all dump-grid points of all 'BURN 'isotopes' specified as dump variables.
166	NZONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all arrays specified as dump variables except 'ions' and 'isotopes.'
167	IFLAGYE	1	The electron EOS is implicitly coupled to nuclear-burning-induced changes in the electron abundance, YE, provided IFLAGYE≠0 and the ISE or NSE network is being used.
168	NJEDITQ	5	Make a ISE edit every NJEDITQ zones.
169	DTQNUM	1.E-4	Relative temperature change used in calculating numerical derivatives in SDOTQ.
170	DDQNUM	1.E-4	Relative density change used in calculating numerical derivatives in SDOTQ.
171	IEXCITEH	1	Include excited states in ISE calculations only if IEXCITEH>0.

172	ITERQMH	1000	Maximum number of iterations allowed in ISE calculation.
173	YPCONVH	1.E-8	Allowed relative convergence error in the proton abundance in the ISE calculation.
174	YNCONVH	1.E-8	Allowed relative convergence error in the neutron abundance in the ISE calculation.
175	YSICONVH	1.E-8	Allowed relative convergence error in the Si28 abundance in the ISE calculation.
176	CNSEH	1.	Increment the proton, neutron, and Si28 abundances by a fraction CNSEH of that calculated by the Newton-Raphson method for an ISE iteration.
177	FYPH	0.05	Maximum allowed relative change in proton abundance during an ISE iteration.
178	FYNH	0.05	Maximum allowed relative change in neutron abundance during an ISE iteration.
179	FYSIH	0.15	Maximum allowed relative change in Si28 abundance during an ISE iteration.
180	NEDITQ	20	Make a detailed edit of the ISE zones every NEDITQ general numerical edits.
181	XITER1QE	0.5	If the relative change of the proton, neutron, or Si28 abundance is opposite in sign and more than XITER1QE in magnitude with respect to the corresponding change during the previous ISE iteration cycle, then cut the current step size in half if more than ITER1NSE iterations have been done.
182	ITER1QE	10	(See P 181).
183	XTHRES	1.E-4	Edit only those ISE isotopes with mass fractions exceeding XTHRES.
184	TQSELIM	1.5E+99	A sufficient condition to change a zone from the APPROX to ISE network is if its temperature exceeds TQSELIM, its O16 mass fraction is less than O16LIM, its iron peak mass fraction exceeds QN56LIM, and its density exceeds DQSELIM.
185	O16LIM	0.04	(See P 184).

186	QN56LIM	0.	(See P 184).
187	SNUWMULT	1.	Multiplier on neutrino energy losses from weak processes on nuclei and nucleons. (ISE only)
188	JNSE	0	Change all ISE zones with J<JNSE to the NSE network.
189	SIQSELIM	1.E-3	A sufficient condition to change a zone from the ISE to the NSE network is for the sum of the silicon and sulfur "group" elemental mass fractions to be less than or equal to SIQSELIM.
190	JLCALC	0	Remove the inner JLCALC zones from the problem and reset the inner boundary conditions on radius (RADIUS0 (P 60)) and mass (SUMM0 (P 61)), but don't change the central luminosity (XLUM0 (P 62) -- note default is 0.).
191	VLIMSET	-1.	The ordinate bounds of the velocity graph are ±VLIMSET if VLIMSET > 0. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
192	JPAUSE	-1	Pause the code at the end of the calculation for zone J = JPAUSE in REGESS ("PAUSE 1") and in UPDATE ("PAUSE 2"). Do not pause if JPAUSE < 0. Type a carriage return to continue.
193	FRACRZ0	-1.	(See P 138 and P 150).
194	RZMULTM	1.	(See P 138).
195	FMAXM	1.	(See P 150).
196	EIONMULT	1.	Multiplier on the contribution of ionization potential energy to the equation of state. (See ES).
197	NNEWOUTF	2000	Start a new labeled ascii output file every NNEWOUTF cycles.
198	NEDITQ1	5	Make an ISE edit for the central zone every NEDITQ1 * NEDIT (P 16) cycles.
199	WILSONMT	-1.	Multiplier on the Wilson-based nuclear EOS (except for the thermal ion component) if it is ≥0. Otherwise, the old non-relativistic, partial degeneracy model for the ion EOS is used. WARNING...setting this parameter ≥ 0 appears

			to cause anomalous contributions to the pressure and energy at densities far below nuclear density and probably should not be used without revision. (See subroutine ES).
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
201	Y56GESSM	1.E-4	Initial guess made in SDOT for the Y56 abundance when initializing a new ISE zone (moles/g). If Y56GESSM is within 1.E-3 of 1., the temperature is greater than TQSEMIN, *and* J > 1, then the initial guesses for the proton, neutron, and Fe56 abundances used in the ISE iteration are taken equal to their values in the next innermost zone (which typically is already in ISE).
202	ISI30BRN	1	Neutron-rich-silicon-burning flows are included in the ISE network if ISI30BRN ≥ 1. (See SDOTQ)
203	DQSELIM	1.E+5	Nominal minimum density for changing a zone from the APPROX to the ISE network (g/cc). (See P 184).
204	ABUNMINX	-1.E-5	Force a backup after a call to BURN in SDOT if a calculated elemental mass fraction change would cause the resulting mass fraction to be less than ABUNMINX or to change by a fractional amount greater than TFCYBU. Such backups are made only if the elemental mass fractions involved are greater than YFLOORBX .
205	TFCYBU	0.5	Maximim allowed fractional change in abundance before an abundance backup is made. (See P 204).
206	YFLOORBX	0.001	Elemental mass fraction floor for making abundance backups. (See P 204).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG ≥ 1, or to terminate if IQERRFLG < 1.
208	C12AGMLT	1.	Multiplier on the **overall** C12(a,g) rate (APPROX only). This parameter is obsolescent. It is better to use E1MLTC12 P 227) and E2MLTC12 (P 228).
209	XLTAUCON	0.	Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAUCON*TAUCONV)) in one

timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).

210 NOQSECON 0 — Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you *really* understand what you're doing.

211 ACCRATE 0. — Mean rate at which mass in the form of new zones is added to the surface of the star (solar masses per year). The accumulated mass is stored in XMACRETE (P 212) until it is large enough to be added as a whole zone. The surface boundary pressure is gradually increased at a rate proportional to ACCRATE until a mass (in XMACRETE) equal to that in the current outer zone is reached. Then a new zone, the mirror image of the old outer zone, is added. Accretion composition is set by the COMPSURF command in TTYCOM. This prescription will work best for coarse and roughly equal surface zoning.

212 XMACRETE 0. — Mass of phantom outer zone used to mediate mass accretion (g). (See P 211).

213 DENCONV 1.E-7 — Allowed fractional convergence error in density when calculating a hydrostatic initial stellar configuration in the generator using the DSTAT option. (See GENER).

214 FLAMERAD 0. — Characteristic flame radius for carbon deflagration studies (cm). If XLTAUCON > 0 and FLAMERAD > 0, multiply the convective timescale, TAUCON, used to calculate the maximum allowed rate that the convective luminosity can increase (see P 209) by an additional factor of FLAMERAD/RFLAME, where RFLAME is the maximum radius at which a temperature above 2.E+9 K exists. This parameter effectively varies the velocity at which a deflagration can propagate and should be used *only* when studying carbon detonations. Note that larger values of FLAMERAD imply slower deflagration speeds, and that the relationship is not linear.

215 COULMULT 1. — Multiplier on the Wigner-Seitz Coulomb corrections to the ion energy and pressure (See Clayton, p. 152, and ES).

216 IRZOPT 0 — Rezoning Option Flag.

IRZOPT = 1 or ≥ 3: Modify the density gradient considered in adzoning by the factor (ZBAR+1)/ABAR in order to suppress runaway adzoning of the density discontinuities that sometimes form at composition interfaces (esp. H/He).
Note that for a nondegenerate, perfect gas this is equivalent to considering the gradient in the matter pressure instead of in the density when adzoning. Dezoning is not affected.
IRZOPT ≥ 2: Don't adzone across the boundaries of fully convective regions.
IRZOPT ≤ 0. Normal rezoning.
(See REZONE).

217 NSURFZ -10 If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface. Otherwise, NSURFZ has no effect. (See REZONE.)
This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

218 FRACSZ0 1. Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

219 FRACSZ1 1. Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

220 XMLOSSM 0. Multiplier on the de Jager mass-loss rate. (See CYCLE and *Ann. Rev. Astron.Astrophys.* **24**, 336 (1986)).

221 XMLOSS0 0. Nominal mass loss rate from the surface of the star (solar masses/year). This constant mass loss rate is added to whatever de Jager-prescription mass loss may have been specified by XMLOSSM (P 220).

222 TOTM0 0. The original total mass of the star (g). This is set during generation and is used in interpreting edit, dump, and rezoning parameters involving stellar mass fractions rather than the current mass of the star (TOTM) which may change

due to mass loss, accretion, etc. Normally, the internally set value of TOTM0 should not be changed by the user.

223 FRACDEZ 0.5 Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.

224 XMRATBAK 0.2 Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.

225 XFRACML 0.01 Subtract any "surface" mass loss specified by XMLOSSM (P 220) or XMLOSS0 (P 221) from the zone closest to the surface that still has more than XFRACML*TOTM0 (P 222) grams of material overlying it. This should be set so that mass is not extracted from zones too near the surface in order to avoid excessive dezoning, small timesteps, and luminosity fluctuations.

226 MLCOMPF 0 Obsolete.

227 E1MLTC12 1. Multiplier on the E1 part of the C12(a,g) cross-section (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)

228 E2MLTC12 1. Multiplier on the E2 part of the C12(a,g) cross-section. (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)

229 NUPDATE 100 Do a forced update of BURN isotopic abundances in every zone every NUPDATE cycles.

230 DTFRAC 0.01 When BURN coprocessing is initiated (or when the ZEROTIME or RESET commands are given), (re)set the zonal timesteps used by the BURN coprocessor to DTFRAC*DTNEW (P 1).

231 BMASSMIN -1. BURN coprocessing is skipped if a zone's exterior mass coordinate is less than BMASSMIN (g).

232 BMASSMAX 1.E+99 BURN coprocessing is skipped if a zone's exterior mass coordinate is greater than BMASSMAX (g).

233 BTEMPMIN 1.E+6 BURN coprocessing is skipped if a zone's temperature

			is less than BTEMPMIN (K).
234	BTEMPMAX	1.E+99	BURN coprocessing is skipped if a zone's temperature is greater than BTEMPMAX (K).
235	SNUCMIN	1.E-99	BURN coprocessing is skipped if the absolute value of a zone's normal nuclear energy generation rate (SNN) is less than SNUCMIN (erg/g/s).
236	BDENMIN	1.E-99	BURN coprocessing is skipped if a zone's density is less than BDENMIN (g/cc).
237	BDENMAX	1.E+99	BURN coprocessing is skipped if a zone's density is greater than BDENMAX (g/cc).
238	TCHANGE	.02	Force a zone to be updated by the BURN coprocessor if its fractional temperature change since its last BURN processing exceeds TCHANGE.
239	DCHANGE	.05	Force a zone to be updated by the BURN coprocessor if its fractional density change since its last BURN processing exceeds DCHANGE.
240	NETMAX	1	BURN coprocessing is skipped if a zones's network number, NETNUM, is greater than NETMAX.
241	NEDITB	5	Make a BURN isotopic abundance edit every NEDITB*NEDIT (P 16) KEPLER cycles.
242	EDMASSL	1.E-4	Obsolete.
243	NEDITA	10	Make an elemental abundance edit every NEDITA*NEDIT (P 16) cycles.
244	JMEDITB	1	Edit only zones whose zone number is ≤ JMEDITB during normal BURN isotopic abundance edits.
245	NEDITALL	100	Make a BURN isotopic abundance edit for all zones every NEDITALL*NEDIT (P 16) cycles regardless of the value of NEDITB (P 241).
246	CHIMIN	1.E-6	Minimum isotopic abundance that affects the calculation of the zonal timestep in the BURN coprocessor (moles/g).
247	DELCHI	.15	Maximum desired fractional change of an isotopic abundance

			used in determining the zonal timestep used in the BURN coprocessor.
248	FDTN	2.	Maximum factor by which the zonal timestep in the BURN coprocessor can be increased in one zonal cycle.
249	DTBKUP	.5	Back up to the previous zonal cycle in the BURN coprocessor if the new zonal timestep is less than DTBKUP times the previous timestep.
250	NCOMP	999999	Make a complete ascii edit of the nuclear processes in all zones considered by the BURN coprocessor every NCOMP cycles.
251	NCENT	999999	Make an ascii edit of the nuclear processes in the central zone considered by the BURN coprocessor every NCENT cycles.
252	NEDT	999999	Make an ascii edit of the nuclear processes involved every nedt BURN coprocessor matrix inversions (debugging only).
253	NZRO	1	Set newly calculated negative BURN isotope abundances to 0. if NZRO not equal to 0.
254	AMAGLIM	0.	Minimum absolute magnitude of a BURN matrix element for which Gauss-Jordan elimination is carried out in solving for changes in isotopic abundances.
255	NINV	0	Total number of BURN-coprocessor matrix inversions so far (internally incremented).
256	NBKUP	0	Total number of BURN-coprocessor backups so far (internally incremented).
257	NTTY	6	FORTRAN I/O unit number for messages sent to the user's terminal.
258	IRATSTOP	-1	Pause while updating zone IRATSTOP if IRATSTOP > 0. Type return to continue.
259	NEGBKUP	0	Cumulative number of BURN coprocessor backups due to encountering negative isotopic abundances (incremented internally).
260	BKUPDIV	10.	Factor by which to reduce the BURN coprocessor zonal timestep when a negative isotopic abundance backup occurs.

261	BKUPMASS	1.E-13	Minimum absolute magnitude of a negative isotopic abundance (except of protons) that can cause a zonal backup in the BURN coprocessor (moles/g).
262	BKUPMP	1.E-19	Minimum absolute magnitude of a negative proton abundance that can cause a zonal backup in the BURN coprocessor (moles/g).
263	NBKUPMAX	10	Maximum number of consecutive negative isotopic abundance backups allowed in the BURN coprocessor before quitting.
264	NSUBCYCM	1	Number of coupled BURN coprocessing / BURN isotope convection subcycles per KEPLER cycle.
265	MAZFUL	1	Use Fuller et. al.'s weak rates in the BURN coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek and Hansen.
266	AL26MULT	100.	Decrease the abundance threshold for Al26 to affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to CHIMIN/AL26MULT.
267	INBURN	0	BURN coprocessing and related edits are done only if INBURN > 0. Note that INBURN is set to 1 by subroutine GENBURN if a BURN generator deck has been specified in the regular generator deck or by command GENBURN. It is an internal flag and should not be changed by the user, except to permanently turn off BURN coprocessing in a problem.
268	NPAGE	53	Number of lines printed per "page" of ascii output. The value 53 causes zone lists to be printed in 50-zone blocks.
269	NSAVEZ	24	Total number of nonBURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with YM and numbering NZONEI + NZONEC in total. NSAVEZ must be at least 14 and no greater than NZONEI + NZONEC. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
270	NSAVEB	10	Total number of BURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with NETNUMB and numbering NZONEB in total. NSAVEB must be at least 6 and no greater than NZONEB. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.

271	VLOSS	1.E+99	Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).
272	ABUNLIMB	1.E-5	Edit only those BURN isotope mass-fractions whose values exceed ABUNLIMB in making terminal edits (including isotopic mass-fraction sums over zones).
273	SCALEM	1.9892E+33	Mass unit used for the mass coordinate employed in making ascii and terminal edits (g).
274	NEDITZ1	10	Make an ascii edit of primary zonal quantities every NEDITZ1*NEDIT (P 16) cycles.
275	NEDITZ2	20	Make an ascii edit of secondary zonal quantities every NEDITZ2*NEDIT (P 16) cycles.
276	MEDIT	0	Flag determining the minimum amount of information printed in an ascii cycle edit regardless of the settings of other edit parameters: ≤ 0 means minimum is a 1 page "short" edit; ≥ 1 means minimum includes a primary zonal edit; ≥ 2 means minimum includes a secondary zonal edit; ≥ 3 means minimum includes an ion abundance edit; ≥ 4 means minimum includes an ISE abundance edit; ≥ 5 means minimum includes a BURN isotope edit; ≥ 6 means minimum includes a BURN isotope edit for all zones; ≥ 7 means minimum includes a parameter edit.
277	MEDITFIN	7	Effective value of MEDIT (P 276) used in determining the scope of the final edit made when the problem is finished.
278	NEDITP	50	Make an ascii edit of all changeable parameters every NEDITP*NEDIT (P 16) cycles.
279	FLAMVA	0.	If FLAMVA ≠ 0., the current problem is a study of a carbon deflagration in a white dwarf. The current radius of the deflagration flame is taken as the radius of the outermost zone where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283) by KEPLER. The outward speed of the flame is controlled by adjusting the opacity for heat conduction between

zones JFLAM and JFLAM + 1 up or down by a factor, XKAPFLAM (P 284), between 0. and 1. Such "gating" is performed in KAPPA and UPDATE and sets the velocity of advance of the 2.E+9 K temperature front to a comoving value that averages:

VFLAME =

VCOND * (RFLAME / XLAMBMIN)**(FLAMVB - 2.),

where: XLAMBMIN = 4π * VCOND**2 / GEFF and VCOND is FLAMVC (P 281) times the heat conduction velocity (given by 1.E+5*(dn(j+1)/2.E+9)**FLAMVE (P 347)), RFLAME is the current radius of the flame front, and GEFF is FLAMVA times the acceleration of gravity at the flame front. The calculated flame velocity is bounded below by VCOND and above by FLAMVD (P 282) times the speed of sound behind the flame front.

Basically the flame front wrinkles as it propagates in a fractal manner and the extra area it thus enjoys causes the flame to burn the entrained material more rapidly. See CYCLE for more details.

FLAMVA would typically be set to a value about 0.2 corresponding to a 20% delta-rho/rho across the burning front to study "plausible" carbon deflagrations using this model.

280 FLAMVB 2.6

Fractal exponent helping determine the relationship between the velocity of heat conduction and the velocity of the carbon deflagration flame based on its degree of "wrinkling." FLAMVB is equivalent to the fractal dimension of the burning front which is 2. for a smooth surface, 2.7 corresponds to fully developed turbulence, and 3. corresponds to filled space.

281 FLAMVC 50.

Multiplier on the heat conduction velocity used to calculate the velocity of the carbon deflagration front. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. The default value of 50 corresponds to the laminar flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc.

282 FLAMVD 1.

The velocity of the carbon deflagration flame front is limited to FLAMVD times the local sound speed. (See the discussion for FLAMVA (P 279)).

283 JFLAM 0

The zone where the carbon deflagration flame is currently located. This parameter is internally set by KEPLER to be the outermost zone whose temperature exceeds 2.E+9 K and its value should not be changed by the user.

284	XKAPFLAM	0.001	Carbon deflagation opacity gating factor. Must be > 0. and <1. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use.
285	XMFLAM	0.	The mass in the current carbon deflagration flame-front zone JFLAM (P 283) that has already been burned (g). This parameter is set internally by KEPLER and should not be changed. When the entire mass of zone JFLAM (P 283) has been burned the opacity coupling it to zone JFLAM + 1 is changed from being divided by XKAPFLAM (P 284) to being multiplied by it. This causes the flame front to advance to the next zone. See the discussion given for FLAMVA (P 279).
286	TAUNU	0.	Time scale for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (sec).
287	ENU53	3.	Total energy (in units of 10**53 ergs) for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse.
288	TMUNU	8.	Temperature of the mu and tau neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
289	TENU	4.	Temperature of the electron neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
290	NOILAND	1	If NOILAND > 0, prevent separated islands of zones employing the ISE network from developing by not letting zone J go to ISE unless zone J - 1 has already done so.
291	CHARSIZG	1.0	Graphics character size for grid labels (relative to MONGO's default character size).
292	CHARSIZC	0.85	Graphics character size for curve labels (relative to MONGO's default character size).
293	CHARSIZZ	0.85	Graphics character size for zone sentinels (relative to MONGO's default character size).
294	CHARSIZH	1.0	Graphics character size for header info (relative to MONGO's default character size).

295	WIDTHTD	60.	Obsolete.
296	IBACKGND	-1	Graphics window background color is white if IBACKGND ≥ 0 and black if IBACKGND < 0. The foreground color is always the inverse of the background color.
297	DSCALEM	1.9892E+33	Mass units used for the internal mass coordinate, YMASS, used for dumping purposes (g). -- See subroutine DUMPQ.
298	NGRIDMIN	10	Minimum number of points allowed in a dump grid. See DUMPQ.
299	NCYCQQ	5	Number of KEPLER cycles between post-processor dump cycles (i.e.. calls to DUMPQ).
300	LENTRACK	16384	Length of the track(s) assigned to each dump variable in the post-processor dump(s) (bytes). See DUMPQ.
301	IDTMAXL	40	Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME. In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used: if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT). if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances). if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables).
302	IDTLOOK	10	Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.
303	BACKFACQ	0.5	If the fractional change in a dump variable since the last dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also dump the old value of that variable at the previous (dump cycle)

time point, where RATZDUMP(IDAT) is the (previously specified) maximum allowed fractional change between dumps of this zonal dump variable (indexed by IDAT). See Chapter 2 on Generator Input.

304 TEMPSTOP 1.E+99 Terminate the problem when the central temperature reaches TEMPSTOP (K).

305 DENSTOP 1.E+99 Terminate the problem when the central density reaches DENSTOP (g/cc).

306 VINSTOP 1.E+99 Terminate the problem when the infall velocity exceeds VINSTOP (cm/sec). Note that positive values of VINSTOP correspond to negative (infalling) velocities. Before terminating the problem, make a restart dump labeled '#presn' and execute the alias-defined "presn" command. Normally this command is used to make final plots and edits.

307 O16STOP -1. Terminate the problem when the O16 mass-fraction drops below O16STOP provided the central temperature exceeds TQSELIM (P 184). Basically this corresponds to a time near the end of core oxygen burning for values of O16STOP about 0.05.

308 TIMEZMS 1.E+99 Time (sec) at which to make zero-age-main-sequence parameter changes and a restart dump labeled '#zms'. TIMEZMS is typically set to 1.E+12 sec.

309 IZONEZMS 1 Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).

310 Q1FACZMS 0.1 Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).

311 TEMPCIG 1.E+99 Central temperature (K) at which to make the pre-carbon-ignition parameter changes and a restart dump labeled '#cig'. TEMPCIG is typically set to 5.E+8.

312 YFLRXCIG 0.003 Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.

313 FMAXMCIG 1. Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.

314 FMAX0CIG 1. Reset the value of FMAX0 (P 150) to FMAX0CIG when the

central temperature specified by TEMPCIG (P 311) is reached.

315	TOFFSET	0.	Cumulative amount of time by which the problem time has been offset by ZEROTIME commands (sec). In other words, TOFFSET should be added to the current problem time to get the actual time since the beginning of the problem. Normally, TOFFSET is reset internally when the ZEROTIME command is issued and should not be reset by the user.
316	ABUNMINB	1.E-4	Lower mass-fraction limit of the isotopic abundance plot.
317	ABUNMAXB	1.	Upper mass-fraction limit of the isotopic abundance plot.
318	NUMISO	0	Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.
319	TIMEREF	-1.E+99	Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
320	TOSETREF	0.	Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.
321	TIMECMIN	0.	Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
322	TIMECMAX	0.	Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
323	YEMAX	0.498	Maximum value of Ye allowed when initializing a new ISE zone (moles/g). This simulates the small amount of neutronization that usually occurs before the end of oxygen burning.
324	ABARSEMI	4.	Value of the zonal mean atomic weight, ABAR, used to divide the star into two regions with separately specifiable values of the semiconvective mixing rate and the overshoot mixing coefficient

(g/mole). (See the definitions of DRMULT (P 24), WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)).

325 DRMULTLO DRMULT Semiconvective mixing will be slower than thermal transport by at least DRMULTLO (about 0.1) in zones where the mean atomic weight, ABAR, is below ABARSEMI (P 324). (See UPDATE and discussion of DRMULT (P 24), WOVERSHT (P 148), and WOVERSLO (P 326)).

326 WOVERSLO WOVERSHT The semiconvective test parameter, W, is taken to be W=WOVERSLO*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR < ABARSEMI (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but is limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSLO=0 no overshoot mixing is done. (Also see WOVERSHT -- P 148).

327 MAPTIME 2 Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP):
0 => use cycle number;
1 => use linear time (sec);
2 => use negative logarithmic time (-log (sec)).
3 => use positive logarithmic time (log (sec)).
Note that the time coordinate is calculated relative to TIMEREF (P 319) + TOSETREF (P 320).

328 VMINMAP 1.E+99 Minimum value of the timemap variable to be mapped. If VMINMAP > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by VRATMAP (P 330), below.

329 VMAXMAP -1.E+99 Maximum value of the timemap variable to be mapped. If VMAXMAP < -1.E+98, then the actual maximum value of the current variable is used as the map limit.

330 VRATMAP 1.E-99 Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.

331 TEMPCDEP 1.E+99 If the central temperature is ≥ TEMPCDEP, then make a restart dump labeled '#cdep', execute the alias-defined "cdep" command, and reset TEMPCDEP to 1.E+99.
Normally, this parameter is used to reset certain parameter values following carbon depletion.

332 O16ODEP -1.E+99 If the central oxygen abundance is ≤ O16ODEP *and* the central temperature is ≥ TQSELIM (P 184), then make a restart dump labeled '#odep', execute the alias-defined "odep" command, and reset O16ODEP to -1.E+99.
Normally, this parameter is used to reset certain parameter values at oxygen depletion.

333 TEMPCHAR 1.E+99 If the central temperature is ≥ TEMPCHAR, then make a restart dump labeled with '#tn' and the current cycle number, reset TEMPCHAR to 1.E+99, and *finally* execute the alias-defined "tnchar" command.
Note that the user -defined "tnchar" command can change the value of TEMPCHAR in such a way as to cause the "tnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

334 DENCHAR 1.E+99 If the central density is ≥ DENCHAR, then make a restart dump labeled with '#dn' and the current cycle number, reset DENCHAR to 1.E+99, and *finally* execute the alias-defined "dnchar" command.
Note that the user -defined "dnchar" command can change the value of DENCHAR in such a way as to cause the "dnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

335 ABARCHAR 1.E+99 If the central mean atomic weight (ABAR) is ≥ ABARCHAR, then make a restart dump labeled with '#ab' and the current cycle number, reset ABARCHAR to 1.E+99, and *finally* execute the alias-defined "abchar" command.
Note that the user -defined "abchar" command can change the value of ABARCHAR in such a way as to cause the "abchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

336 ZONEMMIN 1.E-99 ZONEMMIN is the minimum mass (g) that a zone may have and still be allowed to be adzoned (as part of a zone pair).

337	ICALCNE	0	Calculate more accurate electron densities in partially ionized regions if ICALCNE > 0 using Lisa Ensman's multiple-ion, Saha equilibrium subroutine, CALCNE. Generally this more accurate, but very time-consuming routine is turned on just before shock-breakout while doing supernova light-curve calculations.
338	XNECONV	1.E-05	Maximum allowable fractional convergence error in the electron density calculated by subroutine CALCNE (see P 337).
339	IONFLAG	0	If IONFLAG ≤ 0 and the density and temperature have changed by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154), respectively, since the last iteration, then extrapolate the value of the electron density from its partial derivatives with respect to density and temperature instead of calling CALCNE (when ICALCNE > 0 -- see p 337), unless this is the first iteration. Otherwise call CALCNE all the time, provided ICALCNE > 0.
340	XNEMIN	1.E-05	Minimum mass fraction for which an element is included in the calculation of Saha ionization equilibrium done in subroutine CALCNE (see P 337).
341	XKAPGAM	0.054	Assumed effective opacity (cm^2/g) for the deposition of gamma ray energy from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38).
342	EGAMP	0.60	Dimensionless correction factor used in calculating the escape of gamma rays from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38). See subroutine SDOT for details.
343	TSHOCK	1.E+99	If the problem time is ≥ TSHOCK, then make a restart dump labeled '#shock', reset TSHOCK to 1.E+99, and *finally* execute the alias-defined "tshock" command. Normally, this command is used to reset certain parameter values and/or make edits at the time of the piston-induced bounce of the collapsing iron core that creates an out-going shock wave.
344	TNUCLEO	1.E+99	If the problem time is ≥ TNUCLEO, then make a restart dump labeled '#nucleo', reset TNUCLEO to 1.E+99, and *finally* execute the alias-defined "tnucleo" command. Normally, this command is used to reset certain parameter values and/or make edits at a time just after explosive nucleosynthesis is complete.

345	TENVEL	1.E+99	If the problem time is ≥ TENVEL, then make a restart dump labeled '#envel', reset TENVEL to 1.E+99, and *finally* execute the alias-defined "tenvel" command. Normally, this command is used to reset certain parameter values and/or make edits just before the supernova shock wave breaks through the surface of the presupernova star.
346	NFIRSTQ	0	Default value of the first cycle to be read or plotted in making post-processor edits, time plots, or timemaps. Note that this parameter is reset by the NEWDUMPS command to the current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ) so that KEPLER will not try to read old dumps.
347	FLAMVE	0.805	Density power dependence of the heat conduction velocity used in calculating the velocity of nuclear deflagrations in Type I supernovae. (0.805 for C/O, 1.06 for Ne/O) See P 279-285 and subroutine CYCLE for details.
348	BINM10	TOTM0	The initial mass of the star being evolved (primary) in solar masses that is used in calculating the possibility of mass loss to a binary companion, following the formalism of Podsiadlowski, Joss, and Hsu, ApJ, 391, 246, (1992). The star loses mass when its radius exceeds its Roche radius, with a power-law cutoff to avoid numerical discontinuities. The formalism also involves parameters 349 - 354, defined below. See subroutine CYCLE.
349	BINM20	0.	The initial mass of the binary companion star (in solar masses) used in calculating the possibility of binary mass transfer. No mass transfer is performed if BINM20 ≤ 0. See P 348.
350	BINALP	1.	PJH's alpha parameter, related to the angular momentum of the mass lost in binary transfer. See P 348.
351	BINBET	1.	PJH's beta parameter. Fraction of the total mass spilling over from the Roche lobe of the primary that is transferred to the secondary rather than being lost from the system. BINBET equals 1. for conservative binary mass transfer.
352	BINA0	2.	Initial binary separation in AU used in calculating the possibility of binary mass transfer. See P 348.
353	BINMDT	1.E-3	Mass loss rate due to binary mass transfer assumed when the primary stars exceeds its Roche radius (solar masses per year).

See P 348.

354 ROCHER 1.E+99 Current Roche radius (cm). This is a calculated quantity and should normally not be changed by the user. See P 348.

DEVICE-CONTROL GRAPHICS PARAMETERS

127	ITVSTART	0	Graphics device control parameter. = 0 means no graphics processes are active. = 1 means start an X-window graphics display and reset ITVSTART to 2. = -1 means stop the X-window graphics display and reset ITVSTART to 0. = 2 means keep the X-window display open and display graphs and timeplots as requested. (This value is internally set). = 3 means initialize a portrait-orientation Postscript File and reset ITVSTART to 5. = 4 means initialize a landscape-orientation Postscript File and reset ITVSTART to 5. = 5 means keep the postscript file open for further input (under development). Note that ITVSTART is reset to zero when a problem is restarted.
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
42	IWINSIZE	10240750	Size of graphics window to be created in the form *xxxxyyyy*, where *xxxx* is the number of pixels wide to make the window and *yyyy* is the number of pixels wide it should be. Be sure to include leading zeros if *yyyy* is less than 4 digits.
45	IWINLOC	0	Location of the upper-left-hand corner of the graphics window given in the form *xxxxyyyy*, where *yyyy* is the number of pixels below the top of the screen this corner should be, and *xxxx* is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if *yyyy* is less than 4 digits.
296	IBACKGND	-1	Graphics window background color is white if IBACKGND ≥ 0 and black if IBACKGND < 0. The foreground color is always the inverse of the background color.

PLOT-TYPE GRAPHICS PARAMETER

113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the **SETISO** command first to determine the ions to be displayed). =7 thru 9: only header info is displayed. =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.

'RADIAL'-COORDINATE-CONTROL GRAPHICS PARAMETERS

132	IRTYPE	3	Use the interior mass fraction as the independent coordinate in all graphs if IRTYPE =2; use the interior mass in solar mass units if IRTYPE=3; Otherwise use the radius (in cm).
116	IGRIDT	370	Grid choice for the radial coordinate: If IRTYPE = 1, then the radial coordinate will be log10 (radius) if IGRIDT > 10 and linear in radius otherwise. If IRTYPE ≠ 1, IGRIDT has no effect.
119	JP0	1	Innermost zone to plot. (See P 121).
120	JP1	0	Outermost zone to plot is JM (outermost zone) - JP1. (See P 122)
121	RPMIN0	1.E+7	Minimum radius plotted when JP0 < 0 (cm).
122	RPMAX0	1.E+14	Maximum radius plotted when JP1 < 0 (cm).
134	YPLOTMIN	0.	Minimum mass coordinate plotted (fraction of total mass).
135	YPLOTMAX	1.	Maximum mass coordinate plotted (fraction of total mass).

THERMODYNAMICS-GRAPH PARAMETERS

123	YMINTD	1.	Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
124	YMAXTD	1.E+8	Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
125	SSCALEM	1.E-3	Energy generation rate graph scale multiplier in the TD graph.
126	PSCALEM	1.E-1	Pressure graph scale multiplier in the TD graph.
130	VSCALEM	1.E-5	Velocity graph scale multiplier in the TD graph.
131	RSCALEM	1.E-5	Radius graph scale multiplier in the TD graph.
115	TSCALEM	1.E+7	Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K). Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
133	CONVORD	3.	Ordinate value at which to plot convection sentinels in the TD graph (nominally g/cc).

VELOCITY AND ABUNDANCE GRAPH PARAMETERS

191	VLIMSET	-1.	The ordinate bounds of the velocity graph are ±VLIMSET if VLIMSET > 0. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
316	ABUNMINB	1.E-4	Lower mass-fraction limit of the isotopic abundance plot.
317	ABUNMAXB	1.	Upper mass-fraction limit of the isotopic abundance plot.
318	NUMISO	0	Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.

GRAPHICS LABELING PARAMETERS

291	CHARSIZG	1.0	Graphics character size for grid labels (relative to MONGO's default character size).
292	CHARSIZC	0.85	Graphics character size for curve labels (relative to MONGO's default character size).
293	CHARSIZZ	0.85	Graphics character size for zone sentinels (relative to MONGO's default character size).
294	CHARSIZH	1.0	Graphics character size for header info (relative to MONGO's default character size).
114	NPLOTSYM	8	Label each curve with NPLOTSYM character symbols.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE)

POST-PROCESSOR GRAPHICS PARAMETERS

301 IDTMAXL 40

Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME.
In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used:
if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT).
if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances).
if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables).

302 IDTLOOK 10

Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.

328 VMINMAP 1.E+99

Minimum value of the timemap variable to be mapped.
If VMINMAP > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by VRATMAP (P 330), below.

329 VMAXMAP -1.E+99

Maximum value of the timemap variable to be mapped. If VMAXMAP < -1.d+98, then the actual maximum value of the current variable is used as the map limit.

330 VRATMAP 1.E-99

Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.

TIME-COORDINATE GRAPHICS PARAMETERS

327	MAPTIME	2	Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP): 0 => use cycle number; 1 => use linear time (sec); 2 => use negative logarithmic time (-log (sec)). 3 => use positive logarithmic time (log (sec)). Note that the time coordinate is calculated relative to TIMEREF (P 319) + TOSETREF (P 320).
321	TIMECMIN	0.	Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
322	TIMECMAX	0.	Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
319	TIMEREF	-1.E+99	Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
320	TOSETREF	0.	Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.

23.VII.93
DRAFT

CHAPTER 4

PARAMETER LIST BY NUMBER

This chapter lists in numerical order the 354 changeable ('P') parameters in KEPLER that may be edited changed before or during execution. A list of these parameters grouped by function was given in Chapter 3. Initial values for these parameters may be specified by **P** cards in the problem generator file (see Chapter 2). If no explicit such specification is made their, values are initially set equal to the default values listed below.

These parameters may also be edited or changed during program execution by they following set of keyboard commands (also described in Chapter 5):

P *N*

Display the value of parameter name or number *N:* **'p 113'** or **'p time'**

P *N VALUE*

Change the value of parameter name or number *N* to *VALUE:* **'p 113 31'**

P *N DELTA* **ADD**

Add *DELTA* to the value of parameter name or number *N:* **'p 1 -1.e+14 add'**

Note that, although printed in capital letters for clarity, the parameter names listed below must be given as unquoted, **lowercase** character strings when communicating with KEPLER. The mode of the parameters (fixed or floating point) follows the normal FORTRAN convention.

The current values of the parameters are remembered in the restart dumps and more may readily be added. They are located in the general COMMON in include file KEPCOMS (starting with DTNEW) and their ASCII names and types are listed respectively in the **nameparm** and **iptype** arrays loaded in data block KEPDAT. Newly added parameters are initialized in subroutine subroutine RESTART (see Chapter 5).

#	Name	Default	Description
1	DTNEW	1.	Initial or current timestep (sec).

2	TIME	0.	Initial or current time (sec).
3	EXTRAP	1.	Extrapolation Parameter used in guessing new R, T, and L values. 0. gives old values; 1. gives linear extrapolation.
4	Q2FAC	4.	Quadratic artificial viscosity (Q) factor. Shock transitions are spread over about 2*SQRT(Q2FAC) zones. (see WZW78)
5	MAXIT	40	Maximum number of times subroutine REGESS is called to iterate R, T, and L estimates before the timestep is reduced by DTCUT and the step repeated (termed a "backup").
6	DTCR	0.05	Maximum desired fractional change in radius per step.
7	DTCT	0.05	Maximum desired fractional change in temperature per step.
8	DTCD	0.10	Maximum desired fractional change in density per step.
9	DTCQ	0.05	Maximum desired fractional linear contraction per step.
10	DTCDT	0.99	Maximum fractional change in the timestep per step.
11	FCRMAX	1.E-6	Maximum allowed relative convergence error in radius.
12	FCTMAX	1.E-6	Maximum allowed relative convergence error in temperature.
13	Q1FAC	0.1	Linear artificial viscosity factor. Helps damp sound waves during hydrostatic evolution. Should be set to 0. during hydrodynamic phases. Normally set to 1000. in the generator until the star settles down onto the zero-age main sequence (from an initially rather arbitrary configuration), at which point it is reset to 0.1.
14	NSTOP	100000	Maximum number of cycles.
15	TSTOP	1.E+30	Stop time (sec). Before terminating the problem, make a restart dump labeled '#final' and execute the alias-defined "tfinal" command. Normally this command is used to make final plots and edits.
16	NEDIT	20	Number of cycles between edits.
17	DTEDIT	0.	Time between edits (0. = ∞) (sec).

18	NDUMP	10	Number of cycles between restart dumps.
19	XMLEN	1.	Ratio of the convective mixing length to the pressure scale height.
20	FUDGC	0.01	Fudge factor for convection (about 0.01). Reduces convective efficiency for very small departures from adiabatic gradients and thus makes the numerical onset of convection less abrupt and unstable. (see subroutines REGESS and UPDATE)
21	DIFIM	1.	Multiplier for the rate of convective mixing.
22	FCRBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in radius is still greater than FCRBU after MAXIT iterations.
23	FCTBU	0.01	Reduce timestep by DTCUT and redo step if convergence error in temperature is still greater than FCTBU after MAXIT iterations.
24	DRMULT	0.1	Semi-convective mixing will be slower than thermal transport by at least DRMULT (about 0.1) in zones with mean atomic weight, ABAR, is ≥ ABARSEMI (P 324). (See sub.UPDATE) (Also see DRMULTLO (P 325), WOVERSHT (P 148), and WOVERSLO (P 326)).
25	DTMAX	1.E+99	Maximum timestep allowed (sec).
26	FCREXT	10.	Factor used to reduce noise in radius extrapolation. (See subroutine GESS)
27	FCTEXT	10.	Factor used to reduce noise in temperature extrapolation.
28	IPUP	1	Abundance update parameter. Update abundances only if IPUP≠0.
29	XK1MT	1.	Multiplier on IBEN1 opacity.
30	XK2MT	1.	Multiplier on IBEN2 opacity.
31	XK3MT	1.	Multiplier on Christy opacity.
32	XK4MT	1.	Multiplier on Compton opacity.

33	RXKCMT	1.	Multiplier on conductive opacity.
34	PIMULT	1.	Ion energy and pressure multiplier.
35	PRMULT	1.	Radiation energy and pressure multiplier.
36	PEMULT	1.	Electron energy and pressure multiplier.
37	TRANSM	1.	Multiplier on diffusive heat transport.
38	TIMEX0	-1.E+99	Time at which any Ni56 present in low temperature regions (as determined by P 89 and P 65) of the star is assumed to have been produced and begun to decay, first to Co56 and then to Fe56 (sec). If TIMEX0 ≥ -1.E+50 and the zonal Ni56 abundance, YNI, ≥ 3.E-5, then the nuclear energy generation is take equal to that generated by an initial Ni56 abundance YNI after having decayed for a time interval TIME (P 2) -TIMEX0. Note that the value of YNI in the abundance array is not changed by this "decay", and always represents the initial amount produced. DO NOT set TIMEX0 > TIME (P 2).
39	DYEMULT	200.	If IYTSFLAG≥1, increase the timestep sensitivity to changes in YE by a factor of DYEMULT.
40	DYQMULT	2.5	IF IYTSFLAG≥1, increase the timestep sensitivity to changes in YQ by a factor of DYQMULT.
41	YEMIN	0.02	No further changes in YE are allowed for YE < YEMIN (moles/g).
42	IWINSIZE	10240750	Size of graphics window to be created in the form *xxxxyyyy*, where *xxxx* is the number of pixels wide to make the window and *yyyy* is the number of pixels wide it should be. Be sure to include leading zeros if *yyyy* is less than 4 digits.
43	HSTATM	1.	Multiplier on the inertial terms in the momentum balance equation. Nominally forces hydrostatic equilibrium for for HSTATM = 0., but may result in convergence and consistency problems. This parameter should be kept set to 1. (normal hydrodynamics) unless the user is prepared to make a very careful study of its actual effects (see subroutines REGESS and UPDATE).

44	LENQMAX	3000000	Maximum length of a post-processor file (bytes).
45	IWINLOC	0	Location of the upper-left-hand corner of the graphics window given in the form *xxxxyyyy*, where *yyyy* is the number of pixels below the top of the screen this corner should be, and *xxxx* is the number of pixels from the left-hand edge of the screen it begins. Be sure to include leading zeros if *yyyy* is less than 4 digits.
46	DTCP	0.1	Maximum desired fractional change in abundances per step.
47	YFLOORX	1.E-3	Minimum elemental mass fraction that effects the timestep.
48	CENU	1.0	Velocity centering parameter (Range: 0.5,1.): 0.5 gives exact energy conservation; 1.0 gives greatest stability. Actually, KEPLER only behaves reasonably if CENU=1, so the user should **NOT** change the default value without careful study and a willingness to bear full responsibility for whatever nonsense may result.
49	T7PEEK	1.E+50	Opacity will be no larger than XKMIN+T7PEEK*D*T7**4. (cgs units, except T7=T/(10**7 K)
50	XKMIN	1.E-10	Least upper opacity bound (cm**2/g). (see P 49 and KAPPA)
51	THICKFAC	1.E-3	If the timestep is greater than the thermal timescale for a zone by a factor $\geq$ 0.5*THICKFAC, then consider the zone to be in thermal steady-state and deal with any residual non-convergence in the solution of the energy equation by recalculating the luminosity in terms of the final iterated value of the internal energy. Otherwise, recalculate the internal energy in terms of the final iterated luminosity. (See UPDATE).
52	MAXBAK	5	Maximum number of times a given step is redone before the code quits.
53	DTCUT	0.1	Fractional timestep reduction when a step is redone.
54	TFCRBU	2.	If the maximum fractional change in radius during a timestep exceeds TFCRBU*DTCR then redo step.
55	TFCTBU	2.	If the maximum fractional change in temperature during a timestep exceeds TFCTBU*DTCT then redo step.

56	XIPOT	13.6053	Ionization potential (eV) --see subtoutine ES.
57	DZERO	0.1	Characteristic density for pressure ionization (g/cc).
58	NPFLAG	1	Pairs are included in EOS calculation only if NPFLAG>0.
59	FRACNEUT	0.05	If the semiconvective test parameter, W, is less than zero but greater than -FRACNEUT*ABS(LOG(T1/T0)), then the zonal interface is flagged convectively neutral ("NEUT" or "N"). (see UPDATE)
60	RADIUS0	0.	Radius of inner boundary (cm).
61	SUMM0	0.	Mass inside inner boundary (g).
62	XLUM0	0.	Luminosity emerging from inner surface (erg/s).
63	IRNET	0	If IRNET=0, use APPROX network. If IRNET=1, use SDOT1 (H and He burning network). Otherwise use SDOT2 (NOVA network). Note that SDOT1 and SDOT2 are replaced by dummy routines in the current version of KEPLER and an error message will result if they are entered. The old routines would have to be extensively updated before being used again.
64	NPIXEDIT	50	Graphics edits to the monitor are made every NPIXEDIT KEPLER cycles (if P 127 > 0).
65	TNUCMIN	0.	Don't calculate nuclear burning in APPROX if the temperature is less than TNUCMIN (K). Note that unless the hydrogen burning rate is significant, no APPROX network calculations will be done below 1.E+7 K, even if TNUCMIN < 1.E+7 K. (See P 89).
66	SETPARM	XK+1.	Initialize new parameters in RESTART if SETPARM ≤ XK. XK represents a floating point number used in RESTART as an index for the version of KEPLER is which the last set new parameters has been introduced. After such a new parameter update is made SETPARM is reset to XK+1. This allows restart dumps written by older versions of KEPLER with fewer parameters to be used by any later version of the code.

85	JMMIN	10	Minimum number of zones allowed after dezoning.
86	IZONEF	1	Rezoning Flag: ≤0 means no rezoning (including dezoning); =1 means normal rezoning; =2 means rezoning with before and after edits; =3 means stop after hydrostatic adzoning.
87	IDZONEF	1	Dezoning Flag: ≤0 means no dezoning; =1 means normal dezoning; =2 means dezoning with before and after edits; =3 means dezone, edit, then stop.
88	RNMAX	1.E+99	Maximum radius for which rezoning is considered (cm).
89	DYPMIN	1.E-10	Minimum amount of potential hydrogen burn in the present timestep needed to trigger the use of any reaction network (moles/g). (APPROX only).
90	DYMGMIN	1.E-10	Minimum amount of Mg24 production required in the last timestep to trigger the use of the full reaction network (moles/g). (APPROX only).
91	ZBOUND	0.1	Mass fraction of heavy elements above which IBEN1 opacities are used.
92	ETACONV	1.E-5	Relative convergence required in calculating the electron Fermi degeneracy parameter, ETA.
93	JSHELL0	1	Innermost zone in which there is neutrino deposition.
94	JSHELL1	1000	Outermost zone in which there is neutrino deposition.
95	EEXPLODE	0.	Total neutrino deposition energy (erg).
96	TEXPLODE	1.E+99	Time of neutrino deposition (sec).
97	TAUEXP	1.E-2	Time scale for neutrino deposition (sec).
98	P0CORE	0.	Artificial neutrino core pressure is given by: PCORE = P0CORE*D**D0POWER*EXP(-D0CORE/D), where D is the density in g/cc, PCORE is in erg/cc, and P0CORE is in appropriate cgs units.

67	IYTSFLAG	1	Consider only changes in YE, YQ, YF, YSI, and Y56 in ISE zones when computing the timestep if IYTSFLAG ≥ 1.
68	TBOUND	0.	Temperature at outer boundary (K).
69	PBOUND	0.	Pressure at outer boundary (erg/cc).
70	FCLMAX	1.	Maximum allowed relative convergence error in luminosity.
71	FCLEXT	1.E-5	Factor used to reduce noise in luminosity extrapolation.
72	DTCL	1.E+99	Maximum desired fractional change in luminosity per step.
73	FCLBU	1.	Reduce timestep by DTCUT and redo step if convergence error in luminosity is still greater than FCLBU after MAXIT iterations.
74	TFCLBU	1.E+99	If the maximum fractional change in luminosity during a timestep exceeds TFCLBU*DTCL then redo step.
75	DTSMULT	1.E+99	The fractional amount of semiconvective mixing that can occur in one timestep is limited to approximately DTSMULT.
76	RNRATMAX	0.25	Maximum fractional radius change allowed between zones before adzoning.
77	RNRATMIN	0.1	Minimum fractional radius change allowed between zones before dezoning.
78	TNRATMAX	0.25	Maximum fractional temperature change allowed between zones before adzoning.
79	TNRATMIN	0.1	Minimum fractional temperature change allowed between zones before dezoning.
80	DNRATMAX	0.25	Maximum fractional density change allowed between zones before adzoning.
81	DNRATMIN	0.1	Minimum fractional density change allowed between zones before dezoning.
82	RNMIN	1.E-99	Minimum radius for which adzoning is considered (cm).
83	TNMIN	1.	Minimum temperature for which adzoning is considered (K).
84	DNMIN	1.E-99	Minimum density for which adzoning is considered (g/cc).

99	D0CORE	3.E+11	Core density cutoff (g/cc) -- (see P 98).
100	D0POWER	1.	Core pressure density dependence exponent. (See P 98).
101	SNEUTMT	1.	Neutrino energy loss rate multiplier (APPROX only).
102	SNUCMT	1.	Non-neutrino nuclear energy generation rate multiplier (APPROX only).
103	DSNUM	1.E-6	Fractional density and temperature perturbations used to get nuclear energy generation rate derivatives (APPROX only).
104	TCOREFAC	1.	Increase the rezoner's sensitivity to temperature gradients by a factor of TCOREFAC in the region where FRACM, the culmulative mass fraction measured from the center of the star, is less than or equal FRACRZ1.
105	TQSEMIN	2.E+9	Floor on the temperature used in the ISE calculation (K).
106	JQSE	0	Change all APPROX network zones with J<JQSE to the ISE network.
107	ARTV1	1.	Multiply Q1FAC by ARTV1 in zone J if JARTV1≤J<JARTV2.
108	ARTV2	1.	Multiply Q1FAC by ARTV2 in zone J if JARTV2≤J<JM-JARTV3.
109	ARTV3	1.	Multiply Q1FAC by ARTV3 in zone J if J≥MAX(JARTV1,JARTV2,JM-JARTV3)
110	JARTV1	1000	(See P 107-109).
111	JARTV2	1000	(See P 107-109).
112	JARTV3	1000	(See P 107-109).
113	IPIXTYPE	31	Graphics picture-type control parameter: <0 graphics window is not updated, but is still open. =0 only header info is displayed. =1 thermodynamics (TD) graph only. =2 velocity graph only. =3 mass-fraction graph only. =4 entropy graph only. =5 density-temperature graph only. =6 isotopic mass-fraction graph (use the **SETISO** command

			first to determine the ions to be displayed). =7 thru 9: only header info is displayed. =10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.
114	NPLOTSYM	8	Label each curve with NPLOTSYM character symbols.
115	TSCALEM	1.E+7	Characteristic temperature for choosing the location of the temperature plotting grid in Thermodynamics graph (K). Equivalent to the temperature plotted at the same ordinate value as a density of 1 g/cc.
116	IGRIDT	370	Grid choice for the radial coordinate: If IRTYPE = 1, then the radial coordinate will be log10(radius) if IGRIDT > 10 and linear in radius otherwise. If IRTYPE ≠ 1, IGRIDT has no effect.
117	IGRIDM	498	Obsolete.
118	IGRIDV	496	Obsolete.
119	JP0	1	Innermost zone to plot. (See P 121).
120	JP1	0	Outermost zone to plot is JM (outermost zone) - JP1. (See P 122)
121	RPMIN0	1.E+7	Minimum radius plotted when JP0 < 0 (cm).
122	RPMAX0	1.E+14	Maximum radius plotted when JP1 < 0 (cm).
123	YMINTD	1.	Lower bound of thermodynamics graph ordinate shall be no greater than YMINTD (nominally g/cc).
124	YMAXTD	1.E+8	Upper bound of thermodynamics graph ordinate shall be no less than YMAXTD (nominally g/cc).
125	SSCALEM	1.E-3	Energy generation rate graph scale multiplier in the TD graph.
126	PSCALEM	1.E-1	Pressure graph scale multiplier in the TD graph.
127	ITVSTART	0	Graphics device control parameter. = 0 means no graphics processes are active. = 1 means start an X-window graphics display and reset

ITVSTART to 2.
= -1 means stop the X-window graphics display and reset ITVSTART to 0.
= 2 means keep the X-window display open and display graphs and timeplots as requested. (This value is internally set).
= 3 means initialize a portrait-orientation Postscript File and reset ITVSTART to 5.
= 4 means initialize a landscape-orientation Postscript File and reset ITVSTART to 5.
= 5 means keep the postscript file open for further input (under development).
Note that ITVSTART is reset to zero when a problem is restarted.

128	ABUNLIM	1.E-3	Least elemental mass fraction plotted or listed in a terminal ion edit.
129	IVPLOT	1	Obsolete.
130	VSCALEM	1.E-5	Velocity graph scale multiplier in the TD graph.
131	RSCALEM	1.E-5	Radius graph scale multiplier in the TD graph.
132	IRTYPE	3	Use the interior mass fraction as the independent coordinate in all graphs if IRTYPE =2; use the interior mass in solar mass units if IRTYPE=3; Otherwise use the radius (in cm).
133	CONVORD	3.	Ordinate value at which to plot convection sentinels in the TD graph (nominally g/cc).
134	YPLOTMIN	0.	Minimum mass coordinate plotted (fraction of total mass).
135	YPLOTMAX	1.	Maximum mass coordinate plotted (fraction of total mass).
136	ETACUT	10.	Electron degeneracy parameter, ETA, above which to use temperature interpolation in ADZONE.
137	BETHEMT	0.	Multiplier on fudged Co63 electron decay rate as suggested by Gerry Brown and Hans Bethe (11/89).
138	FRACRZ1	1.	The effective values of the density, temperature, and radius gradients used to determine the necessity for adzoning or dezoning are multiplied by: RZMULTM if FRACM ≤ FRACRZ0,

RZMULT0 if FRACRZ0 < FRACM ≤ FRACRZ1,
RZMULT1 if FRACRZ1 < FRACM ≤ FRACRZ2, and
RZMULT2 if FRACM > FRACRZ2,
where FRACM is the cumulative mass fraction measured from the center of the star. (See also P 104 and P 150).

139 FRACRZ2 1. (See P 138 and P 150).

140 RZMULT0 1. (See P 138).

141 RZMULT1 1. (See P 138).

142 RZMULT2 1. (See P 138).

143 ABARRAT0 2. The effective values of the density, radius, and temperature gradients used for adzoning are formed by multiplying the actual gradients by the factor:
(1.+ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT));
and for dezoning by the factor:
(1.+1.5*ABARRATM*ABARRAT0*ABARRAT /
(ABARRAT0+ABARRAT),
where ABARRAT is the average relative ABAR change between adjacent zones.
Do this for adzoning only if the sum of the masses in the involved zones divided by the total mass of the star exceeds FRACMLIM.

144 ABARRATM 1.3 (See P 143).

145 FRACMLIM 0.01 (See P 143).

146 FRCSOUND 0.1 Don't do convection if the absolute value of the zone velocity exceeds FRCSOUND times the local sound speed.

147 CONVLIM 1. Limit the convective velocity to a fraction CONVLIM of the local sound speed.

148 WOVERSHT 0.01 The semiconvective test parameter, W, is taken to be W=WOVERSHT*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR ≥ ABARSEMI (P 324).
Overshoot mixing occurs at a rate calculated from this value of W, but limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE &

			WZW78). If WOVERSHT=0 no overshoot mixing is done. (Also see WOVERSLO -- P 326).
149	XMIMULT	1.	The mass used in calculating ion degeneracy is XMIMULT times the mass of a neutron.
150	FMAX0	1.	Always adzone if the total mass fraction of any pair of zones exceeds: FMAXM if FRACM ≤ FRACRZ0, FMAX0 if FRACRZ0 < FRACM ≤ FRACRZ1, FMAX1 if FRACRZ1 < FRACM ≤ FRACRZ2, and FMAX2 if FRACM > FRACRZ2, where FRACM is the cumulative mass fraction measured from the center of the star.
151	FMAX1	1.	(See P 150).
152	FMAX2	1.	(See P 150).
153	DDSFRAC	0.01	Maximum fractional change in density since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
154	DTSFRAC	0.001	Maximum fractional change in temperature since the last iteration for which ABAR changes and energy generation rates can be extrapolated from their previous values (APPROX only).
155	IUDFLAG	0	Extrapolate energy generation rates and ABAR changes in cases of small temperature and density change only if IUDFLAG is also ≤0.
156	NSDUMP	10	Save every NSDUMP restart dumps.
157	NITERBAR	1	Total number of cycles used to compute ITERBAR, the average number of iterations per cycle. (Internally set.)
158	ITERBARM	100	Maximum allowed value of NITERBAR without terminating the problem.
159	IAUTOOUT	0	Send out two copies of the ASCII output if IAUTOOUT>1. Also send out two copies of the graphics output if IAUTOOUT>2. Note: No output files are destroyed. (CRAY only! -- this is an obsolescent parameter that should

			not be used on UNIX machines without recasting.)
160	IFLGABAR	0	The mean atomic weight, ABAR, calculated in subroutine SDOT is implicitly coupled to the ion equation of state only if IFLGABAR≠0 and the normal APPROX network (IN=1) is being used. (This is an obsolescent parameter and the coding should be carefully rechecked if it is set ≠0).
161	FRACCORE	1.1	The effective number of zones used in REGESS (JMCALC) shall be the minimum needed to contain the inner FRACCORE mass-fraction of the initial mass of the star.
162	JMCALC	JM	Effective number of zones used in subroutine REGESS. JMCALC is internally calculated from FRACCORE and should not be changed.
163	IUPDFLAG	1	Don't calculate derivatives in subroutine SDOT when called from subroutine UPDATE if IUPDFLAG ≥ 0 (APPROX only).
164	NIONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all 'ions' specified as dump variables.
165	NISODUMP	400	Number of dump cycles between forced dumps of all dump-grid points of all 'BURN 'isotopes' specified as dump variables.
166	NZONDUMP	40	Number of dump cycles between forced dumps of all dump-grid points of all arrays specified as dump variables except 'ions' and 'isotopes.'
167	IFLAGYE	1	The electron EOS is implicitly coupled to nuclear-burning-induced changes in the electron abundance, YE, provided IFLAGYE≠0 and the ISE or NSE network is being used.
168	NJEDITQ	5	Make a ISE edit every NJEDITQ zones.
169	DTQNUM	1.E-4	Relative temperature change used in calculating numerical derivatives in SDOTQ.
170	DDQNUM	1.E-4	Relative density change used in calculating numerical derivatives in SDOTQ.
171	IEXCITEH	1	Include excited states in ISE calculations only if IEXCITEH>0.

172	ITERQMH	1000	Maximum number of iterations allowed in ISE calculation.
173	YPCONVH	1.E-8	Allowed relative convergence error in the proton abundance in the ISE calculation.
174	YNCONVH	1.E-8	Allowed relative convergence error in the neutron abundance in the ISE calculation.
175	YSICONVH	1.E-8	Allowed relative convergence error in the Si28 abundance in the ISE calculation.
176	CNSEH	1.	Increment the proton, neutron, and Si28 abundances by a fraction CNSEH of that calculated by the Newton-Raphson method for an ISE iteration.
177	FYPH	0.05	Maximum allowed relative change in proton abundance during an ISE iteration.
178	FYNH	0.05	Maximum allowed relative change in neutron abundance during an ISE iteration.
179	FYSIH	0.15	Maximum allowed relative change in Si28 abundance during an ISE iteration.
180	NEDITQ	20	Make a detailed edit of the ISE zones every NEDITQ general numerical edits.
181	XITER1QE	0.5	If the relative change of the proton, neutron, or Si28 abundance is opposite in sign and more than XITER1QE in magnitude with respect to the corresponding change during the previous ISE iteration cycle, then cut the current step size in half if more than ITER1NSE iterations have been done.
182	ITER1QE	10	(See P 181).
183	XTHRES	1.E-4	Edit only those ISE isotopes with mass fractions exceeding XTHRES.
184	TQSELIM	1.5E+99	A sufficient condition to change a zone from the APPROX to ISE network is if its temperature exceeds TQSELIM, its O16 mass fraction is less than O16LIM, its iron peak mass fraction exceeds QN56LIM, and its density exceeds DQSELIM.
185	O16LIM	0.04	(See P 184).

186	QN56LIM	0.	(See P 184).
187	SNUWMULT	1.	Multiplier on neutrino energy losses from weak processes on nuclei and nucleons. (ISE only)
188	JNSE	0	Change all ISE zones with J<JNSE to the NSE network.
189	SIQSELIM	1.E-3	A sufficient condition to change a zone from the ISE to the NSE network is for the sum of the silicon and sulfur "group" elemental mass fractions to be less than or equal to SIQSELIM.
190	JLCALC	0	Remove the inner JLCALC zones from the problem and reset the inner boundary conditions on radius (RADIUS0 (P 60)) and mass (SUMM0 (P 61)), but don't change the central luminosity (XLUM0 (P 62) -- note default is 0.).
191	VLIMSET	-1.	The ordinate bounds of the velocity graph are ±VLIMSET if VLIMSET > 0. Otherwise the ordinate bounds are rescaled automatically. (cm/s).
192	JPAUSE	-1	Pause the code at the end of the calculation for zone J = JPAUSE in REGESS ("PAUSE 1") and in UPDATE ("PAUSE 2"). Do not pause if JPAUSE < 0. Type a carriage return to continue.
193	FRACRZ0	-1.	(See P 138 and P 150).
194	RZMULTM	1.	(See P 138).
195	FMAXM	1.	(See P 150).
196	EIONMULT	1.	Multiplier on the contribution of ionization potential energy to the equation of state. (See ES).
197	NNEWOUTF	2000	Start a new labeled ascii output file every NNEWOUTF cycles.
198	NEDITQ1	5	Make an ISE edit for the central zone every NEDITQ1 * NEDIT (P 16) cycles.
199	WILSONMT	-1.	Multiplier on the Wilson-based nuclear EOS (except for the thermal ion component) if it is ≥0. Otherwise, the old non-relativistic, partial degeneracy model for the ion EOS is used. WARNING...setting this parameter ≥ 0 appears

			to cause anomalous contributions to the pressure and energy at densities far below nuclear density and probably should not be used without revision. (See subroutine ES).
200	T11CUT	1.	Upper bound on the temperature used to calculate the energy in nuclear excited states and nuclear partition functions (E+11 K units). (See subroutines ES and SDOTQ).
201	Y56GESSM	1.E-4	Initial guess made in SDOT for the Y56 abundance when initializing a new ISE zone (moles/g). If Y56GESSM is within 1.E-3 of 1., the temperature is greater than TQSEMIN, *and* J > 1, then the initial guesses for the proton, neutron, and Fe56 abundances used in the ISE iteration are taken equal to their values in the next innermost zone (which typically is already in ISE).
202	ISI30BRN	1	Neutron-rich-silicon-burning flows are included in the ISE network if ISI30BRN ≥ 1. (See SDOTQ)
203	DQSELIM	1.E+5	Nominal minimum density for changing a zone from the APPROX to the ISE network (g/cc). (See P 184).
204	ABUNMINX	-1.E-5	Force a backup after a call to BURN in SDOT if a calculated elemental mass fraction change would cause the resulting mass fraction to be less than ABUNMINX or to change by a fractional amount greater than TFCYBU. Such backups are made only if the elemental mass fractions involved are greater than YFLOORBX .
205	TFCYBU	0.5	Maximim allowed fractional change in abundance before an abundance backup is made. (See P 204).
206	YFLOORBX	0.001	Elemental mass fraction floor for making abundance backups. (See P 204).
207	IQERRFLG	1	Fatal errors in QBURN encountered during a normal REGESS iteration will cause KEPLER to back-up if IQERRFLG ≥ 1, or to terminate if IQERRFLG < 1.
208	C12AGMLT	1.	Multiplier on the **overall** C12(a,g) rate (APPROX only). This parameter is obsolescent. It is better to use E1MLTC12 P 227) and E2MLTC12 (P 228).
209	XLTAUCON	0.	Don't allow the convective velocity to increase by a factor greater than EXP (DT/(XLTAUCON*TAUCONV)) in one

timestep, where DT is the current timestep and TAUCONV is the timescale for convective mixing (see REGESS and UPDATE). Useful in modeling detonations. (See P 214 for studying deflagrations).

210 NOQSECON 0 — Don't force zones that are convectively coupled to ISE zones to go to ISE if NOQSECON > 0. This parameter should be kept zero unless you *really* understand what you're doing.

211 ACCRATE 0. — Mean rate at which mass in the form of new zones is added to the surface of the star (solar masses per year). The accumulated mass is stored in XMACRETE (P 212) until it is large enough to be added as a whole zone. The surface boundary pressure is gradually increased at a rate proportional to ACCRATE until a mass (in XMACRETE) equal to that in the current outer zone is reached. Then a new zone, the mirror image of the old outer zone, is added. Accretion composition is set by the COMPSURF command in TTYCOM. This prescription will work best for coarse and roughly equal surface zoning.

212 XMACRETE 0. — Mass of phantom outer zone used to mediate mass accretion (g). (See P 211).

213 DENCONV 1.E-7 — Allowed fractional convergence error in density when calculating a hydrostatic initial stellar configuration in the generator using the DSTAT option. (See GENER).

214 FLAMERAD 0. — Characteristic flame radius for carbon deflagration studies (cm). If XLTAUCON > 0 and FLAMERAD > 0, multiply the convective timescale, TAUCON, used to calculate the maximum allowed rate that the convective luminosity can increase (see P 209) by an additional factor of FLAMERAD/RFLAME, where RFLAME is the maximum radius at which a temperature above 2.E+9 K exists. This parameter effectively varies the velocity at which a deflagration can propagate and should be used *only* when studying carbon detonations. Note that larger values of FLAMERAD imply slower deflagration speeds, and that the relationship is not linear.

215 COULMULT 1. — Multiplier on the Wigner-Seitz Coulomb corrections to the ion energy and pressure (See Clayton, p. 152, and ES).

216 IRZOPT 0 — Rezoning Option Flag.

IRZOPT = 1 or ≥ 3: Modify the density gradient considered in adzoning by the factor (ZBAR+1)/ABAR in order to suppress runaway adzoning of the density discontinuities that sometimes form at composition interfaces (esp. H/He).
Note that for a nondegenerate, perfect gas this is equivalent to considering the gradient in the matter pressure instead of in the density when adzoning. Dezoning is not affected.
IRZOPT ≥ 2: Don't adzone across the boundaries of fully convective regions.
IRZOPT ≤ 0. Normal rezoning.
(See REZONE).

217 NSURFZ -10 If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic ramp in zonal mass of the NSURFZ zones at the surface of the star, where FRACSZ0 (P 218) is twice the desired mass-fraction of the surface zone and FRACSZ1 (P 219) is twice the desired mass-fraction of the NSURFZth zone from the surface. Otherwise, NSURFZ has no effect. (See REZONE.)
This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

218 FRACSZ0 1. Inner surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

219 FRACSZ1 1. Outer surface zoning parameter (see REZONE and the discussion under P 217). This is an obsolescent parameter involving an old mass-loss scheme and should not be used without a careful check of the detailed coding in REZONE.

220 XMLOSSM 0. Multiplier on the de Jager mass-loss rate. (See CYCLE and *Ann. Rev. Astron.Astrophys.* **24**, 336 (1986)).

221 XMLOSS0 0. Nominal mass loss rate from the surface of the star (solar masses/year). This constant mass loss rate is added to whatever de Jager-prescription mass loss may have been specified by XMLOSSM (P 220).

222 TOTM0 0. The original total mass of the star (g). This is set during generation and is used in interpreting edit, dump, and rezoning parameters involving stellar mass fractions rather than the current mass of the star (TOTM) which may change

due to mass loss, accretion, etc. Normally, the internally set value of TOTM0 should not be changed by the user.

223 FRACDEZ 0.5 Dezone the mass-losing zone if its mass drops below FRACDEZ times the average mass of the zones on either side of it.

224 XMRATBAK 0.2 Redo the timestep ("backup") if the fractional change of mass in the mass-losing zone exceeds XMRATBAK.

225 XFRACML 0.01 Subtract any "surface" mass loss specified by XMLOSSM (P 220) or XMLOSS0 (P 221) from the zone closest to the surface that still has more than XFRACML*TOTM0 (P 222) grams of material overlying it. This should be set so that mass is not extracted from zones too near the surface in order to avoid excessive dezoning, small timesteps, and luminosity fluctuations.

226 MLCOMPF 0 Obsolete.

227 E1MLTC12 1. Multiplier on the E1 part of the C12(a,g) cross-section (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)

228 E2MLTC12 1. Multiplier on the E2 part of the C12(a,g) cross-section. (affects both APPROX and the the BURN coprocessor, but currently has no effect on the C12(a,g) rate used to calculate photodisintegration flows in ISE.)

229 NUPDATE 100 Do a forced update of BURN isotopic abundances in every zone every NUPDATE cycles.

230 DTFRAC 0.01 When BURN coprocessing is initiated (or when the ZEROTIME or RESET commands are given), (re)set the zonal timesteps used by the BURN coprocessor to DTFRAC*DTNEW (P 1).

231 BMASSMIN -1. BURN coprocessing is skipped if a zone's exterior mass coordinate is less than BMASSMIN (g).

232 BMASSMAX 1.E+99 BURN coprocessing is skipped if a zone's exterior mass coordinate is greater than BMASSMAX (g).

233 BTEMPMIN 1.E+6 BURN coprocessing is skipped if a zone's temperature

			is less than BTEMPMIN (K).
234	BTEMPMAX	1.E+99	BURN coprocessing is skipped if a zone's temperature is greater than BTEMPMAX (K).
235	SNUCMIN	1.E-99	BURN coprocessing is skipped if the absolute value of a zone's normal nuclear energy generation rate (SNN) is less than SNUCMIN (erg/g/s).
236	BDENMIN	1.E-99	BURN coprocessing is skipped if a zone's density is less than BDENMIN (g/cc).
237	BDENMAX	1.E+99	BURN coprocessing is skipped if a zone's density is greater than BDENMAX (g/cc).
238	TCHANGE	.02	Force a zone to be updated by the BURN coprocessor if its fractional temperature change since its last BURN processing exceeds TCHANGE.
239	DCHANGE	.05	Force a zone to be updated by the BURN coprocessor if its fractional density change since its last BURN processing exceeds DCHANGE.
240	NETMAX	1	BURN coprocessing is skipped if a zones's network number, NETNUM, is greater than NETMAX.
241	NEDITB	5	Make a BURN isotopic abundance edit every NEDITB*NEDIT (P 16) KEPLER cycles.
242	EDMASSL	1.E-4	Obsolete.
243	NEDITA	10	Make an elemental abundance edit every NEDITA*NEDIT (P 16) cycles.
244	JMEDITB	1	Edit only zones whose zone number is ≤ JMEDITB during normal BURN isotopic abundance edits.
245	NEDITALL	100	Make a BURN isotopic abundance edit for all zones every NEDITALL*NEDIT (P 16) cycles regardless of the value of NEDITB (P 241).
246	CHIMIN	1.E-6	Minimum isotopic abundance that affects the calculation of the zonal timestep in the BURN coprocessor (moles/g).
247	DELCHI	.15	Maximum desired fractional change of an isotopic abundance

			used in determining the zonal timestep used in the BURN coprocessor.
248	FDTN	2.	Maximum factor by which the zonal timestep in the BURN coprocessor can be increased in one zonal cycle.
249	DTBKUP	.5	Back up to the previous zonal cycle in the BURN coprocessor if the new zonal timestep is less than DTBKUP times the previous timestep.
250	NCOMP	999999	Make a complete ascii edit of the nuclear processes in all zones considered by the BURN coprocessor every NCOMP cycles.
251	NCENT	999999	Make an ascii edit of the nuclear processes in the central zone considered by the BURN coprocessor every NCENT cycles.
252	NEDT	999999	Make an ascii edit of the nuclear processes involved every nedt BURN coprocessor matrix inversions (debugging only).
253	NZRO	1	Set newly calculated negative BURN isotope abundances to 0. if NZRO not equal to 0.
254	AMAGLIM	0.	Minimum absolute magnitude of a BURN matrix element for which Gauss-Jordan elimination is carried out in solving for changes in isotopic abundances.
255	NINV	0	Total number of BURN-coprocessor matrix inversions so far (internally incremented).
256	NBKUP	0	Total number of BURN-coprocessor backups so far (internally incremented).
257	NTTY	6	FORTRAN I/O unit number for messages sent to the user's terminal.
258	IRATSTOP	-1	Pause while updating zone IRATSTOP if IRATSTOP > 0. Type return to continue.
259	NEGBKUP	0	Cumulative number of BURN coprocessor backups due to encountering negative isotopic abundances (incremented internally).
260	BKUPDIV	10.	Factor by which to reduce the BURN coprocessor zonal timestep when a negative isotopic abundance backup occurs.

261	BKUPMASS	1.E-13	Minimum absolute magnitude of a negative isotopic abundance (except of protons) that can cause a zonal backup in the BURN coprocessor (moles/g).
262	BKUPMP	1.E-19	Minimum absolute magnitude of a negative proton abundance that can cause a zonal backup in the BURN coprocessor (moles/g).
263	NBKUPMAX	10	Maximum number of consecutive negative isotopic abundance backups allowed in the BURN coprocessor before quitting.
264	NSUBCYCM	1	Number of coupled BURN coprocessing / BURN isotope convection subcycles per KEPLER cycle.
265	MAZFUL	1	Use Fuller et. al.'s weak rates in the BURN coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek and Hansen.
266	AL26MULT	100.	Decrease the abundance threshold for Al26 to affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to CHIMIN/AL26MULT.
267	INBURN	0	BURN coprocessing and related edits are done only if INBURN > 0. Note that INBURN is set to 1 by subroutine GENBURN if a BURN generator deck has been specified in the regular generator deck or by command GENBURN. It is an internal flag and should not be changed by the user, except to permanently turn off BURN coprocessing in a problem.
268	NPAGE	53	Number of lines printed per "page" of ascii output. The value 53 causes zone lists to be printed in 50-zone blocks.
269	NSAVEZ	24	Total number of nonBURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with YM and numbering NZONEI + NZONEC in total. NSAVEZ must be at least 14 and no greater than NZONEI + NZONEC. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.
270	NSAVEB	10	Total number of BURN zonal arrays to save in restart dumps. These arrays are listed in KEPCOMS, starting with NETNUMB and numbering NZONEB in total. NSAVEB must be at least 6 and no greater than NZONEB. Saving more than the minimum number of arrays needed to restart the problem is often useful for edit purposes.

271	VLOSS	1.E+99	Remove the outer zone if its velocity exceeds VLOSS, but do not change the previous values of PBOUND (P 69) or TBOUND (P 68) (cm/sec).
272	ABUNLIMB	1.E-5	Edit only those BURN isotope mass-fractions whose values exceed ABUNLIMB in making terminal edits (including isotopic mass-fraction sums over zones).
273	SCALEM	1.9892E+33	Mass unit used for the mass coordinate employed in making ascii and terminal edits (g).
274	NEDITZ1	10	Make an ascii edit of primary zonal quantities every NEDITZ1*NEDIT (P 16) cycles.
275	NEDITZ2	20	Make an ascii edit of secondary zonal quantities every NEDITZ2*NEDIT (P 16) cycles.
276	MEDIT	0	Flag determining the minimum amount of information printed in an ascii cycle edit regardless of the settings of other edit parameters: ≤ 0 means minimum is a 1 page "short" edit; ≥ 1 means minimum includes a primary zonal edit; ≥ 2 means minimum includes a secondary zonal edit; ≥ 3 means minimum includes an ion abundance edit; ≥ 4 means minimum includes an ISE abundance edit; ≥ 5 means minimum includes a BURN isotope edit; ≥ 6 means minimum includes a BURN isotope edit for all zones; ≥ 7 means minimum includes a parameter edit.
277	MEDITFIN	7	Effective value of MEDIT (P 276) used in determining the scope of the final edit made when the problem is finished.
278	NEDITP	50	Make an ascii edit of all changeable parameters every NEDITP*NEDIT (P 16) cycles.
279	FLAMVA	0.	If FLAMVA ≠ 0., the current problem is a study of a carbon deflagration in a white dwarf. The current radius of the deflagration flame is taken as the radius of the outermost zone where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283) by KEPLER. The outward speed of the flame is controlled by adjusting the opacity for heat conduction between

zones JFLAM and JFLAM + 1 up or down by a factor, XKAPFLAM (P 284), between 0. and 1. Such "gating" is performed in KAPPA and UPDATE and sets the velocity of advance of the 2.E+9 K temperature front to a comoving value that averages:

VFLAME =

VCOND * (RFLAME / XLAMBMIN)**(FLAMVB - 2.),

where: XLAMBMIN = 4π * VCOND**2 / GEFF and VCOND is FLAMVC (P 281) times the heat conduction velocity (given by 1.E+5*(dn(j+1)/2.E+9)**FLAMVE (P 347)), RFLAME is the current radius of the flame front, and GEFF is FLAMVA times the acceleration of gravity at the flame front. The calculated flame velocity is bounded below by VCOND and above by FLAMVD (P 282) times the speed of sound behind the flame front.

Basically the flame front wrinkles as it propagates in a fractal manner and the extra area it thus enjoys causes the flame to burn the entrained material more rapidly. See CYCLE for more details.

FLAMVA would typically be set to a value about 0.2 corresponding to a 20% delta-rho/rho across the burning front to study "plausible" carbon deflagrations using this model.

280 FLAMVB 2.6

Fractal exponent helping determine the relationship between the velocity of heat conduction and the velocity of the carbon deflagration flame based on its degree of "wrinkling." FLAMVB is equivalent to the fractal dimension of the burning front which is 2. for a smooth surface, 2.7 corresponds to fully developed turbulence, and 3. corresponds to filled space.

281 FLAMVC 50.

Multiplier on the heat conduction velocity used to calculate the velocity of the carbon deflagration front. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use. The default value of 50 corresponds to the laminar flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc.

282 FLAMVD 1.

The velocity of the carbon deflagration flame front is limited to FLAMVD times the local sound speed. (See the discussion for FLAMVA (P 279)).

283 JFLAM 0

The zone where the carbon deflagration flame is currently located. This parameter is internally set by KEPLER to be the outermost zone whose temperature exceeds 2.E+9 K and its value should not be changed by the user.

284	XKAPFLAM	0.001	Carbon deflagation opacity gating factor. Must be > 0. and <1. See the discussion given for FLAMVA (P 279) for a more detailed explanation of its use.
285	XMFLAM	0.	The mass in the current carbon deflagration flame-front zone JFLAM (P 283) that has already been burned (g). This parameter is set internally by KEPLER and should not be changed. When the entire mass of zone JFLAM (P 283) has been burned the opacity coupling it to zone JFLAM + 1 is changed from being divided by XKAPFLAM (P 284) to being multiplied by it. This causes the flame front to advance to the next zone. See the discussion given for FLAMVA (P 279).
286	TAUNU	0.	Time scale for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (sec).
287	ENU53	3.	Total energy (in units of 10**53 ergs) for the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse.
288	TMUNU	8.	Temperature of the mu and tau neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
289	TENU	4.	Temperature of the electron neutrinos in the neutrino pulse considered by the BURN coprocessor in calculating neutrino-induced nucleosynthesis after core collapse (MeV).
290	NOILAND	1	If NOILAND > 0, prevent separated islands of zones employing the ISE network from developing by not letting zone J go to ISE unless zone J - 1 has already done so.
291	CHARSIZG	1.0	Graphics character size for grid labels (relative to MONGO's default character size).
292	CHARSIZC	0.85	Graphics character size for curve labels (relative to MONGO's default character size).
293	CHARSIZZ	0.85	Graphics character size for zone sentinels (relative to MONGO's default character size).
294	CHARSIZH	1.0	Graphics character size for header info (relative to MONGO's default character size).

295	WIDTHTD	60.	Obsolete.
296	IBACKGND	-1	Graphics window background color is white if IBACKGND ≥ 0 and black if IBACKGND < 0. The foreground color is always the inverse of the background color.
297	DSCALEM	1.9892E+33	Mass units used for the internal mass coordinate, YMASS, used for dumping purposes (g). -- See subroutine DUMPQ.
298	NGRIDMIN	10	Minimum number of points allowed in a dump grid. See DUMPQ.
299	NCYCQQ	5	Number of KEPLER cycles between post-processor dump cycles (i.e.. calls to DUMPQ).
300	LENTRACK	16384	Length of the track(s) assigned to each dump variable in the post-processor dump(s) (bytes). See DUMPQ.
301	IDTMAXL	40	Maximum number of post-processor dump cycles beyond the currently-specified dump cycle (LTIME) that READQ will search to try to get values for each point in the 'advanced' grid formed from dump variable values at or beyond LTIME. In PLOTMAP, IDTMAXL is used as a flag for the plot and interpolation mode to be used: if IDTMAXL = 0, strips of retarded-value rectangles are plotted, based on the reconstructed grids (best for very discontinuous variables, esp. CONVECT). if IDTMAXL = 1, forward and backward facing triangles are plotted for each dump point. These triangles have a uniform color determined by the value at their most retarded vertex (best for moderately discontinuous variables, such as abundances). if IDTMAXL > 1, forward and backward triangles are plotted for each dump point which are Gouraud-shaded to interpolate between the variable values at each corner (fastest and smoothest for continuous variables, worst for discontinuous variables).
302	IDTLOOK	10	Default number of post-processor dump cycles between LOOK plots or prints or reconstructed TIMEMAP grids.
303	BACKFACQ	0.5	If the fractional change in a dump variable since the last dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also dump the old value of that variable at the previous (dump cycle)

time point, where RATZDUMP(IDAT) is the (previously specified) maximum allowed fractional change between dumps of this zonal dump variable (indexed by IDAT). See Chapter 2 on Generator Input.

304 TEMPSTOP 1.E+99 Terminate the problem when the central temperature reaches TEMPSTOP (K).

305 DENSTOP 1.E+99 Terminate the problem when the central density reaches DENSTOP (g/cc).

306 VINSTOP 1.E+99 Terminate the problem when the infall velocity exceeds VINSTOP (cm/sec). Note that positive values of VINSTOP correspond to negative (infalling) velocities. Before terminating the problem, make a restart dump labeled '#presn' and execute the alias-defined "presn" command. Normally this command is used to make final plots and edits.

307 O16STOP -1. Terminate the problem when the O16 mass-fraction drops below O16STOP provided the central temperature exceeds TQSELIM (P 184). Basically this corresponds to a time near the end of core oxygen burning for values of O16STOP about 0.05.

308 TIMEZMS 1.E+99 Time (sec) at which to make zero-age-main-sequence parameter changes and a restart dump labeled '#zms'. TIMEZMS is typically set to 1.E+12 sec.

309 IZONEZMS 1 Reset the value of IZONEF (P 86) to IZONEZMS at the time specified by TIMEZMS (P 308).

310 Q1FACZMS 0.1 Reset the value of Q1FAC (P 13) to Q1FACZMS at the time specified by TIMEZMS (P 308).

311 TEMPCIG 1.E+99 Central temperature (K) at which to make the pre-carbon-ignition parameter changes and a restart dump labeled '#cig'. TEMPCIG is typically set to 5.E+8.

312 YFLRXCIG 0.003 Reset the value of YFLOORX (P 47) to YFLRXCIG when the central temperature specified by TEMPCIG (P 311) is reached.

313 FMAXMCIG 1. Reset the value of FMAXM (P 195) to FMAXCIG when the central temperature specified by TEMPCIG (P 311) is reached.

314 FMAX0CIG 1. Reset the value of FMAX0 (P 150) to FMAX0CIG when the

central temperature specified by TEMPCIG (P 311) is reached.

315	TOFFSET	0.	Cumulative amount of time by which the problem time has been offset by ZEROTIME commands (sec). In other words, TOFFSET should be added to the current problem time to get the actual time since the beginning of the problem. Normally, TOFFSET is reset internally when the ZEROTIME command is issued and should not be reset by the user.
316	ABUNMINB	1.E-4	Lower mass-fraction limit of the isotopic abundance plot.
317	ABUNMAXB	1.	Upper mass-fraction limit of the isotopic abundance plot.
318	NUMISO	0	Number of BURN isotopes to be plotted, starting from the first one listed by the most recent SETISO command. Normally NUMISO is set to the total number of isotopes listed in the SETISO command at the time that command is processed and does not need to be set by the user.
319	TIMEREF	-1.E+99	Reference time used in calculating the time coordinate in timeplots and timemaps (sec). If TIMEREF < -1. E+98, then a time 10 timesteps beyond the last timepoint is used in its place.
320	TOSETREF	0.	Reference offset time used in calculating the time-coordinate for timeplots and timemaps (sec). If TIMEREF < -1. E+98, then the value of TOFFSET prevailing for the last timestep is used for TOSETREF.
321	TIMECMIN	0.	Minimum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
322	TIMECMAX	0.	Maximum value of the time-coordinate to be plotted in timeplots and timemaps (time coordinate units--see P 327). If both TIMECMIN (P 321) = 0 and TIMECMAX (P 322) = 0, all available time-points will be plotted.
323	YEMAX	0.498	Maximum value of Ye allowed when initializing a new ISE zone (moles/g). This simulates the small amount of neutronization that usually occurs before the end of oxygen burning.
324	ABARSEMI	4.	Value of the zonal mean atomic weight, ABAR, used to divide the star into two regions with separately specifiable values of the semiconvective mixing rate and the overshoot mixing coefficient

(g/mole). (See the definitions of DRMULT (P 24), WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)).

325 DRMULTLO DRMULT Semiconvective mixing will be slower than thermal transport by at least DRMULTLO (about 0.1) in zones where the mean atomic weight, ABAR, is below ABARSEMI (P 324). (See UPDATE and discussion of DRMULT (P 24), WOVERSHT (P 148), and WOVERSLO (P 326)).

326 WOVERSLO WOVERSHT The semiconvective test parameter, W, is taken to be W=WOVERSLO*ABS(LOG(T1/T0)) for the special overshoot semiconvective zones where W would otherwise be less than 0 and when ABAR < ABARSEMI (P 324). Overshoot mixing occurs at a rate calculated from this value of W, but is limited by the thermal diffusion timescale as in normal semiconvection. (see UPDATE & WZW78). If WOVERSLO=0 no overshoot mixing is done. (Also see WOVERSHT -- P 148).

327 MAPTIME 2 Flag indicating the desired time coordinate in timeplots and timemaps (see PLOT and TIMEMAP):
0 => use cycle number;
1 => use linear time (sec);
2 => use negative logarithmic time (-log (sec)).
3 => use positive logarithmic time (log (sec)).
Note that the time coordinate is calculated relative to TIMEREF (P 319) + TOSETREF (P 320).

328 VMINMAP 1.E+99 Minimum value of the timemap variable to be mapped. If VMINMAP > 1.E+98, then the actual minimum value of the current variable is used as the map limit, except as limited by VRATMAP (P 330), below.

329 VMAXMAP -1.E+99 Maximum value of the timemap variable to be mapped. If VMAXMAP < -1.E+98, then the actual maximum value of the current variable is used as the map limit.

330 VRATMAP 1.E-99 Minimum ratio of the minimum timemap variable limit to the maximum timemap variable limit in the case when the actual minimum value of the current timemap variable would otherwise be used as the minimum timemap limit.

331 TEMPCDEP 1.E+99 If the central temperature is ≥ TEMPCDEP, then make a restart dump labeled '#cdep', execute the alias-defined "cdep" command, and reset TEMPCDEP to 1.E+99.
Normally, this parameter is used to reset certain parameter values following carbon depletion.

332 O16ODEP -1.E+99 If the central oxygen abundance is ≤ O16ODEP *and* the central temperature is ≥ TQSELIM (P 184), then make a restart dump labeled '#odep', execute the alias-defined "odep" command, and reset O16ODEP to -1.E+99.
Normally, this parameter is used to reset certain parameter values at oxygen depletion.

333 TEMPCHAR 1.E+99 If the central temperature is ≥ TEMPCHAR, then make a restart dump labeled with '#tn' and the current cycle number, reset TEMPCHAR to 1.E+99, and *finally* execute the alias-defined "tnchar" command.
Note that the user -defined "tnchar" command can change the value of TEMPCHAR in such a way as to cause the "tnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

334 DENCHAR 1.E+99 If the central density is ≥ DENCHAR, then make a restart dump labeled with '#dn' and the current cycle number, reset DENCHAR to 1.E+99, and *finally* execute the alias-defined "dnchar" command.
Note that the user -defined "dnchar" command can change the value of DENCHAR in such a way as to cause the "dnchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

335 ABARCHAR 1.E+99 If the central mean atomic weight (ABAR) is ≥ ABARCHAR, then make a restart dump labeled with '#ab' and the current cycle number, reset ABARCHAR to 1.E+99, and *finally* execute the alias-defined "abchar" command.
Note that the user -defined "abchar" command can change the value of ABARCHAR in such a way as to cause the "abchar" command to be issued recursively (i.e., by using the command: "**P** *N DELTA* **ADD**" -- see Chapter 5).

336 ZONEMMIN 1.E-99 ZONEMMIN is the minimum mass (g) that a zone may have and still be allowed to be adzoned (as part of a zone pair).

337	ICALCNE	0	Calculate more accurate electron densities in partially ionized regions if ICALCNE > 0 using Lisa Ensman's multiple-ion, Saha equilibrium subroutine, CALCNE. Generally this more accurate, but very time-consuming routine is turned on just before shock-breakout while doing supernova light-curve calculations.
338	XNECONV	1.E-05	Maximum allowable fractional convergence error in the electron density calculated by subroutine CALCNE (see P 337).
339	IONFLAG	0	If IONFLAG ≤ 0 and the density and temperature have changed by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154), respectively, since the last iteration, then extrapolate the value of the electron density from its partial derivatives with respect to density and temperature instead of calling CALCNE (when ICALCNE > 0 -- see p 337), unless this is the first iteration. Otherwise call CALCNE all the time, provided ICALCNE > 0.
340	XNEMIN	1.E-05	Minimum mass fraction for which an element is included in the calculation of Saha ionization equilibrium done in subroutine CALCNE (see P 337).
341	XKAPGAM	0.054	Assumed effective opacity (cm^2/g) for the deposition of gamma ray energy from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38).
342	EGAMP	0.60	Dimensionless correction factor used in calculating the escape of gamma rays from the radioactive decay of Ni56 and Co56, as controlled by TIMEX0 (P 38). See subroutine SDOT for details.
343	TSHOCK	1.E+99	If the problem time is ≥ TSHOCK, then make a restart dump labeled '#shock', reset TSHOCK to 1.E+99, and *finally* execute the alias-defined "tshock" command. Normally, this command is used to reset certain parameter values and/or make edits at the time of the piston-induced bounce of the collapsing iron core that creates an out-going shock wave.
344	TNUCLEO	1.E+99	If the problem time is ≥ TNUCLEO, then make a restart dump labeled '#nucleo', reset TNUCLEO to 1.E+99, and *finally* execute the alias-defined "tnucleo" command. Normally, this command is used to reset certain parameter values and/or make edits at a time just after explosive nucleosynthesis is complete.

345	TENVEL	1.E+99	If the problem time is ≥ TENVEL, then make a restart dump labeled '#envel', reset TENVEL to 1.E+99, and *finally* execute the alias-defined "tenvel" command. Normally, this command is used to reset certain parameter values and/or make edits just before the supernova shock wave breaks through the surface of the presupernova star.
346	NFIRSTQ	0	Default value of the first cycle to be read or plotted in making post-processor edits, time plots, or timemaps. Note that this parameter is reset by the NEWDUMPS command to the current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ) so that KEPLER will not try to read old dumps.
347	FLAMVE	0.805	Density power dependence of the heat conduction velocity used in calculating the velocity of nuclear deflagrations in Type I supernovae. (0.805 for C/O, 1.06 for Ne/O) See P 279-285 and subroutine CYCLE for details.
348	BINM10	TOTM0	The initial mass of the star being evolved (primary) in solar masses that is used in calculating the possibility of mass loss to a binary companion, following the formalism of Podsiadlowski, Joss, and Hsu, ApJ, 391, 246, (1992). The star loses mass when its radius exceeds its Roche radius, with a power-law cutoff to avoid numerical discontinuities. The formalism also involves parameters 349 - 354, defined below. See subroutine CYCLE.
349	BINM20	0.	The initial mass of the binary companion star (in solar masses) used in calculating the possibility of binary mass transfer. No mass transfer is performed if BINM20 ≤ 0. See P 348.
350	BINALP	1.	PJH's alpha parameter, related to the angular momentum of the mass lost in binary transfer. See P 348.
351	BINBET	1.	PJH's beta parameter. Fraction of the total mass spilling over from the Roche lobe of the primary that is transferred to the secondary rather than being lost from the system. BINBET equals 1. for conservative binary mass transfer.
352	BINA0	2.	Initial binary separation in AU used in calculating the possibility of binary mass transfer. See P 348.
353	BINMDT	1.E-3	Mass loss rate due to binary mass transfer assumed when the primary stars exceeds its Roche radius (solar masses per year).

See P 348.

354 ROCHER 1.E+99 Current Roche radius (cm). This is a calculated quantity and should normally not be changed by the user. See P 348.

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DRAFT

CHAPTER 5

TERMINAL INPUT

GENERAL

All terminal input is in the form of space delimited words. All normal floating point and fixed point formats are recognized (termed "field-free" format). Floating point numbers must be distinguished from integers by a decimal point or exponent. All actual communication with the computer should be made in lower case and character parameters are never enclosed in quotes.

STARTING AND RESTARTING

KEPLER is initiated by typing:

KEPLER *NAMEP NAMEG/Z* [*OPTIONS*]
e.g.: ' **kepler s25s2a s25s2ag s** '

KEPLER is the version of KEPLER which is to be run. Possible choices include:
kepler.....The most tested current 'floor' version of KEPLER,
keplerx.....The less tested, but 'new and improved,' experimental version, or
kepler.*ddmmmyy*... An old version of KEPLER made on ***ddmmmyy***, e.g. ' **kepler.13apr91** '
On UNIX machines, **kepler** and **keplerx** are stored in **/usr/local/bin**, while old versions of KEPLER are archived in **/usr/local/bin/oldkep** on the General Studies ('P') Group Silicon Graphics UNIX computer **leonardo** (Internet address 128.115.10.33).
The version used for a given run and its date are recorded at the beginning of each ASCII output file.

NAMEP is the ≤ 8 character name given to the current problem. This name is also used to begin the names for various output and dump files created during this problem (see below).

NAMEG/Z is a ≤ 16 character name of either a generator file (in which case its name **must** end in ' **g** ' (e.g., ' **s25s2ag** '), or a restart dump (in which case its name **must not** end in ' **g** ' (e.g., ' **s25s2az** ' or ' **s25s2a#10350** ' or ' **s25s2a#presn** ').

Special Cases:	**Meaning:**
g.....	To generate from file *NAMEP*//'g'.
z.....	To restart from file *NAMEP*//'z'.
p.....	To restart from file *NAMEP(with last character deleted)*//'#presn'.

OPTIONS (optional) is a set of one or more space delimited words in arbitrary order chosen from among the following possibilities:

Option:	**Meaning:**
s.....	To suspend the code after starting.
d.....	To destroy the ASCII output files after sending them to the microfiche printer (not currently implemented -- see also the discussion of parameter IAUTOOUT (P 159) given in Chapter 4).
h.....	To automatically make a paper copy of the ASCII output files (not currently implemented).

INITIAL OPERATION

In the absence of any *OPTIONS*, the code will begin calculations immediately and keep its ASCII output files on disk. It will either generate from cycle 0 if *NAMEG/Z* is the name of a valid generator file (see Chapter 2) or restart a previous problem if *NAMEG/Z* is the name of a restart dump compatible with this version of KEPLER. The code will attempt to restart from restart dumps created by older versions of KEPLER by setting any newly added parameters to their default values, and printing warning messages concerning possible incompatibilities. Such compatibility, however, is **not** guaranteed, and it is the user's responsibility to carefully check whether such a restart operation has been performed correctly (see subroutine RESTART). If equation of state routine changes have been made in the interim, the **NEWE** or **EOSTRANS** commands (see below) may be helpful.

REQUIRED INPUT FILES

The current working directory must contain the specified compiled version of KEPLER or (more desirably) a PATH specification to **/usr/local/bin** or **/usr/local/bin/oldkep**, where such files are likely to be located. The named generator or restart file must also be physically resident in the

current directory, as must any BURN generator file specified in the generator file (see Chapter 2).

If BURN co-processing has been specified, the directory in which KEPLER is run must also contain the file BDAT, which contains the needed nuclear cross-sections for detailed isotopic networks. This file should be stored as **/usr/local/bin/bdat** and can be soft-linked to the current working directory by the command ' **ln -s /usr/local/bin/bdat bdat** '.

The 'qlib' library file and the 'qq' post-processor dump file corresponding to the named restart dump (see below for definitions) are also required for restarting a problem making post-processor dumps. Note that KEPLER will overwrite information generated by the previous problem for duplicated cycles. Post-processor dump files not containing the restart cycle may also be in the working directory, but are not required.

POST-PROCESSOR FILES

If post-processor dumps have been requested in the generator file (or less desirably initiated by a command from the terminal), KEPLER will create a ('qlib') library file with a name in the form *NAMEP*.**lib** (e.g. ' **s25s2a.lib** ') which maintains a record of zonal mass coordinates and stores a time history of the time edit variables. A series of post-processor dump ('qq') files are also created starting with a file named in the form *NAMEP*.**qa** (e.g. ' **s25s2a.qa** ') which stores a compressed time history of the dump variables specified by **DUMP** commands or generator cards. These files are updated every NCYCQQ (P 299) cycles. The 'qlib' library file can store information for up to 20,000*NCYCQQ KEPLER cycles and up to 17,999 distinct grid points before becoming full. For ease in handling, however, the post-processor dump files are limited to a size of LENQMAX (P 44) whose default value is 3,000,000 bytes. New post-processor dumps will be created as required with suffixes in the sequence: **.qa, .qb,.... .qz, .q0... .q9, .ra, .rb,.... .rz, .r0... .r9**, etc.

The qlib library file must always stay on-line while the problem it corresponds to is running, but all but the most recent post-processor dump ('qq') files may be stored elsewhere if disk space is a problem. This will limit the range of possible **LOOK** and **TIMEMAP** commands (see below), however.

RESTART DUMP FILES

KEPLER will create a running restart ('z') file named in the form *NAMEP***z** (e.g. ' **s25s2az** '), which it overwrites every NDUMP (P 18) cycles. It will also create labeled restart dumps with names in the form *NAMEP#NCYC* (e.g. ' **s25s2az#12750** ') every NDUMP*NSDUMP (P 156) cycles, where where *NCYC* is the current cycle number. If a file with the name *NAMEP#NCYC* already exists, it will be overwritten.

ASCII OUTPUT FILES

KEPLER will also create ASCII output files with names in the form *NAMEP_NCYC0* (e.g. : ' **s25s2az_0** '), where *NCYC0* is the cycle number at which the problem is being generated or restarted. To prevent such files from becoming too large, however, the current output file is closed whenever MOD (NCYC, NNEWOUTF (P 197)) = 0 (by current default every 2000 cycles) and a new output file with a name in the form *NAMEP_NCYC* (e.g. : ' **s25s2az_2000** ') is created. Both of these types of ASCII output file will overwrite any file by the same name that might already exist.

DUMP-GRID STATUS FILES

If post-processor dumps are being made, KEPLER will also alternately create, read, and destroy files with names in the form *NAMEP.***0** and *NAMEP.***1** (e.g. : ' **s25s2a.0** ' and ' **s25s2a.1** ') which contain information about the grids currently being used to represent each requested dump variable. This reduces the size of the KEPLER executable file at the cost of some extra files on disk. If for any reason (restart, disk crash, etc.), these files are not available, KEPLER will automatically generate a new set of dump grids along with a warning message. This is not really a problem except that it takes up a little extra space in the post-processor dumps.

INTERACTIVE KEYBOARD COMMANDS

At the beginning of each cycle, the code checks for and executes commands that the user may have typed during the cycle. If it is in "stepping" mode (see the S command below), it acknowledges completion of the command with a '.' which serves as a prompt for the next command. If the code is in normal running mode, command completion is acknowledged by an **'ok'** and code execution continues. **'oops!'** is returned if the command can't be understood or if an argument has an inappropriate value, and code execution (or suspension) is continued.

Interactive keyboard commands may be entered more than one to a line by using commas as delimiters. The resulting construct is termed a "'keyboard message." The keyboard message may be up to 80 characters long and may contain any possible number of comma-delimited command lines, which are executed sequentially. Except as noted below, words representing input character variables are truncated to 8 characters, while numerical input is "field-free," except that floating point numbers must be distinguished from integers by a decimal point or exponent. The number of blank-delimited symbol(s)/word(s) in the current command line is limited to a maximum of 60.

Allowed interactive keyboard commands are listed below. Each command keyword is given in bold capital letters, followed by its arguments, if any, in italic capital letters. For the more complex commands, an example printed in boldface characters and enclosed in quotes is given, which also serves to indicate the type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case and that character parameters are never enclosed in quotes.

NORMAL PROGRAM MANAGEMENT COMMANDS

Here *J, N and M* stand for integers corresponding to allowed zone number where $N > M$; *IONSYM* is the ASCII symbol for one of the 'ions' in the APPROX, ISE or NSE networks, *ISOSYM* is the ASCII symbol for one of the isotopes in the current BURN coprocessor network, and *REACSYM* is the ASCII symbol for the editable nuclear reaction rates. A more detailed explanation of the edits that result from some of these commands is given in Chapter 9.

Command: **Meaning:**

D..... Force the restart dump to be updated to the current cycle.

D *NAME*..... Make a restart dump called *NAME* at the current cycle.

Normal Program Management Commands (Cont.)

E..... Make a current energy edit on the terminal.
ED..... Force an edit of the current cycle to be written in the Ascii output file.
ED *M*..... Force an edit with MEDIT (P 276) = *M*
EDP..... Force a parameter edit for the current cycle to be written in the output file.
END..... Terminate the problem.
FIN..... Same as **END**.
G..... Resume normal calculations after a suspension.

J ..... Make a current edit for zone *J* on the terminal.
J **I**..... Make a current edit of ion mass fractions for zone *J* on the terminal.
J **I** *IONSYM* ..... Edit the mass fraction of ion type *IONSYM* on the terminal.
J **B**..... Make an edit of BURN isotope mass fractions for zone *J* on the terminal.
J **B** *ISOSYM* ..... Edit the mass fraction of BURN isotope type *ISOSYM* on the terminal.
J **Q**..... Make a QNSE edit for zone *J* on the terminal.

SUMB *M N*..... Display an edit of the mass of all BURN isotopes in zones *M* thru *N* (M_O).
SUMB *M N ISOSYM*... Display an edit of the mass of burn isotope *ISOSYM* in zones *M* thru *N* (M_O).
SUMI *M N*..... Display an edit of the mass of all ions in zones *M* thru *N* (M_O).
SUMI *M N IONSYM*... Display an edit of the mass of ion *IONSYM* in zones *M* thru *N* (M_O).

P *N*..... Display the value of parameter name or number *N*.
P *N VALUE*..... Change the value of parameter name or number *N* to *VALUE*.
P *N DELTA* **ADD**..... Add *DELTA* to the value of parameter name or number *N*.
Q *N*..... Display the value of 'edit' parameter name or number *N*.

S..... Suspend execution, or step one cycle if suspended.
S *N*..... Run the problem for *N* more cycles, then suspend

T..... Make a current time edit on the terminal.
TED..... Display a 'short' ASCII edit on the terminal.
TED *M*..... Display an ASCII edit on the terminal with MEDIT (P 276) = *M*.
TIME..... Make an edit of computer time usage (in seconds).
TN..... Make a nuclear reaction rate edit on the terminal (moles/s -- over whole star).
TQ..... Make a combined time and surface edit on the terminal.

OTHER TERMINAL EDIT COMMANDS

EDITISO *[JINNER [JOUTER]]*
EDISO *[JINNER [JOUTER]]* (abbreviated form)
' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

TEST *TESTVAR J T D*
' test p 1 3.E+9 2.E+7 '

Gives a terminal edit of quantity *A* for the materials in zone *J*, but at the temperature *T* (K) and density *D* (g/cc) specified. *TESTVAR* is a variable symbol which may be any one of the following:

k..... Opacity (cm**2 /g).
s..... Energy Production Rate (ergs/g/s).
p..... Pressure (erg/cc).
e..... Energy (erg/g).

TN *REACSYM*
' tn he3+he4 '

Make an edit of the total rate of nuclear reaction *REACSYM* on the terminal.
Allowed values for *REACSYM* are:

p+p	**he3+he3**	**he3+he4**	**c12(pg)**	**n14(pg)**	(1-5)
o16(pg)	**3a-c12**	**n14(ag)**	**c12(ag)**	**c12+c12**	(6-10)
c12+o16	**o16+o16**	**o16(ag)**	**ne20(ag)**	**mg24(ag)**	(11-15)
si28(ag)	**s32(ag)**	**ar36(ag)**	**ca40(ag)**	**ti44(ag)**	(16-20)
cr48(ag)	**fe52(ag)**	**fe52:2ng**	**fe52:a2p**	**fe54:2pg**	(21-25)
he4-2n2p	**p(e-nu)n**	**n(e+nu)p**	**weak**		(26-29)

Here **p** denotes a proton; **n**, a neutron; **a**, an alpha particle; **g**, a gamma-ray; **nu**, a neutrino; and **ecap**, the rate for electron capture (ISE zones only). The values edited are the total net rates (forward-back) summed over the whole star (in moles/s).
**add reference by reaction number

Other Terminal Edit Commands (Cont.)

V *EDITVAR* [*JMIN* [*JMAX*]]

' v ionye 1 100 '

To make a terminal edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VERSION

Type out information about the dates on which the current code modules were last modified.

VF *EDITVAR* [*JMIN* [*JMAX*]]

' vf ionye 1 100 '

Same as the V command except that edited values are given to 14 decimal places instead of 3.

Z *EDITVAR1* [*EDITVAR2....EDITVAR10*] [*JMIN* [*JMAX*]]

' z dn tn sige sigi sigr 1 100 '

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX*. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

OTHER ASCII-OUTPUT-FILE EDIT COMMANDS

EDITISO *[JINNER [JOUTER]]*
EDISO *[JINNER [JOUTER]]* (abbreviated form)
' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

EOSTABLE *JJ TLOW THI NTEMP DLOW DHI NRHO*
' eostable 1 1.E+6 1.E+9 20 1. 1.E+6 30 '

Using the composition from zone *JJ*, a table of EOS and opacity information is written into the normal ASCII output file for a logarithmic grid of temperatures (from *TLOW* to *THI* with *NTEMP* + 1 grid points) and densities (from *DLOW* to *DHI* with *NRHO* + 1 grid points). Here *TLOW* and *THI* are in degrees K and *DLOW* and *DHI* are in g/cc.

EOSTRANS *TRANSMULT*
' eostrans 1. '

Add *TRANSMULT* times the energy in nuclear excited states to all zonal specific energies. Useful in certain EOS transitions.

EOSWRITE *JTAB JJ NTEMP NRHO NEOSM*
' eoswrite 626 1 20 30 10 '

This command writes an EOS table identified by EOS # *JTAB* based on the composition of zone *JJ*, and having *NTEMP* temperature points and *NRHO* density points. This file is written after the last entry in ASCII file EOSKEP. If file EOSKEP does not exist, it is created with a sufficiently large size to contain *NEOSM* table sets. Before the **EOSWRITE** command is used, the TZ array must be set by the **TVAL** command so that it contains the *NTEMP* temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc). *NRHO* and *NTEMP* can sum to at most NTEMPZ (a parameter in KEPCOMS currently set to 60).

WARNING, WARNING, WARNING.....this command is no longer supported -- see version **.tw:kepn:kepn3/25** for the old coding if you want to try to revive it, but see **EOSTABLE** first.

Other Ascii-Output-File Edit Commands (Cont.)

LINKEDIT

Make an ascii file containing terse information on structure and composition, e.g. for linking a presupernova model to Wilson (or others). File name will be in the form probname@cyclenumber.

TVAL *N VAL1 [VAL2 VAL3 ..... VAL10]*

' tval 1 .1 .3 1. 3. 10. 30. 100. '

This command sets values in the temporary array TZ such that TZ(*N*), TZ(*N* + 1), ...etc. are respectively reset to *VAL1, VAL2,*...etc. At least one, and up to 10 values may be specified on each line. This command can be used (repeatedly if necessary) to set or change the TZ array so that it contains the *NTEMP* EOS table temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc) required to specify EOS tables. (See the **EOSWRITE** command). Attempts to write beyond TZ(NTEMPZ), where NTEMPZ is a parameter currently set to 60, will generate an error message. Note that this information is **not** saved in the restart dump.

WARNING, WARNING, WARNING.....this command is no longer supported -- see version **.tw:kepn:kepn3/25** for the old coding if you want to try to revive it, but see **EOSTABLE** first.

VED *EDITVAR* [*JMIN* [*JMAX*]]

' ved ionye 1 100 '

This command makes an ASCII-output-file edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VEDF *EDITVAR* [*JMIN* [*JMAX*]]

' vedf ionye 1 100 '

Same as the **VED** command except that edited values are given to 14 decimal places instead of 3.

ZED *EDITVAR1* [*EDITVAR2....EDITVAR10*] [*JMIN* [*JMAX*]]

' zed dn tn sige sigi sigr 1 100 '

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX* in the current ASCII-ouput file. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding

Other Ascii-Output-File Edit Commands (Cont.)

values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

ZEDIT *IZED NCYCZED EDITVAR1* [*EDITVAR2....EDITVAR10*] [*ZEDMASS1* [*ZEDMASS2*]]

' zedit 1 50 dn tn sige sigi sigr 0. 2. '

This command causes a special multiple column ASCII edit of the specified zonal edit variables (*EDITVAR1*, etc.) to be written every *NCYCZED* cycles. A detailed list of the allowed zonal edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. Here *IZED* is an index number (max of NZEDZ, which currently is 30 -- see KEPCOMS) that distinguishes separate **ZEDIT** requests, and *ZEDMASS1* and *ZEDMASS2* specify an optional interior mass range (in SCALEM (P 273) units) to be edited. If only *ZEDMASS1* is specified, a ±1% range around it is edited, and if no masses are specified, an edit of the whole star is made. Previously specified edits can be changed or terminated by overwriting them with a new **ZEDIT** command with the same index number. (Note: setting *NCYCZED* = 0 terminates the edit.)

GRAPHICS EDIT COMMANDS

ADDISO *ISOSYM1 [ISOSYM2 ... ISOSYM50]*

' addiso h1 he4 c12 o16 mg25 al26 '

This command adds the detailed isotopic abundances listed to those to be plotted by the "plot 6" or "look 6" commands. At least 1 and no more than 50 isotopic symbols (isosym1...isosym20) must be specified in the form: "addiso h1 he4 c12 o16 mg25 al26"

LISTISO

List the current set of isotopes to be plotted as set by the **SETISO** command.

LOOK *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]]
L *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] (Alternate form)

' look 31 10000 15000 1000 '

This command makes a movie of plot type *NPLOT* starting as closely as possible to cycle *NCYCL0* and ending as closely as possible to cycle *NCYCL1* at intervals as close as possible to *NDELCYCL* using information from the qq-files specified by **SETQ** or (by default) those available for the current problem. Plot types and output modes are as specified in the **PLOT** command and by the values of ITVSTART (P 127). Plot limits are assumed the same as those displayed for the current cycle by **PLOT** for this plot type, and can be adjusted using the usual graphics parameters (see Chapter 3). If not specified, *NCYCL1* is assumed to be equal to *NCYCL0*, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by IDTLOOK (P 302).

LPRINTL *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*]
LPL *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCl*]] [*FILENAME*] (Abbreviated form)

' lpl 3 10000 15000 1000 s25n2a.abun '

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCL0* in landscape orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by **SETQ** or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCL1*, or both NCYCL1 and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at 'look' cycle *NCYCL0* and continuing to 'look' cycle *NCYCL1* at intervals of *NDELCYCL*. A ':' followed by the current 'look' cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

Graphics Edit Commands (Cont.)

LPRINTP *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*]
LPP *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*] (Abbreviated form)
' lpp 3 10000 15000 1000 s25n2a.abun '

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCL0* in portrait orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by **SETQ** or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCL1*, or both NCYCL1 and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at 'look' cycle *NCYCL0* and continuing to 'look' cycle *NCYCL1* at intervals of *NDELCYCL*. A ':' followed by the current 'look' cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

MAPLIM *[VMINMAP VMAXMAP [VRATMAP]]*
' maplim 7. 9. 1.e-5 '

This command defines the limits of the timemap variable by setting the values of parameters *VMINMAP* (P 328), *VMAXMAP* (P 329), and *VRATMAP* (P 330). If no arguments are given, the entire range of the variable is mapped. If the specified values of *VMINMAP* and *VMAXMAP* are equal, they are reset to 1.E+99 and -1.d+99, respectively, resulting in the actual range of the variable being limited only by *VRATMAP* (see P 328 - 330).

MLIM *[YMLOW YMHI]*
MLIM *['OLD']*
' mlim 2.1 10. '
' mlim old '

Set lower and upper limits on the mass coordinate used in making plots and timemaps to *YMLOW* and *YMHI* (in units of solar masses). This is accomplished by resetting YPLOTMIN (P 134) to *YMLOW**1.9892d+33/TOTM and YPLOTMAX (P 135) to *YMHI**1.9892d+33/TOTM. If no arguments are given, or if *YMLOW=YMHI*, then YPLOTMIN is set to 0. and YPLOTMAX is set to 1. If the second argument is the flag 'old' then the previous values of YPLOTMIN and YPLOTMAX are restored.

Graphics Edit Commands (Cont.)

MONGO *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]]
MON *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]] (Abbreviated form)
' mon dn tn log lin '

This command makes an X-Window plot of the first two zonal edit varaibles listed (*EDITVAR2* and *EDITVAR3)* vs. the mass coordinate specified by the value of parameter IRTYPE (P 132). It leaves the user in interactive MONGO, where he or she may modify or print the graph before typing **'end'** to return to KEPLER. Note that either ITVSTART must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result of the **PLOT** command) for this command to have any effect. The mass coordinate is loaded into MONGO data column 1, and the corresponding values of each zonal edit variable, *EDITVARI*, is loaded into MONGO data column *I*.

At least one, and no more than seven zonal edit variables (*EDITVAR2* thru *EDITVAR8*) must be specified from the list given in Chapter 7.

On entry into MONGO, graphs of the first one or two (if specified) variables are made automatically vs. the specified mass coordinate. The range of mass coordinate plotted is controlled by YPLOTMIN (P 134) and YPLOTMAX (P 135) which are the innermost and outermost mass fractions to plot. For most quantities, the ordinate is logarithmic by default (with negative data values, or a small range of values, defaulting the plot instead to linear), but can be set explicitly by setting *AXISY2* and/or *AXISY3* to **'lin'** or **'log'**. The code assumes that one **'lin'** or **'log'** value appended to the command line (after at least one *EDITVARI*) refers to *AXISY2*, the flag for plotting *EDITVAR2*. If two **'log'** or **'lin'** values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *EDITVAR2* and *EDITVAR3*, respectively. The flag **'same'** can also be used as the last word on the command line in order to set the axis type for plotting *EDITVAR3* to be the same as for *EDITVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The **'same'** flag can be proceeded by at most one **'lin'** or **'log'** flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive MONGO, you can (among other things):

Type **'curses'** to get mouse coordinate display, corresponding to the values of the last-defined axes.
Type **'help'** to get a list of interactive mongo commands.
Type the command sequence: **'psland filename' , 'play', 'hard'** to get a postscript file named **filename** containing the currently displayed plot. File **filename** must not already exist.
Type **'end'** to quit interactive MONGO.

Graphics Edit Commands (Cont.)

MONPL *ARRAYNAME2 ARRAYNAME3 ... ARRAYNAME8 [AXISY2 AXISY3]*

Like the 'MONGO' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

MONPP *ARRAYNAME2 ARRAYNAME3... ARRAYNAME8 [AXISY2 AXISY3]*

Like the 'MONGO' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

PLOT *NPLOT*

' plot 31 '

This command makes an X-Window plot of the status of the current problem of the type specified by plot number *NPLOT*. Note that either ITVSTART (P 127) must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result a previous **PLOT** command) for this command to have any effect. Currently allowed values of *NPLOT* are the same as those allowed for parameter IPIXTYPE (P 113) and produce the same types of plots:

<0 graphics window is not updated, but is still open.
=0 only header info is displayed.
=1 thermodynamics graph only.
=2 velocity graph only.
=3 elemental ('ion') mass-fraction graph only.
=4 entropy graph only.
=5 density-temperature graph only.
=6 isotopic mass-fraction graph (use the **SETISO** command first to determine the ions to be displayed).
=7 thru 9: only header info is displayed.
=10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.

Graphics Edit Commands (Cont.)

PRINTL [*NPLOT* [*FILENAME*]]
PL [*NPLOT* [*FILENAME*]] (Abbreviated form)
' pl 31 k '

This command makes a Postscript plot of the current problem status in landscape orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be IPIXTYPE (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If **'k'** is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

PRINTP [*NPLOT* [*FILENAME*]]
PP [*NPLOT* [*FILENAME*]] (Abbreviated form)
' pp 31 k '

This command makes a Postscript plot of the current problem status in portrait orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be IPIXTYPE (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If **'k'** is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

SETISO *ISOSYM1* [*ISOSYM2* ... *ISOSYM50*]
' setiso h1 he4 c12 o16 mg25 al26 '

This command sets the detailed isotopic abundances to be plotted by the **'PLOT** 6' or **'LOOK** 6' commands. At least 1 and no more than 50 isotopic symbols (*ISOSYM2* ... *ISOSYM20*) must be specified from the set of current BURN isotopic symbols (see Chapter 7 for the usual list).

SETLIB [*NAMETLIB* [*NCYCT0* [*NCYCT1* [*NCYCTDEL* [*NCYCQQT* [*LENTDMPT* [*NIYMAXT*]...]
' setlib s25s2a.lib 0 18345 10 5 384 20000 '

This command sets the dump library file and associated parameters to be used in making time-plots. The optional arguments (and their default values if not specified) are defined as follows:

NAMETLIB..... Name of desired dump library file. The default is the one for the current job.
NCYCT0..... First dump cycle to be read and plotted. (Default is 0)
NCYCT1..... Last dump cycle to be read and plotted. (Default is last cycle in dump library)
NCYCTDEL..... The interval in dump cycles between dump library reads. (Default is NCYCQQ)

Graphics Edit Commands (Cont.)

NCYCQQT..... Number of cycles between dump library dumps. (Default is NCYCQQ).
LENDMPT..... Length of each time dump in *NAMETLIB*. (Default is 384)
NIYMAXT..... Maximum number of IY coordinate values in *NAMETLIB*. (Default is 20000)

IF **SETLIB** is not called, the default values are set when **TIMEPLOT** or **TP** is first called. Calling **SETLIB** without arguments resets all these variables to their default values if they have previously been changed by a **SETLIB** command.

SETQ [*NAMEQQL0* [*NAMEQQL1*]]
' setq s25s2a.qa s25s2a.qk '

This command sets the names of the qq-files to be post-processed by other commands such as **LOOK, LPRINT**, etc., where *NAMEQQL0* and *NAMEQQL1* are the first and last members of the sequence of qq-files to be read. Used without arguments, **SETQ** implies that all the qq files for the current problem in the current working directory are to be used. Note that this is the default situation for most post-processing commands and that **SETQ** only has to be used in this mode to restore the specified qq-files to this default. If only *NAMEQQL0* is specified, all available qq-files in the sequence starting with *NAMEQQL0* will be read. Note that qq-file names can be up to 16 characters long (at least on UNIX machines) and need not be those generated by the current problem.

TIMEMAP *NAMEVAR* [*LOGFLAG* [*NCYCL0* [*NCYCL1* [*NDELCYCL*]]]]
TM *NAMEVAR* [*LOGFLAG* [*NCYCL0* [*NCYCL1* [*NDELCYCL*]]]] (Abbreviated form)
' timemap convect lin 0 18750 1 '

This command makes a space-time map for zonal edit variable *NAMEVAR* starting as closely as possible to cycle *NCYCL0* and ending as closely as possible to cycle *NCYCL1*. It uses information from the qq-files specified by **SETQ** or (by default) those available for the current problem. *LOGFLAG* can be given as either **'log'** or **'lin'** to specify the desired scaling for the variable being displayed. The mass coordinate axis type and limits is set by the same parameters as for normal KEPLER plots. (See the comments for the timemap routine for other relevant input parameters). If not specified, *NCYCL1*, is assumed to be the last cycle for which information is available in the qq-files specified by **SETQ**, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by IDTLOOK (P 302). If a colormap whose name is in the form, *NAMEVAR*.map (e.g. **'convect.map'**), is available in the local directory (or as a second alternative, is in the directory **/usr/local/map**), it will be used to make the plot. Otherwise a simple default rainbow-style map, **/usr/local/map/spectral.map**, will be used. After the plot is made, the user can manipulate it further (including changing to a new variable and/or color map) by using the menus

displayed when the right mouse button is depressed. Depressing the left mouse button displays an overlay rectangle that can be positioned and/or stretched to indicate a time-space region to zoom into and replot. WARNING....This command currently only works on a Silicon Graphics terminal.

TIMEPLOT *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*]
TP *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*] (Abbreviated form)
' timeplot eni enk enp log same '

This command makes an X-Window plot of the first two time-edit variables listed (*TIMEVAR2* and *TIMEVAR3)* vs. the time coordinate specified by the value of MAPTIME (P 327). It leaves the user in interactive MONGO, where he or she may modify or print the graph before typing **'end'** to return to KEPLER. Note that either ITVSTART must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result of the PLOT command) for this command to have any effect. Unless a **SETLIB** command has previously been issued to the contrary, the time histories for these variables are read from the **'.lib'** file for the current problem for the entire range of available cycles. The time coordinate is loaded into MONGO data column 1, and the corresponding time sequence for each timeplot variable, *TIMEVARI*, is loaded into MONGO data column *I*.

At least one, and no more than seven time-edit variables (*TIMEVAR2* thru *TIMEVAR8*) must be specified from the list given in Chapter 8.

The range of the time coordinates plotted is controlled by TIMECMIN (P 321) and TIMECMAX (P 322) and defaults to the entire available range. For most quantities, the ordinate is logarithmic by default (with negative data values or a small range of values defaulting the plot instead to linear), but axis type can be set explicitly by setting *AXISY2* and/or *AXISY3* to **'lin'** or **'log'**. The code assumes that one **'lin'** or **'log'** value appended to the command line (after at least one *TIMEVARI)* refers to *AXISY2*, the flag for plotting *TIMEVAR2*. If two **'log'** or **'lin'** values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *TIMEVAR2* and *TIMEVAR3*, respectively. The flag **'same'** can also be used as the last word on the command line in order to set the axis type for plotting *TIMEVAR3* to be the same as for *TIMEVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The **'same'** flag can be proceeded by at most one **'lin'** or **'log'** flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive MONGO, you can (among other things):

Type **'curses'** to get mouse coordinate display, corresponding to the values of the last-defined axes.
Type **'help'** to get a list of interactive mongo commands.
Type the command sequence: **'psland filename'** , **'play'**, **'hard'** to get a postscript file named **filename** containing the currently displayed plot. File **filename** must not already exist.
Type **'end'** to quit interactive MONGO.

Graphics Edit Commands (Cont.)

TPPL *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TPPP *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TLIM *[TIMECMIN TIMECMAX]*
TLIM *['OLD']*

' tlim -15.3 -10. '
' tlim old '

Set limits on the time coordinate used in making timeplots and timemaps by resetting the values of TIMECMIN (P 321) and TIMECMAX (P 322) to the specified values. If no arguments are given or if TIMECMIN = TIMECMAX, then all available time points are plotted. Note that time-coordinate units are specified by MAPTIME (P 327) and must be floating point numbers. If the second argument is the flag 'old' then the previous values of TIMECMIN (P 321) and TIMECMAX (P 322) are restored.

YLIM *[Y2LOWMON Y2HIMON [SAME]]*
YLIM *[Y2LOWMON Y2HIMON [Y3LOWMON Y3HIMON]]*

' ylim 3. 5. '
' ylim 3. 5. same '
' ylim 3. 5. 0.44 0.5 '

This command sets the y-axes limits on MONGO plots. *Y2LOWMON* and *Y2HIMON* are the lower and upper limits for the variable plotted on the left-hand y-axis, while *Y3LOWMON* and *Y3HIMON* are the lower and upper limits for the variable plotted on the right-hand y-axis. If no arguments are specified for a given axis, or if their high and low values are equal, then the entire range of the corresponding variable will be plotted. If the flag 'same' is specified in place of the right-hand y-axis limits, they will be set to be the same as for the left-hand y-axis.

SPECIAL PURPOSE COMMANDS

ADDATMOS *NATMOS RHOATM1 [TEMPATM]*

' addatmos 10 3.e-12 '

Add an isothermal, exponential atmosphere to the surface of the star consisting of *NATMOS* zones and extending out to a density of *RHOATM1* (g/cc). The atmospheric conditions are scaled from the surface gravity, density, temperature and radius of the outer zone. The atmosphere is assumed to be thin (slab-like) compared to the star's radius and its composition is taken to be the same as that of the outer zone. If *TEMPATM* (degK) is specified, it is used instead of the temperature of the outer zone in constructing the atmosphere.

ADDLOOK *EDITVAR* [*DELFLAG*]

' addlook sneut delete '

Add zonal edit variable *EDITVAR* to the list of ('look') variables that subroutine READQ reads from the qq dump files. *DUMPVAR* may be any zonal edit variable listed in Chapter 7. If the second argument is present and is equal to **'delete'**, then variable *EDITVAR* is instead deleted from the list of look variables. Note that all current commands such as **PLOT** automatically load their own 'look' lists and then return the list to its original state when they're finished. Future commands, however, may require the use of **ADDLOOK**.

ADDSURF *NSURF TMSURF TEMPSURF RHOSURF VELSURF*

' addsurf 10 1.E+32 1.E+4 1.E-11 0. '

Add *NSURF* zones of equal mass totaling *TMSURF* total mass (g) with temperature, *TSURF* (K), density, *RHOSURF* (g/cc), velocity, *VELSURF* (cm/s), and the composition last specified by the **COMPSURF** command. Note that each time **ADDSURF** is called, the sum of the mass fractions in the COMPSURF array is normalized to unity.

ALIAS *NAMEA "COMMAND-STRING"*

' alias t1 "tq, 1, 1 i" '

Define alias *NAMEA* to invoke the command string *COMMAND-STRING*. *COMMAND-STRING* must be enclosed in double quotes and be less than 71 characters long. The command string may be a series of comma-delimited TTY commands. Note that the entire alias command may not exceed 80 characters and may not, itself, be comma-delimited. There is a limit of 200 (parameter NCSAVEDZ) total aliases.

Special Purpose Commands (Cont.)

BOX *BOX#*
'box v98'

Change the output box number to *BOX#* (three character symbol).

ADDWIND *NWIND WINDMASS RATEWIND VELWIND [VESCMULT[TEFFWIND[RADPWIND]]]*
' addwind 5 1.0e-5 1.e-4 10. 1. 3.098e+3 3.443e+13 '

Add *NWIND* zones of equal mass totaling *WINDMASS* (Msun) with mass-loss rate *RATEWIND* (Msun/year), terminal velocity *VELWIND* (km/s). Optional inputs are the escape-velocity multiplier *VESCMULT* (default=1.) and the effective photospheric temperature *TEFFWIND* (degK) and radius *RADPWIND* (cm) used in generating the wind profile. The mass-loss rate is assumed to stay constant at *RATEWIND* during the time these zones "took" to leave the surface of the star, and the velocity at any point is the sum of the local escape velocity times *VESCMULT* and the wind's terminal velocity *VELWIND*. The wind's local temperature is calculated by assuming that it is in LTE with the photosphere specified by *TEFFWIND* and *RADPWIND*. If no explicit values of these photospheric variables are given, they default to the existing photospheric temperature (*TEFF*) and radius (*RADIUS*). The composition of the wind is taken to be the same as that of the outer zone. Note that several ADDWIND commands can be used in succession to build up a wind with a time-dependent mass-loss rate, or to achieve non-constant-mass zoning.

CHECK

Type out the number of errors (NIOERR) the code has encountered sending out ASCII output files since the last restart. This command is only meaningful on a CRAY computer.

CHNGCOMP *JMIN JMAX FIRSTION# MFRAC1 [MFRAC2 ..... MFRAC8]*
' chngcomp 20 10 1 0. 0. 0. 0. 0. .5 0. .5 '

Change the composition in zones *JMIN* through *JMAX* to the ion mass fractions specified. At least one and up to eight mass fractions can be given on each command line. The compositions changed begin with that of the ion corresponding to ion number *FIRSTION#* and continue on in ion number order. For the APPROX network, the ion numbers correspond to: neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19]. (see Chapter 7 for the ion types and numbers in the ISE and NSE networks.) Repeated use of this command can set all the elements in the XNWCOMP array in subroutine TTYCOM (which is then used to change the zonal abundances). Mass fractions will be renormalized to sum to unity, and the

Special Purpose Commands (Cont.)

equation of state will be recomputed for the new composition. WARNING --Non-specified abundances are given whatever garbage values may have initially been in XNWCOMP, and multiple use of this command is complicated by the fact that the mass fractions of the current contents of the XNWCOMP array are renormalized to unity after ***each*** use. All old abundance information from these zones is disregarded. Check zonal compositions afterwards using the *"J I"* command.

****CAUTION****

Radically altering the composition in any zone may cause discontinuous changes in its internal energy, pressure, etc. and lead to convergence problems. Take special care in degenerate cases. The **NEWE** command may be useful here. **Note: The user takes full responsibility for any misleading and/or unphysical results that may be produced due to the use of this command.**

COMPSURF *FIRSTION# MFRAC1* [*MFRAC2 MFRAC3 ..... MFRAC10*]

' compsurf 1 0. .7 0. 0. .28 0. .02 '

Starting with its *FIRSTION#* th entry, set the values of the COMPSURF array in KEPCOMS equal respectively to *MFRAC1, MFRAC2, MFRAC3,* etc. At least one, and up to 10 such values can be given on each command line. Repeated use of this command can thus set all the elements of the COMPSURF array. These elements represent respectively the mass fractions of neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19] that are used to set the composition of the surface zones added by the **ADDSURF** command. Note that this array is stored in the restart dump for later use.

CUTSURF *NSURF*

' cutsurf 3 '

Remove *NSURF* zones from the surface of the star. PBOUND (P 69) and TBOUND (P 68) are automatically reset to correspond to the innermost zone removed. This option is sometimes useful in removing essentially "frozen" outer layers of the star so that available zones can be concentrated on core processing or to remove high velocity surface zones that are trying to form a stellar wind.

DECAYNI

Convert all Ni56 to Fe54 in such a way as to conserve mass, but with no energy generation.

Special Purpose Commands (Cont.)

DET *JDET0 JDET1 ENDET*

' det 1 30 7.867E+17 '

Add *ENDET* ergs/g to the specific energies of zones *JET0* to *JDET1*, inclusive, to simulate the passage of a detonation wave through these zones. Also change detonated zones to Ni56. This command should be used only for zones using the APPROX network, and is normally used in conjunction with setting TIMEX0 (P 38) to the current problem time (TIME, P 2), so that the decay energy from this "newly formed" Ni56 is appropriately deposited in the star (see P 38).

DUMP *DUMPVAR RATZDUMP RATIODEZ RATIOADZ*

' dump convect .1 -1. 0. '

Add dump variable *DUMPVAR* to the list of variables to be dumped to the qq post-processor dump file or change its dump parameters if it is already in the dump list. *DUMPVAR* may be any zonal edit variable listed in Chapter 7, and in addition it may take the values:

parm -- to dump the values of the changeable ('p') parameters, or

qparm -- to dump the values of the edit ('q') parameters.

The associated dump parameters which must be given for each variable are:

RATZDUMP -- the maximum allowed fractional change between dumps of the specified zonal dump variable.

RATIODEZ -- the minimum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is dezoned.

RATIOADZ -- the maximum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is adzoned.

In the case of **parm** and **qparm** the values of *RATIOADZ* and *RATIODEZ* are ignored but must be given. Note that the **DUMP** command for new variables is usually given in the problem generator file (see Chapter 2).

GENBURN *NAMEBG*

' genburn sol160bg '

Read BURN generator, *NAMEBG*, and begin BURN co-processing. Note that this command is usually given in the problem generator file (see Chapter 2).

LINK *NAMELINK*

' link linkwlsn '

Read and execute the LINK file named *NAMELINK*. The link file contains the information

Special Purpose Commands (Cont.)

needed to link the results of specialized core collapse calculations or parameterized models back to KEPLER in order to follow the subsequent explosion and nuclear processing. See the LINK subroutine and Chapter 6.

LISTA

List all aliases, including those not yet defined (which are denoted by "null").

MIX *NZMIN NZMAX DELMASS*

' mix 293 507 0.5 '

Mix composition outwards starting with zone *NZMIN* and ending with zone *NZMAX* in mass increments of *DELMASS* (solar masses). Reset the equation of state in mixed zones. Used for light-curve calculations to simulate Rayleigh-Taylor mixing.

NEWDUMPS

Reset all dump-file names and delete all old dump variables.

NEWE

Calculate new internal energies from current densities and temperatures. This is *usually* wise when changing EOS's in the middle of a problem via code modifications or changing EOS parameter settings. Note that total energies are also readjusted so that the resulting "virtual " energy nonconservation is not reflected in the energy edits.

NEWQNAME

Reset the names of the expected qq-file and qlib-file to reflect the current problem name.

NEWSTART

Reinitialize the problem by making an edit and restart dump of the current status of the problem, putting out output files, and storing dumps. This command is obsolescent and should not be used on UNIX machines without careful checking of the coding involved.

STORE *NSDIRECT*

' store /usr/leo/weaver/s25s2a '

Set the directory into which ASCII output files and labeled restart dumps will be written to *NSDIRECT*. If *NSDIRECT* is set to **'no-store'** (the default), output files will be placed in the current

Special Purpose Commands (Cont.)

working directory. The name of *NSDIRECT* may be up to 48 characters long.

SYSTEM *"COMMAND-STRING"*

' system "cd /usr/leo/weaver" '

Execute the system command, *COMMAND-STRING* (which must be enclosed in double quotes and be less than than 72 characters long). Note that the entire system command may not exceed 80 characters and may not, itself, be comma-delimited.

UNALIAS *NAMEA*

' unalias t1 '

Remove the previously defined alias *NAMEA*. If *NAMEA* is "all", then all aliases are removed, including those defined in the generator.

ZEROTIME

Set the problem time, TIME (P 2), to 0. Add the old value of TIME to TOFFSET (P 315). Also reset the **timen** array and take a small time step if BURN co-processing is being done.

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CHAPTER 6

LINK INPUT FILE

LINK input files allow information derived from other codes (especially detailed core collapse calculations) or from parameterized models to be introduced into KEPLER. Typically this information specifies that a certain mass at the center of the star is to be removed and replaced with a time dependent inner boundary condition whose motion and neutrino emission acts like a "piston" to explode the outer layers of the star. The format conventions in LINK file command lines (called "cards" for historical reasons) and those for generator cards are identical (see Chapter 2).

A link input file named *NAMELINK* is read into KEPLER when the command **LINK** *NAMELINK* (e.g.: ' **link linkwlsn** ') is issued from the terminal (see Chapter 5). Allowed LINK file cards are listed below.

LINK INPUT CARDS

CUT *JCORE*
' cut 57 '
Core Cut Card (optional).
Remove the inner *JCORE* zones from the center of the star. Add their mass to SUMM0 (P 61), the boundary condition parameter giving the mass inside the inner boundary of the calculation.

APPROX *JLO JHI*
' approx 1 9 '
APPROX Network Card (optional).
Change zones between *JLO* and *JHI* to the APPROX network (if not already using it). The code

assumes that non-APPROX zones are either NSE or ISE zones and repacks the abundance array appropriately to put it into APPROX format. Since the ISE abundance array does not store information on (the usually very small) abundances of ions **h1, he3, c12, n14,** and **ne20,** these end up being zeroed in going to APPROX. Also, isotopes more neutron rich than ^{54}Fe (e.g. ^{56}Fe) are stored as **fe52** in such a way as to conserve mass (but not Y_e -- also see the **"YESET"** command below). This command should not be used (or be rewritten) if the resulting abundance of **"fe52"** is significant. In its current form, it is intended to be used to transform relatively unneutronized zones containing newly synthesized ^{56}Ni and/or ^{54}Fe which the APPROX network is able to deal with sensibly. Remember to turn on low-temperature ^{56}Ni decay (if desired) by resetting TIMEX0 (P 38), and, if desired, TIME (P 2).

PST *TIME(I)* *INNER-RADIUS(I)*
' pst 0. 1.0072e+7
pst 1.e+10 1.0072e+7 '

Piston Cards (Optional, but at least two required if any are specified).
This card specifies the radius of the inner boundary of the problem, *INNER-RADIUS(I),* in cm at time, *TIME(I),* in seconds. A series of such cards with monotonically increasing values of *TIME(I)* are used to build up a discrete time history of the inner problem boundary, which the code uses to get intermediate values by interpolation. If the *INNER-RADIUS(I)* given is 0., this serves as a flag for the code to reset its value to RADIUS0 (P 60), so that a higher precision value can given. This is sometimes useful in treating compact configurations such as surface layers on neutron stars. The range of times covered must exceed the range of times for which the problem is to be run and at least two piston cards must be specified. The code does not remember data from **"PST"** cards in any previously read LINK decks, but *does* remember this current **"PST"** data in restart dumps. Currently, a maximum of NPISTZ = 300 **"PST"** cards are allowed. (Here, NPISTZ is a FORTRAN parameter set in KEPCOMS).

NFLUX *TBOUNCE FLUXNU0 A0 CHI0 A1 CHI1 A2 CHI2*
' nflux 0.21569 9.e+24 2.5e-8 8.0e+7 0.25e-8 8.0e+8 0.4e-8 2.2e+9 (typical) '
' nflux 0.223 0. 0. 0. 0. 0. 0. 0. (no flux) '

Neutrino Flux Card (optional).
This card contains the fitting coefficients for the "reduced" neutrino momentum flux, FLUXNU, in the form:

FLUXNU (TIME, R0) = *FLUXNU0* / ((1. + EXP (-*A0* * (CHI - *CHI0*))) *

(1. + EXP (-*A1* * (CHI - *CHI1*))) * (1. + EXP (+*A2* * (CHI - *CHI2*))),

where CHI = C * (TIME - *TBOUNCE*) - R0 , C is the speed of light (cm/sec), TIME is the current problem time (P 2) in seconds, and R0 is the radius in cm. (See REGESS). Here *TBOUNCE* has units of seconds; CHI, *CHI0, CHI1,* and *CHI2* have units of cm; *A0, A1,* and *A2* have units of cm^{-1}; and FLUXNU and *FLUXNU0* have units of cm**3 / sec**2. Note the positive coefficient of *A2* in this fit.

Basically, this fit represents the neutrinos as a wave that propagates outward from the inner boundary without significant attenuation. In a typical case, such as that given in the example, this wave turns on exponentially near retarded time *CHI0,* peaks about retarded time *CHI1,* and decays away exponentially near retarded time *CHI2.* The acceleration of the matter due to scattering with this neutrino wave is then given by ABAR * FLUXNU / R0**2 cm/sec**2, where ABAR is the average atomic weight. This scattering is currently assumed to be elastic, and no thermal energy is deposited. Typically FLUXNU is derived from edits of neutrino-induced acceleration in the inner mantle zones of detailed core collapse calculations, such as that of Wilson and coworkers. [See 7/25/78 KEPLER notes.]

YE	*ARBITRARY*	*INTERIOR-MASS(I)*	*YEQ0(I)*
'ye	**1**	**0.**	**0.48**
ye	**2**	**2.**	**0.50 '**

Y_e Cards for ISE initialization. (Optional, but at least two are required if any are given).

ARBITRARY is an arbitrary, but required, value that is generally used to number the "YE" cards.

INTERIOR-MASS(I) is the interior mass coordinate (in solar masses) for this Y_e point.

YEQ0(I) (moles/g) is the value of Y_e to be used to initialize new ISE zones at this mass coordinate.

A series of such cards with monotonically increasing values of *INTERIOR-MASS(I)* are used to build up a discrete representation of the post-oxygen burning Y_e profile, which the code uses to get intermediate values by linear interpolation (see subroutine SDOT). Out of the range of mass coordinates specified by such a set of "YE" cards, the code uses the minimum of the current (APPROX-generated) value of Y_e and YEMAX (P 323 -- default = 0.498 moles/g) in order to initialize a new ISE zone. The code does not remember data from "YE" cards in any previously read LINK decks, but *does* remember this current "YE" data in restart dumps.

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CHAPTER 7

ZONAL EDIT AND DUMP VARIABLES

GENERAL

This chapter lists the currently defined zonal edit variables by type. An alphabetical summary is given in Appendix C. Any of these variables can be edited in various ways by name (or list of names) or specified as a variable to be included in the post-processor dumps using the **DUMP** command or generator card (see Chapters 5 and 2, respectively). The **V**, **VF**, and **Z** commands are used to make terminal edits of these zonal edit variables. Periodic edits to the Ascii output file can be made automatically while the problem is running by using the **ZEDIT** command, while edits on demand to the output file are made in various formats by the **VED**, **VEDF**, and **ZED** commands. In addition, X-Window and Postscript plots can be made of the current values of these variables using the **MONGO** or **MON** commands, while a color-coded 'timemap' of each variable's space-time history can be made on Silicon Graphics workstation monitors using the **TIMEMAP** or **TM** commands.

The list of zonal edit variables given here is easily extensible, as indicated in the sections on EDITCOM and miscellaneous edit variables below. In addition, KEPLER will automatically incorporate changes in the BURN and ISE isotope networks into the lists of isotopes and ISE-quantities that can be edited.

KEPCOM ZONAL INTERFACE ARRAY VARIABLES

ym..... Exterior mass coordinate (g).
rn..... Radius of outer zone boundary (cm).
rd..... Calculated change in radius (cm) -- during a cycle;
Radius at last timestep (cm) -- at the end of a cycle.
un..... Velocity of the outer zone boundary (cm/s).
xln..... Calculated non-neutrino luminosity at the outer zone boundary (erg/s).
qln..... Converged non-neutrino luminosity at the outer zone boundary (erg/s).
qld..... Calculated change in converged luminosity (erg/s) -- during a cycle;
Converged luminosity at last timestep (erg/s) -- at the end of a cycle.
difi..... Diffusion coefficient for material mixing due to convection (cm**2/s).

KEPCOM ZONE-CENTERED ARRAY VARIABLES

netnum..... Number of the nuclear network currently used in the zone.
xm..... Zonal mass (g).
dn..... Density (g/cc).
tn..... Temperature (K).
td..... Calculated change in temperature (K) -- during a cycle;
Temperature at last timestep (K) -- at the end of a cycle.
en..... Specific energy density (erg/g).
pn..... Pressure (erg/cc)
zn..... Viscous stress -- including linear and quadratic artificial viscosity (ergs).
etan..... Electron degeneracy parameter (μ_e / kT).
sn..... Total energy generation rate -- including neutrino losses (erg/g/s).
snn..... Nuclear energy generation rate -- excluding neutrino losses (erg/g/s)
abar..... Mean atomic weight (g/mole).
zbar..... Mean atomic charge.
xkn..... Rosseland mean opacity (cm**2/g).
xnei..... Number density of ionized electrons (electrons/cc) -- **not implemented yet.**
stot..... Total zonal entropy (k/baryon).
dsold..... Density at which the energy generation rate was last calculated (g/cc).
tsold..... Temperature at which the energy generation rate was last calculated (K).
snold..... Last calculated energy generation rate (erg/g/s).
snbd..... Last calculated partial derivative of the energy generation rate with respect to density (s*cm**5/g).
snbt..... Last calculated partial derivative of the energy generation rate with respect to temperature (erg/g/s/K).
abarold..... Last calculated value of ABAR
abarnbd..... Last calculated partial derivative of ABAR with respect to density (cc/g).
abarnbt..... Last calculated partial derivative of ABAR with respect to temperature (1/K).
ypbtime..... Last calculated total time derivative of the proton abundance (mole/g/sec).
ynbtime..... Last calculated total time derivative of the proton abundance (mole/g/sec).

KEPCOM BURN COPROCESSOR ARRAY VARIABLES

netnumb..... Number of the BURN isotopic nuclear network used in this zone.

limnuc..... Integer containing the Z and A of the isotope controlling the BURN timestep along with the KEPLER cycle that this zone was last burned coded in the form:

LIMNUC = A + 100*Z + 10000* NCYC

timen..... Time to which the BURN coprocessing in this zone has been updated (sec).

dtimen..... Current timestep for BURN coprocessing in this zone (sec).

dnold..... Density at which BURN coprocessing was last done in this zone (g/cc).

tnold..... Temperature at which BURN coprocessing was last done in this zone (K).

ymb..... Mass interior to the outer boundary of this zone, as last considered by the BURN coprocessor (g).

sburn..... BURN nuclear energy generation rate, excluding neutrino losses (erg/g/s).

etab..... Burn neutron excess (moles/g). The corresponding BURN electron abundance is given by: **yeburn** = 0.5 * (1. - **etab**)

pbuf..... Abundance buffer (internal working array -- see CONVECTB) (moles/g).

ZONAL 'ELEMENTAL' MASS FRACTIONS AND RELATED VARIABLES

The edit or dump variables corresponding to the elemental mass fractions of the 'ions' involved in the APPROX, NSE, and ISE networks take the form, **'ionfe54'**, where **fe54** exemplifies any valid network 'ion' symbol. Valid ion symbols are shown below in **bold-face** letters in the table that follows. The symbol with which each ion's curve is labeled in abundance plots is shown in square brackets, followed by (in the case of ISE or NSE) the isotopes whose mass fractions are explicitly summed to get each 'elemental' mass fraction. A list of the precise isotopes included is given on the next page.

ION#	APPROX Network		ISE and NSE Networks		
1	**nt1**	[n]	**nt1**	[n]	(neutron only)
2	**h1**	[H]	**ye**	[none]	(electron abundance)
3	**pn1**	[p]	**pn1**	[p]	(proton only)
4	**he3**	[^{3}He]	**yq**	[none]	($A \geq 24$ abundance)
5	**he4**	[He]	**he4**	[He]	($2 \leq A \leq 5$)
6	**c12**	[C]	**yf**	[none]	($A > 46$ plus ^{46}Ti abundance)
7	**n14**	[N]	**eb0**	[none]	(binding energy / nucleon)
8	**o16**	[O]	**o16**	[O]	('unburned' ^{16}O only)
9	**ne20**	[Ne]	**fe56**	[^{56}Fe]	(^{56}Fe only)
10	**mg24**	[Mg]	**mg24**	[Mg]	($23 \leq A \leq 28$, ex. ^{28}Si)
11	**si28**	[Si]	**si28**	[Si]	(^{28}Si only)
12	**s32**	[S]	**s32**	[S]	($29 \leq A \leq 35$)
13	**ar36**	[Ar]	**ar36**	[Ar]	($36 \leq A \leq 39$)
14	**ca40**	[Ca]	**ca40**	[Ca]	($40 \leq A \leq 43$)
15	**ti44**	[Ti]	**ti44**	[Ca]	($44 \leq A \leq 47$)
16	**cr48**	[Cr]	**cr48**	[Cr]	($48 \leq A \leq 51$)
17	**fe52**	[^{52}Fe]	**'fe'**	['Fe']	($A \geq 2*Z + 4$ Iron Peak, ex. ^{56}Fe)
18	**fe54**	[Fe]	**fe54**	[Fe]	($A \approx 2*Z + 2$ Iron Peak)
19	**ni56**	[Ni]	**ni56**	[Ni]	($A \leq 2*Z + 1$ Iron Peak)

The distinction between **h1** and **pn1** in the APPROX network is that the former represents unburned hydrogen, while the latter represents protons resulting from photodisintegration. This separation makes inverting the resulting reaction matrix more efficient. Note also that, while not explicitly included in the APPROX network, flows proceeding through the ~~elements~~ Isotopes ^{27}Al, ^{31}P, ^{35}Cl,

^{39}K, ^{43}Sc, ^{47}V, ^{51}Mn, ^{55}Co, ^{53}Fe, and ^{2}H are included implicitly by assuming that their abundances are in steady state with their neighboring nuclei (see WZW78).

For zones using the ISE or NSE networks, the exact list of isotopes whose mass fractions are summed to get the edited values for each 'ion' symbol are as follows:

ionnt1 = **nt1**

ionpn1 = **pn1**

ionhe4 = **h2 + h3 + he3 + he4 + he5 + li5** ($2 \le A \le 5$)

ionmg24 = **na23 + mg24 + mg25 + mg26 + al26 + al27 + al28** ($23 \le A \le 28$)

iono16 = **o16**

ionsi28 = **si28**

ions32 = **si29 + si30 + p30 + p31 + s31 + p32 + s32 + p33 + s33 + s34 + cl35** ($29 \le A \le 35$)

ionar36 = **cl36 + ar36 + cl37 + ar37 + ar38 + ar39 + k39** ($36 \le A \le 39$)

ionca40 = **ar40 + k40 + ca40 + k41 + ca41 + k42 + ca42 + k43 + ca43 + sc43** ($40 \le A \le 43$)

ionti44 = **ca44 + sc44 + ti44 + sc45 + ti45 + ca46 + sc46 + ti46 + sc47 + ti47 + v47** ($44 \le A \le 47$)

ioncr48 = **ca48 + sc48 + ti48 + v48 + cr48 + sc49 + ti49 + v49 + cr49 + ti50 + v50 + cr50 + ti51 + v51 + cr51 + mn51** ($48 \le A \le 51$)

ion'fe' = **ti52 + v52 + cr52 + v53 + cr53 + v54 + cr54 + mn54 + cr55 + mn55 + cr56 + mn56 + mn57 + fe57 + mn58 + fe58 + co58 + fe59 + co59 + fe60 + co60 + ni60 + fe61 + co61 + ni61 + fe62 + co62 + ni62 + co63 + ni63 + co64 + ni64 + ni65 + ni66** ($A \ge 2*Z + 4$ Iron Peak)

ionfe54 = **mn52 + mn53 + fe54 + fe55 + co56 + co57 + ni58 + ni59** ($A \approx 2*Z + 2$ Iron Peak)

ionni56 = **fe52 + fe53 + co54 + co55 + ni56 + ni57 + cu59 + zn60** ($A \le 2*Z + 1$ Iron Peak)

ionfe56 = **fe56**

The special cases where the edit variables formed from the 'ion' symbols listed do not correspond to 'elemental' mass fractions are as follows:

ionye..... Electron abundance in any current (non-BURN) network (moles/g).
ionyq..... Total abundance of ISE or NSE isotopes with A $\geq$ 24 (moles/g).
ionyf..... Total abundance of ISE or NSE isotopes with A > 46 plus ^{46}Ti (moles/g).
ioneb0..... Mean binding energy per nucleon of all ISE or NSE isotopes (MeV).

ISE EDIT QUANTITIES

Zonal edit variables for ISE network isotopic mass-fractions, weak rates, and related quantities can be referenced in the form: **'insefe56'** where **'nse'** is a fixed flag, **'fe56'** represents the symbol of an isotope in the ISE network (stored in array NUCSYMD in subroutine QNSE – see below), and **'i'** represents a variable flag depending on which isotopic quantity or rate is desired.

'i' may take the values:

'i' .....to get the isotopic mass fraction,
'w' .....to get the isotopic statistical weight,
'r' ..... to get the total weak interaction rate due to this isotope (moles/g/sec),
'c' ..... to get the electron capture rate due to this isotope (moles/g/sec),
'p' ..... to get the positron emission rate due to this isotope (moles/g/sec),
'b' ..... to get the beta decay rate due to this isotope (moles/g/sec),
'e' ..... to get the total neutrino energy loss due to this isotope (ergs/g/sec),
'k' ..... to get the neutrino energy loss due to e^- capture and e^+ decay on this isotope (erg/g/sec),
'x' ..... to get the energy stored in the excited states of this isotope (MeV/nucleus).

The symbols of the 125 isotopes comprising the ISE (and NSE) network are:

n1	**h1**	**h2**	**h3**	**he3**	**he4**	**he5**	**li5**	**c12**	**o16**	(1-10)
ne20	**na23**	**mg24**	**mg25**	**mg26**	**al26**	**al27**	**al28**	**si28**	**si29**	(11-20)
si30	**p30**	**p31**	**s31**	**p32**	**s32**	**p33**	**s33**	**s34**	**cl35**	(21-30)
cl36	**ar36**	**cl37**	**ar37**	**ar38**	**ar39**	**k39**	**ar40**	**k40**	**ca40**	(31-40)
k41	**ca41**	**k42**	**ca42**	**k43**	**ca43**	**sc43**	**ca44**	**sc44**	**ti44**	(41-50)
sc45	**ti45**	**ca46**	**sc46**	**ti46**	**sc47**	**ti47**	**v47**	**ca48**	**sc48**	(51-60)
ti48	**v48**	**cr48**	**sc49**	**ti49**	**v49**	**cr49**	**ti50**	**v50**	**cr50**	(61-70)
ti51	**v51**	**cr51**	**mn51**	**ti52**	**v52**	**cr52**	**mn52**	**fe52**	**v53**	(71-80)
cr53	**mn53**	**fe53**	**v54**	**cr54**	**mn54**	**fe54**	**co54**	**cr55**	**mn55**	(81-90)
fe55	**co55**	**cr56**	**mn56**	**fe56**	**co56**	**ni56**	**mn57**	**fe57**	**co57**	(91-100)
ni57	**mn58**	**fe58**	**co58**	**ni58**	**fe59**	**co59**	**ni59**	**cu59**	**fe60**	(101-110)
co60	**ni60**	**zn60**	**fe61**	**co61**	**ni61**	**fe62**	**co62**	**ni62**	**co63**	(111-120)
ni63	**co64**	**ni64**	**ni65**	**ni66**						(120-125)

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CHAPTER 5

TERMINAL INPUT

GENERAL

All terminal input is in the form of space delimited words. All normal floating point and fixed point formats are recognized (termed "field-free" format). Floating point numbers must be distinguished from integers by a decimal point or exponent. All actual communication with the computer should be made in lower case and character parameters are never enclosed in quotes.

STARTING AND RESTARTING

KEPLER is initiated by typing:

KEPLER *NAMEP NAMEG/Z* [*OPTIONS*]
e.g.: ' **kepler s25s2a s25s2ag s** '

KEPLER is the version of KEPLER which is to be run. Possible choices include:
kepler.....The most tested current 'floor' version of KEPLER,
keplerx.....The less tested, but 'new and improved,' experimental version, or
kepler.*ddmmmyy*... An old version of KEPLER made on ***ddmmmyy***, e.g. ' **kepler.13apr91** '
On UNIX machines, **kepler** and **keplerx** are stored in **/usr/local/bin**, while old versions of KEPLER are archived in **/usr/local/bin/oldkep** on the General Studies ('P') Group Silicon Graphics UNIX computer **leonardo** (Internet address 128.115.10.33).
The version used for a given run and its date are recorded at the beginning of each ASCII output file.

NAMEP is the ≤ 8 character name given to the current problem. This name is also used to begin the names for various output and dump files created during this problem (see below).

NAMEG/Z is a ≤ 16 character name of either a generator file (in which case its name **must** end in ' **g** ' (e.g., ' **s25s2ag** '), or a restart dump (in which case its name **must not** end in ' **g** ' (e.g., ' **s25s2az** ' or ' **s25s2a#10350** ' or ' **s25s2a#presn** ').

Special Cases:	**Meaning:**
g.....	To generate from file *NAMEP*//'g'.
z.....	To restart from file *NAMEP*//'z'.
p.....	To restart from file *NAMEP(with last character deleted)*//'#presn'.

OPTIONS (optional) is a set of one or more space delimited words in arbitrary order chosen from among the following possibilities:

Option:	**Meaning:**
s.....	To suspend the code after starting.
d.....	To destroy the ASCII output files after sending them to the microfiche printer (not currently implemented -- see also the discussion of parameter IAUTOOUT (P 159) given in Chapter 4).
h.....	To automatically make a paper copy of the ASCII output files (not currently implemented).

INITIAL OPERATION

In the absence of any *OPTIONS*, the code will begin calculations immediately and keep its ASCII output files on disk. It will either generate from cycle 0 if *NAMEG/Z* is the name of a valid generator file (see Chapter 2) or restart a previous problem if *NAMEG/Z* is the name of a restart dump compatible with this version of KEPLER. The code will attempt to restart from restart dumps created by older versions of KEPLER by setting any newly added parameters to their default values, and printing warning messages concerning possible incompatibilities. Such compatibility, however, is **not** guaranteed, and it is the user's responsibility to carefully check whether such a restart operation has been performed correctly (see subroutine RESTART). If equation of state routine changes have been made in the interim, the **NEWE** or **EOSTRANS** commands (see below) may be helpful.

REQUIRED INPUT FILES

The current working directory must contain the specified compiled version of KEPLER or (more desirably) a PATH specification to **/usr/local/bin** or **/usr/local/bin/oldkep**, where such files are likely to be located. The named generator or restart file must also be physically resident in the

current directory, as must any BURN generator file specified in the generator file (see Chapter 2).

If BURN co-processing has been specified, the directory in which KEPLER is run must also contain the file BDAT, which contains the needed nuclear cross-sections for detailed isotopic networks. This file should be stored as **/usr/local/bin/bdat** and can be soft-linked to the current working directory by the command ' **ln -s /usr/local/bin/bdat bdat** '.

The 'qlib' library file and the 'qq' post-processor dump file corresponding to the named restart dump (see below for definitions) are also required for restarting a problem making post-processor dumps. Note that KEPLER will overwrite information generated by the previous problem for duplicated cycles. Post-processor dump files not containing the restart cycle may also be in the working directory, but are not required.

POST-PROCESSOR FILES

If post-processor dumps have been requested in the generator file (or less desirably initiated by a command from the terminal), KEPLER will create a ('qlib') library file with a name in the form *NAMEP*.**lib** (e.g. ' **s25s2a.lib** ') which maintains a record of zonal mass coordinates and stores a time history of the time edit variables. A series of post-processor dump ('qq') files are also created starting with a file named in the form *NAMEP*.**qa** (e.g. ' **s25s2a.qa** ') which stores a compressed time history of the dump variables specified by **DUMP** commands or generator cards. These files are updated every NCYCQQ (P 299) cycles. The 'qlib' library file can store information for up to 20,000*NCYCQQ KEPLER cycles and up to 17,999 distinct grid points before becoming full. For ease in handling, however, the post-processor dump files are limited to a size of LENQMAX (P 44) whose default value is 3,000,000 bytes. New post-processor dumps will be created as required with suffixes in the sequence: **.qa, .qb,.... .qz, .q0... .q9, .ra, .rb,.... .rz, .r0... .r9**, etc.

The qlib library file must always stay on-line while the problem it corresponds to is running, but all but the most recent post-processor dump ('qq') files may be stored elsewhere if disk space is a problem. This will limit the range of possible **LOOK** and **TIMEMAP** commands (see below), however.

RESTART DUMP FILES

KEPLER will create a running restart ('z') file named in the form *NAMEP***z** (e.g. ' **s25s2az** '), which it overwrites every NDUMP (P 18) cycles. It will also create labeled restart dumps with names in the form *NAMEP#NCYC* (e.g. ' **s25s2az#12750** ') every NDUMP*NSDUMP (P 156) cycles, where where *NCYC* is the current cycle number. If a file with the name *NAMEP#NCYC* already exists, it will be overwritten.

ASCII OUTPUT FILES

KEPLER will also create ASCII output files with names in the form *NAMEP_NCYC0* (e.g. : ' **s25s2az_0** '), where *NCYC0* is the cycle number at which the problem is being generated or restarted. To prevent such files from becoming too large, however, the current output file is closed whenever MOD (NCYC, NNEWOUTF (P 197)) = 0 (by current default every 2000 cycles) and a new output file with a name in the form *NAMEP_NCYC* (e.g. : ' **s25s2az_2000** ') is created. Both of these types of ASCII output file will overwrite any file by the same name that might already exist.

DUMP-GRID STATUS FILES

If post-processor dumps are being made, KEPLER will also alternately create, read, and destroy files with names in the form *NAMEP.***0** and *NAMEP.***1** (e.g. : ' **s25s2a.0** ' and ' **s25s2a.1** ') which contain information about the grids currently being used to represent each requested dump variable. This reduces the size of the KEPLER executable file at the cost of some extra files on disk. If for any reason (restart, disk crash, etc.), these files are not available, KEPLER will automatically generate a new set of dump grids along with a warning message. This is not really a problem except that it takes up a little extra space in the post-processor dumps.

INTERACTIVE KEYBOARD COMMANDS

At the beginning of each cycle, the code checks for and executes commands that the user may have typed during the cycle. If it is in "stepping" mode (see the S command below), it acknowledges completion of the command with a '.' which serves as a prompt for the next command. If the code is in normal running mode, command completion is acknowledged by an **'ok'** and code execution continues. **'oops!'** is returned if the command can't be understood or if an argument has an inappropriate value, and code execution (or suspension) is continued.

Interactive keyboard commands may be entered more than one to a line by using commas as delimiters. The resulting construct is termed a "'keyboard message." The keyboard message may be up to 80 characters long and may contain any possible number of comma-delimited command lines, which are executed sequentially. Except as noted below, words representing input character variables are truncated to 8 characters, while numerical input is "field-free," except that floating point numbers must be distinguished from integers by a decimal point or exponent. The number of blank-delimited symbol(s)/word(s) in the current command line is limited to a maximum of 60.

Allowed interactive keyboard commands are listed below. Each command keyword is given in bold capital letters, followed by its arguments, if any, in italic capital letters. For the more complex commands, an example printed in boldface characters and enclosed in quotes is given, which also serves to indicate the type of the arguments. Note that, as indicated by the examples, actual communication with the computer should be made in lower case and that character parameters are never enclosed in quotes.

NORMAL PROGRAM MANAGEMENT COMMANDS

Here *J, N and M* stand for integers corresponding to allowed zone number where $N > M$; *IONSYM* is the ASCII symbol for one of the 'ions' in the APPROX, ISE or NSE networks, *ISOSYM* is the ASCII symbol for one of the isotopes in the current BURN coprocessor network, and *REACSYM* is the ASCII symbol for the editable nuclear reaction rates. A more detailed explanation of the edits that result from some of these commands is given in Chapter 9.

Command: **Meaning:**

D..... Force the restart dump to be updated to the current cycle.

D *NAME*..... Make a restart dump called *NAME* at the current cycle.

Normal Program Management Commands (Cont.)

E..... Make a current energy edit on the terminal.
ED..... Force an edit of the current cycle to be written in the Ascii output file.
ED *M*..... Force an edit with MEDIT (P 276) = *M*
EDP..... Force a parameter edit for the current cycle to be written in the output file.
END..... Terminate the problem.
FIN..... Same as **END**.
G..... Resume normal calculations after a suspension.

J ..... Make a current edit for zone *J* on the terminal.
J **I**..... Make a current edit of ion mass fractions for zone *J* on the terminal.
J **I** *IONSYM* ..... Edit the mass fraction of ion type *IONSYM* on the terminal.
J **B**..... Make an edit of BURN isotope mass fractions for zone *J* on the terminal.
J **B** *ISOSYM* ..... Edit the mass fraction of BURN isotope type *ISOSYM* on the terminal.
J **Q**..... Make a QNSE edit for zone *J* on the terminal.

SUMB *M N*..... Display an edit of the mass of all BURN isotopes in zones *M* thru *N* (M_O).
SUMB *M N ISOSYM*... Display an edit of the mass of burn isotope *ISOSYM* in zones *M* thru *N* (M_O).
SUMI *M N*..... Display an edit of the mass of all ions in zones *M* thru *N* (M_O).
SUMI *M N IONSYM*... Display an edit of the mass of ion *IONSYM* in zones *M* thru *N* (M_O).

P *N*..... Display the value of parameter name or number *N*.
P *N VALUE*..... Change the value of parameter name or number *N* to *VALUE*.
P *N DELTA* **ADD**..... Add *DELTA* to the value of parameter name or number *N*.
Q *N*..... Display the value of 'edit' parameter name or number *N*.

S..... Suspend execution, or step one cycle if suspended.
S *N*..... Run the problem for *N* more cycles, then suspend

T..... Make a current time edit on the terminal.
TED..... Display a 'short' ASCII edit on the terminal.
TED *M*..... Display an ASCII edit on the terminal with MEDIT (P 276) = *M*.
TIME..... Make an edit of computer time usage (in seconds).
TN..... Make a nuclear reaction rate edit on the terminal (moles/s -- over whole star).
TQ..... Make a combined time and surface edit on the terminal.

OTHER TERMINAL EDIT COMMANDS

EDITISO *[JINNER [JOUTER]]*
EDISO *[JINNER [JOUTER]]* (abbreviated form)
' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

TEST *TESTVAR J T D*
' test p 1 3.E+9 2.E+7 '

Gives a terminal edit of quantity *A* for the materials in zone *J*, but at the temperature *T* (K) and density *D* (g/cc) specified. *TESTVAR* is a variable symbol which may be any one of the following:

k..... Opacity (cm**2 /g).
s..... Energy Production Rate (ergs/g/s).
p..... Pressure (erg/cc).
e..... Energy (erg/g).

TN *REACSYM*
' tn he3+he4 '

Make an edit of the total rate of nuclear reaction *REACSYM* on the terminal.
Allowed values for *REACSYM* are:

p+p	**he3+he3**	**he3+he4**	**c12(pg)**	**n14(pg)**	(1-5)
o16(pg)	**3a-c12**	**n14(ag)**	**c12(ag)**	**c12+c12**	(6-10)
c12+o16	**o16+o16**	**o16(ag)**	**ne20(ag)**	**mg24(ag)**	(11-15)
si28(ag)	**s32(ag)**	**ar36(ag)**	**ca40(ag)**	**ti44(ag)**	(16-20)
cr48(ag)	**fe52(ag)**	**fe52:2ng**	**fe52:a2p**	**fe54:2pg**	(21-25)
he4-2n2p	**p(e-nu)n**	**n(e+nu)p**	**weak**		(26-29)

Here **p** denotes a proton; **n**, a neutron; **a**, an alpha particle; **g**, a gamma-ray; **nu**, a neutrino; and **ecap**, the rate for electron capture (ISE zones only). The values edited are the total net rates (forward-back) summed over the whole star (in moles/s).
**add reference by reaction number

Other Terminal Edit Commands (Cont.)

V *EDITVAR* [*JMIN* [*JMAX*]]

' v ionye 1 100 '

To make a terminal edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VERSION

Type out information about the dates on which the current code modules were last modified.

VF *EDITVAR* [*JMIN* [*JMAX*]]

' vf ionye 1 100 '

Same as the V command except that edited values are given to 14 decimal places instead of 3.

Z *EDITVAR1* [*EDITVAR2....EDITVAR10*] [*JMIN* [*JMAX*]]

' z dn tn sige sigi sigr 1 100 '

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX*. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

OTHER ASCII-OUTPUT-FILE EDIT COMMANDS

EDITISO *[JINNER [JOUTER]]*
EDISO *[JINNER [JOUTER]]* (abbreviated form)
' ediso 171 417 '

Make an edit of the isotopic yields, summed between zones *JINNER* and *JOUTER* inclusive, both on the terminal and in a special file with suffix '.yield'//*JINNER*. If *JINNER*=1, it is omitted from the suffix. This file overwrites any such existing file and is automatically sent to the laser printer ('lpr') to be printed.

EOSTABLE *JJ TLOW THI NTEMP DLOW DHI NRHO*
' eostable 1 1.E+6 1.E+9 20 1. 1.E+6 30 '

Using the composition from zone *JJ*, a table of EOS and opacity information is written into the normal ASCII output file for a logarithmic grid of temperatures (from *TLOW* to *THI* with *NTEMP* + 1 grid points) and densities (from *DLOW* to *DHI* with *NRHO* + 1 grid points). Here *TLOW* and *THI* are in degrees K and *DLOW* and *DHI* are in g/cc.

EOSTRANS *TRANSMULT*
' eostrans 1. '

Add *TRANSMULT* times the energy in nuclear excited states to all zonal specific energies. Useful in certain EOS transitions.

EOSWRITE *JTAB JJ NTEMP NRHO NEOSM*
' eoswrite 626 1 20 30 10 '

This command writes an EOS table identified by EOS # *JTAB* based on the composition of zone *JJ*, and having *NTEMP* temperature points and *NRHO* density points. This file is written after the last entry in ASCII file EOSKEP. If file EOSKEP does not exist, it is created with a sufficiently large size to contain *NEOSM* table sets. Before the **EOSWRITE** command is used, the TZ array must be set by the **TVAL** command so that it contains the *NTEMP* temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc). *NRHO* and *NTEMP* can sum to at most NTEMPZ (a parameter in KEPCOMS currently set to 60).

WARNING, WARNING, WARNING.....this command is no longer supported -- see version **.tw:kepn:kepn3/25** for the old coding if you want to try to revive it, but see **EOSTABLE** first.

Other Ascii-Output-File Edit Commands (Cont.)

LINKEDIT

Make an ascii file containing terse information on structure and composition, e.g. for linking a presupernova model to Wilson (or others). File name will be in the form probname@cyclenumber.

TVAL *N VAL1 [VAL2 VAL3 ..... VAL10]*

' tval 1 .1 .3 1. 3. 10. 30. 100. '

This command sets values in the temporary array TZ such that TZ(*N*), TZ(*N* + 1), ...etc. are respectively reset to *VAL1, VAL2,*...etc. At least one, and up to 10 values may be specified on each line. This command can be used (repeatedly if necessary) to set or change the TZ array so that it contains the *NTEMP* EOS table temperature points (in keV), immediately followed by the *NRHO* density points (in g/cc) required to specify EOS tables. (See the **EOSWRITE** command). Attempts to write beyond TZ(NTEMPZ), where NTEMPZ is a parameter currently set to 60, will generate an error message. Note that this information is **not** saved in the restart dump.

WARNING, WARNING, WARNING.....this command is no longer supported -- see version **.tw:kepn:kepn3/25** for the old coding if you want to try to revive it, but see **EOSTABLE** first.

VED *EDITVAR* [*JMIN* [*JMAX*]]

' ved ionye 1 100 '

This command makes an ASCII-output-file edit of the zonal edit variable denoted by *EDITVAR* from zones *JMIN* to *JMAX*, inclusive. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding values of *EDITVAR* is given in Chapter 7.

VEDF *EDITVAR* [*JMIN* [*JMAX*]]

' vedf ionye 1 100 '

Same as the **VED** command except that edited values are given to 14 decimal places instead of 3.

ZED *EDITVAR1* [*EDITVAR2....EDITVAR10*] [*JMIN* [*JMAX*]]

' zed dn tn sige sigi sigr 1 100 '

This command makes a columnar zonal edit of arrays *EDITVAR1* through *EDITVAR10* (if requested) for zones *JMIN* through *JMAX* in the current ASCII-ouput file. If only *JMIN* is specified, *JMAX* is assumed = *JMIN*. If neither *JMIN* or *JMAX* is given, then *JMIN* = 1 and *JMAX* = JM, the index of the current outer zone. A detailed list of the allowed edit variables and their corresponding

Other Ascii-Output-File Edit Commands (Cont.)

values of *EDITVAR* is given in Chapter 7. The first column in the edit gives the convection sentinel and the zone number, while the second column lists the interior mass in SCALEM (P 273) units. Values of the requested arrays start in column 3. At least one array must be requested, up to a maximum of 10. Note that 5 array requests fit nicely in an 80-column screen window, while 10 fill a 132 column edit page.

ZEDIT *IZED NCYCZED EDITVAR1* [*EDITVAR2....EDITVAR10*] [*ZEDMASS1* [*ZEDMASS2*]]

' zedit 1 50 dn tn sige sigi sigr 0. 2. '

This command causes a special multiple column ASCII edit of the specified zonal edit variables (*EDITVAR1*, etc.) to be written every *NCYCZED* cycles. A detailed list of the allowed zonal edit variables and their corresponding values of *EDITVAR* is given in Chapter 7. Here *IZED* is an index number (max of NZEDZ, which currently is 30 -- see KEPCOMS) that distinguishes separate **ZEDIT** requests, and *ZEDMASS1* and *ZEDMASS2* specify an optional interior mass range (in SCALEM (P 273) units) to be edited. If only *ZEDMASS1* is specified, a ±1% range around it is edited, and if no masses are specified, an edit of the whole star is made. Previously specified edits can be changed or terminated by overwriting them with a new **ZEDIT** command with the same index number. (Note: setting *NCYCZED* = 0 terminates the edit.)

GRAPHICS EDIT COMMANDS

ADDISO *ISOSYM1 [ISOSYM2 ... ISOSYM50]*

' addiso h1 he4 c12 o16 mg25 al26 '

This command adds the detailed isotopic abundances listed to those to be plotted by the "plot 6" or "look 6" commands. At least 1 and no more than 50 isotopic symbols (isosym1...isosym20) must be specified in the form: "addiso h1 he4 c12 o16 mg25 al26"

LISTISO

List the current set of isotopes to be plotted as set by the **SETISO** command.

LOOK *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]]
L *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] (Alternate form)

' look 31 10000 15000 1000 '

This command makes a movie of plot type *NPLOT* starting as closely as possible to cycle *NCYCL0* and ending as closely as possible to cycle *NCYCL1* at intervals as close as possible to *NDELCYCL* using information from the qq-files specified by **SETQ** or (by default) those available for the current problem. Plot types and output modes are as specified in the **PLOT** command and by the values of ITVSTART (P 127). Plot limits are assumed the same as those displayed for the current cycle by **PLOT** for this plot type, and can be adjusted using the usual graphics parameters (see Chapter 3). If not specified, *NCYCL1* is assumed to be equal to *NCYCL0*, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by IDTLOOK (P 302).

LPRINTL *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*]
LPL *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCl*]] [*FILENAME*] (Abbreviated form)

' lpl 3 10000 15000 1000 s25n2a.abun '

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCL0* in landscape orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by **SETQ** or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCL1*, or both NCYCL1 and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at 'look' cycle *NCYCL0* and continuing to 'look' cycle *NCYCL1* at intervals of *NDELCYCL*. A ':' followed by the current 'look' cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

Graphics Edit Commands (Cont.)

LPRINTP *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*]
LPP *NPLOT NCYCL0* [*NCYCL1* [*NDELCYCL*]] [*FILENAME*] (Abbreviated form)
' lpp 3 10000 15000 1000 s25n2a.abun '

Make a Postscript plot of plot-type *NPLOT* at cycle *NCYCL0* in portrait orientation on the local laser printer, where *NPLOT* is as defined in the plot command and use is made of information from the qq-files specified by **SETQ** or (by default) those available for the current problem. If a *FILENAME* is specified, then the picture is also saved in a Postscript file with that name. If *NCYCL1*, or both NCYCL1 and *NDELCYCL*, are given (before *FILENAME*, if any is specified), then a series of prints will be produced starting at 'look' cycle *NCYCL0* and continuing to 'look' cycle *NCYCL1* at intervals of *NDELCYCL*. A ':' followed by the current 'look' cycle number will be appended to the *FILENAME* specified (but limited to a total of 16 characters).

MAPLIM *[VMINMAP VMAXMAP [VRATMAP]]*
' maplim 7. 9. 1.e-5 '

This command defines the limits of the timemap variable by setting the values of parameters *VMINMAP* (P 328), *VMAXMAP* (P 329), and *VRATMAP* (P 330). If no arguments are given, the entire range of the variable is mapped. If the specified values of *VMINMAP* and *VMAXMAP* are equal, they are reset to 1.E+99 and -1.d+99, respectively, resulting in the actual range of the variable being limited only by *VRATMAP* (see P 328 - 330).

MLIM *[YMLOW YMHI]*
MLIM *['OLD']*
' mlim 2.1 10. '
' mlim old '

Set lower and upper limits on the mass coordinate used in making plots and timemaps to *YMLOW* and *YMHI* (in units of solar masses). This is accomplished by resetting YPLOTMIN (P 134) to *YMLOW**1.9892d+33/TOTM and YPLOTMAX (P 135) to *YMHI**1.9892d+33/TOTM. If no arguments are given, or if *YMLOW=YMHI*, then YPLOTMIN is set to 0. and YPLOTMAX is set to 1. If the second argument is the flag 'old' then the previous values of YPLOTMIN and YPLOTMAX are restored.

Graphics Edit Commands (Cont.)

MONGO *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]]
MON *EDITVAR2* [*EDITVAR3... EDITVAR8*] [*AXISY2* [*AXISY3*]] (Abbreviated form)
' mon dn tn log lin '

This command makes an X-Window plot of the first two zonal edit varaibles listed (*EDITVAR2* and *EDITVAR3)* vs. the mass coordinate specified by the value of parameter IRTYPE (P 132). It leaves the user in interactive MONGO, where he or she may modify or print the graph before typing **'end'** to return to KEPLER. Note that either ITVSTART must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result of the **PLOT** command) for this command to have any effect. The mass coordinate is loaded into MONGO data column 1, and the corresponding values of each zonal edit variable, *EDITVARI*, is loaded into MONGO data column *I*.

At least one, and no more than seven zonal edit variables (*EDITVAR2* thru *EDITVAR8*) must be specified from the list given in Chapter 7.

On entry into MONGO, graphs of the first one or two (if specified) variables are made automatically vs. the specified mass coordinate. The range of mass coordinate plotted is controlled by YPLOTMIN (P 134) and YPLOTMAX (P 135) which are the innermost and outermost mass fractions to plot. For most quantities, the ordinate is logarithmic by default (with negative data values, or a small range of values, defaulting the plot instead to linear), but can be set explicitly by setting *AXISY2* and/or *AXISY3* to **'lin'** or **'log'**. The code assumes that one **'lin'** or **'log'** value appended to the command line (after at least one *EDITVARI*) refers to *AXISY2*, the flag for plotting *EDITVAR2*. If two **'log'** or **'lin'** values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *EDITVAR2* and *EDITVAR3*, respectively. The flag **'same'** can also be used as the last word on the command line in order to set the axis type for plotting *EDITVAR3* to be the same as for *EDITVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The **'same'** flag can be proceeded by at most one **'lin'** or **'log'** flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive MONGO, you can (among other things):

Type **'curses'** to get mouse coordinate display, corresponding to the values of the last-defined axes.
Type **'help'** to get a list of interactive mongo commands.
Type the command sequence: **'psland filename' , 'play', 'hard'** to get a postscript file named **filename** containing the currently displayed plot. File **filename** must not already exist.
Type **'end'** to quit interactive MONGO.

Graphics Edit Commands (Cont.)

MONPL *ARRAYNAME2 ARRAYNAME3 ... ARRAYNAME8 [AXISY2 AXISY3]*

Like the 'MONGO' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

MONPP *ARRAYNAME2 ARRAYNAME3... ARRAYNAME8 [AXISY2 AXISY3]*

Like the 'MONGO' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

PLOT *NPLOT*

' plot 31 '

This command makes an X-Window plot of the status of the current problem of the type specified by plot number *NPLOT*. Note that either ITVSTART (P 127) must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result a previous **PLOT** command) for this command to have any effect. Currently allowed values of *NPLOT* are the same as those allowed for parameter IPIXTYPE (P 113) and produce the same types of plots:

<0 graphics window is not updated, but is still open.
=0 only header info is displayed.
=1 thermodynamics graph only.
=2 velocity graph only.
=3 elemental ('ion') mass-fraction graph only.
=4 entropy graph only.
=5 density-temperature graph only.
=6 isotopic mass-fraction graph (use the **SETISO** command first to determine the ions to be displayed).
=7 thru 9: only header info is displayed.
=10 thru 99: Two graphs will be displayed in split-screen fashion with the type of the top graph determined by the value of the first digit and the type of the second graph determined by the value of second digit as specified above.

Graphics Edit Commands (Cont.)

PRINTL [*NPLOT* [*FILENAME*]]
PL [*NPLOT* [*FILENAME*]] (Abbreviated form)
' pl 31 k '

This command makes a Postscript plot of the current problem status in landscape orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be IPIXTYPE (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If **'k'** is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

PRINTP [*NPLOT* [*FILENAME*]]
PP [*NPLOT* [*FILENAME*]] (Abbreviated form)
' pp 31 k '

This command makes a Postscript plot of the current problem status in portrait orientation on the local laser printer where *NPLOT* is the plot type defined in the same way as in the **PLOT** command. If *NPLOT* is not specified, it is taken to be IPIXTYPE (P 113). If *FILENAME* is specified, the picture is also saved in a Postscript file with that name (note that *NPLOT* must also be specified in this case). If **'k'** is given for *FILENAME*, a new file-name is generated automatically in the form *NAMEPROB:NCYC*, where *NAMEPROB* is the current problem name and *NCYC* is the current cycle.

SETISO *ISOSYM1* [*ISOSYM2* ... *ISOSYM50*]
' setiso h1 he4 c12 o16 mg25 al26 '

This command sets the detailed isotopic abundances to be plotted by the **'PLOT** 6' or **'LOOK** 6' commands. At least 1 and no more than 50 isotopic symbols (*ISOSYM2* ... *ISOSYM20*) must be specified from the set of current BURN isotopic symbols (see Chapter 7 for the usual list).

SETLIB [*NAMETLIB* [*NCYCT0* [*NCYCT1* [*NCYCTDEL* [*NCYCQQT* [*LENTDMPT* [*NIYMAXT*]...]
' setlib s25s2a.lib 0 18345 10 5 384 20000 '

This command sets the dump library file and associated parameters to be used in making time-plots. The optional arguments (and their default values if not specified) are defined as follows:

NAMETLIB..... Name of desired dump library file. The default is the one for the current job.
NCYCT0..... First dump cycle to be read and plotted. (Default is 0)
NCYCT1..... Last dump cycle to be read and plotted. (Default is last cycle in dump library)
NCYCTDEL..... The interval in dump cycles between dump library reads. (Default is NCYCQQ)

Graphics Edit Commands (Cont.)

NCYCQQT..... Number of cycles between dump library dumps. (Default is NCYCQQ).
LENDMPT..... Length of each time dump in *NAMETLIB*. (Default is 384)
NIYMAXT..... Maximum number of IY coordinate values in *NAMETLIB*. (Default is 20000)

IF **SETLIB** is not called, the default values are set when **TIMEPLOT** or **TP** is first called. Calling **SETLIB** without arguments resets all these variables to their default values if they have previously been changed by a **SETLIB** command.

SETQ [*NAMEQQL0* [*NAMEQQL1*]]
' setq s25s2a.qa s25s2a.qk '

This command sets the names of the qq-files to be post-processed by other commands such as **LOOK, LPRINT**, etc., where *NAMEQQL0* and *NAMEQQL1* are the first and last members of the sequence of qq-files to be read. Used without arguments, **SETQ** implies that all the qq files for the current problem in the current working directory are to be used. Note that this is the default situation for most post-processing commands and that **SETQ** only has to be used in this mode to restore the specified qq-files to this default. If only *NAMEQQL0* is specified, all available qq-files in the sequence starting with *NAMEQQL0* will be read. Note that qq-file names can be up to 16 characters long (at least on UNIX machines) and need not be those generated by the current problem.

TIMEMAP *NAMEVAR* [*LOGFLAG* [*NCYCL0* [*NCYCL1* [*NDELCYCL*]]]]
TM *NAMEVAR* [*LOGFLAG* [*NCYCL0* [*NCYCL1* [*NDELCYCL*]]]] (Abbreviated form)
' timemap convect lin 0 18750 1 '

This command makes a space-time map for zonal edit variable *NAMEVAR* starting as closely as possible to cycle *NCYCL0* and ending as closely as possible to cycle *NCYCL1*. It uses information from the qq-files specified by **SETQ** or (by default) those available for the current problem. *LOGFLAG* can be given as either **'log'** or **'lin'** to specify the desired scaling for the variable being displayed. The mass coordinate axis type and limits is set by the same parameters as for normal KEPLER plots. (See the comments for the timemap routine for other relevant input parameters). If not specified, *NCYCL1*, is assumed to be the last cycle for which information is available in the qq-files specified by **SETQ**, and *NDELCYCL* is assumed to be the cycle interval between post-processor dump writes multiplied by IDTLOOK (P 302). If a colormap whose name is in the form, *NAMEVAR*.map (e.g. **'convect.map'**), is available in the local directory (or as a second alternative, is in the directory **/usr/local/map**), it will be used to make the plot. Otherwise a simple default rainbow-style map, **/usr/local/map/spectral.map**, will be used. After the plot is made, the user can manipulate it further (including changing to a new variable and/or color map) by using the menus

displayed when the right mouse button is depressed. Depressing the left mouse button displays an overlay rectangle that can be positioned and/or stretched to indicate a time-space region to zoom into and replot. WARNING....This command currently only works on a Silicon Graphics terminal.

TIMEPLOT *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*]
TP *TIMEVAR2 TIMEVAR3...TIMEVAR8* [*AXISY2 AXISY3*] (Abbreviated form)
' timeplot eni enk enp log same '

This command makes an X-Window plot of the first two time-edit variables listed (*TIMEVAR2* and *TIMEVAR3)* vs. the time coordinate specified by the value of MAPTIME (P 327). It leaves the user in interactive MONGO, where he or she may modify or print the graph before typing **'end'** to return to KEPLER. Note that either ITVSTART must be set to 1 or an X Graphics Window for KEPLER must already be open (e.g., as a result of the PLOT command) for this command to have any effect. Unless a **SETLIB** command has previously been issued to the contrary, the time histories for these variables are read from the **'.lib'** file for the current problem for the entire range of available cycles. The time coordinate is loaded into MONGO data column 1, and the corresponding time sequence for each timeplot variable, *TIMEVARI*, is loaded into MONGO data column *I*.

At least one, and no more than seven time-edit variables (*TIMEVAR2* thru *TIMEVAR8*) must be specified from the list given in Chapter 8.

The range of the time coordinates plotted is controlled by TIMECMIN (P 321) and TIMECMAX (P 322) and defaults to the entire available range. For most quantities, the ordinate is logarithmic by default (with negative data values or a small range of values defaulting the plot instead to linear), but axis type can be set explicitly by setting *AXISY2* and/or *AXISY3* to **'lin'** or **'log'**. The code assumes that one **'lin'** or **'log'** value appended to the command line (after at least one *TIMEVARI)* refers to *AXISY2*, the flag for plotting *TIMEVAR2*. If two **'log'** or **'lin'** values are appended, they are interpreted as *AXISY2* and *AXISY3*, the flags for plotting *TIMEVAR2* and *TIMEVAR3*, respectively. The flag **'same'** can also be used as the last word on the command line in order to set the axis type for plotting *TIMEVAR3* to be the same as for *TIMEVAR2*, except that the axis limits are expanded to cover the extremes of both variables. The **'same'** flag can be proceeded by at most one **'lin'** or **'log'** flag specifying the common axis type. If an axis type is not given, a default value is chosen according to the character of the data.

Once in interactive MONGO, you can (among other things):

Type **'curses'** to get mouse coordinate display, corresponding to the values of the last-defined axes.
Type **'help'** to get a list of interactive mongo commands.
Type the command sequence: **'psland filename'** , **'play'**, **'hard'** to get a postscript file named **filename** containing the currently displayed plot. File **filename** must not already exist.
Type **'end'** to quit interactive MONGO.

Graphics Edit Commands (Cont.)

TPPL *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in landscape mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TPPP *TIMEVAR2 TIMEVAR3 ... TIMEVAR8 [AXISY2 AXISY3]*

Like the 'TIMEPLOT' command described above, except that the requested plot is printed in portrait mode on the local laser printer and MONGO quits, instead of the plot being displayed in an x-window and MONGO left in interactive mode.

TLIM *[TIMECMIN TIMECMAX]*
TLIM *['OLD']*

' tlim -15.3 -10. '
' tlim old '

Set limits on the time coordinate used in making timeplots and timemaps by resetting the values of TIMECMIN (P 321) and TIMECMAX (P 322) to the specified values. If no arguments are given or if TIMECMIN = TIMECMAX, then all available time points are plotted. Note that time-coordinate units are specified by MAPTIME (P 327) and must be floating point numbers. If the second argument is the flag 'old' then the previous values of TIMECMIN (P 321) and TIMECMAX (P 322) are restored.

YLIM *[Y2LOWMON Y2HIMON [SAME]]*
YLIM *[Y2LOWMON Y2HIMON [Y3LOWMON Y3HIMON]]*

' ylim 3. 5. '
' ylim 3. 5. same '
' ylim 3. 5. 0.44 0.5 '

This command sets the y-axes limits on MONGO plots. *Y2LOWMON* and *Y2HIMON* are the lower and upper limits for the variable plotted on the left-hand y-axis, while *Y3LOWMON* and *Y3HIMON* are the lower and upper limits for the variable plotted on the right-hand y-axis. If no arguments are specified for a given axis, or if their high and low values are equal, then the entire range of the corresponding variable will be plotted. If the flag 'same' is specified in place of the right-hand y-axis limits, they will be set to be the same as for the left-hand y-axis.

SPECIAL PURPOSE COMMANDS

ADDATMOS *NATMOS RHOATM1 [TEMPATM]*

' addatmos 10 3.e-12 '

Add an isothermal, exponential atmosphere to the surface of the star consisting of *NATMOS* zones and extending out to a density of *RHOATM1* (g/cc). The atmospheric conditions are scaled from the surface gravity, density, temperature and radius of the outer zone. The atmosphere is assumed to be thin (slab-like) compared to the star's radius and its composition is taken to be the same as that of the outer zone. If *TEMPATM* (degK) is specified, it is used instead of the temperature of the outer zone in constructing the atmosphere.

ADDLOOK *EDITVAR* [*DELFLAG*]

' addlook sneut delete '

Add zonal edit variable *EDITVAR* to the list of ('look') variables that subroutine READQ reads from the qq dump files. *DUMPVAR* may be any zonal edit variable listed in Chapter 7. If the second argument is present and is equal to **'delete'**, then variable *EDITVAR* is instead deleted from the list of look variables. Note that all current commands such as **PLOT** automatically load their own 'look' lists and then return the list to its original state when they're finished. Future commands, however, may require the use of **ADDLOOK**.

ADDSURF *NSURF TMSURF TEMPSURF RHOSURF VELSURF*

' addsurf 10 1.E+32 1.E+4 1.E-11 0. '

Add *NSURF* zones of equal mass totaling *TMSURF* total mass (g) with temperature, *TSURF* (K), density, *RHOSURF* (g/cc), velocity, *VELSURF* (cm/s), and the composition last specified by the **COMPSURF** command. Note that each time **ADDSURF** is called, the sum of the mass fractions in the COMPSURF array is normalized to unity.

ALIAS *NAMEA "COMMAND-STRING"*

' alias t1 "tq, 1, 1 i" '

Define alias *NAMEA* to invoke the command string *COMMAND-STRING*. *COMMAND-STRING* must be enclosed in double quotes and be less than 71 characters long. The command string may be a series of comma-delimited TTY commands. Note that the entire alias command may not exceed 80 characters and may not, itself, be comma-delimited. There is a limit of 200 (parameter NCSAVEDZ) total aliases.

Special Purpose Commands (Cont.)

BOX *BOX#*
'box v98'

Change the output box number to *BOX#* (three character symbol).

ADDWIND *NWIND WINDMASS RATEWIND VELWIND [VESCMULT[TEFFWIND[RADPWIND]]]*
' addwind 5 1.0e-5 1.e-4 10. 1. 3.098e+3 3.443e+13 '

Add *NWIND* zones of equal mass totaling *WINDMASS* (Msun) with mass-loss rate *RATEWIND* (Msun/year), terminal velocity *VELWIND* (km/s). Optional inputs are the escape-velocity multiplier *VESCMULT* (default=1.) and the effective photospheric temperature *TEFFWIND* (degK) and radius *RADPWIND* (cm) used in generating the wind profile. The mass-loss rate is assumed to stay constant at *RATEWIND* during the time these zones "took" to leave the surface of the star, and the velocity at any point is the sum of the local escape velocity times *VESCMULT* and the wind's terminal velocity *VELWIND*. The wind's local temperature is calculated by assuming that it is in LTE with the photosphere specified by *TEFFWIND* and *RADPWIND*. If no explicit values of these photospheric variables are given, they default to the existing photospheric temperature (*TEFF*) and radius (*RADIUS*). The composition of the wind is taken to be the same as that of the outer zone. Note that several ADDWIND commands can be used in succession to build up a wind with a time-dependent mass-loss rate, or to achieve non-constant-mass zoning.

CHECK

Type out the number of errors (NIOERR) the code has encountered sending out ASCII output files since the last restart. This command is only meaningful on a CRAY computer.

CHNGCOMP *JMIN JMAX FIRSTION# MFRAC1 [MFRAC2 ..... MFRAC8]*
' chngcomp 20 10 1 0. 0. 0. 0. 0. .5 0. .5 '

Change the composition in zones *JMIN* through *JMAX* to the ion mass fractions specified. At least one and up to eight mass fractions can be given on each command line. The compositions changed begin with that of the ion corresponding to ion number *FIRSTION#* and continue on in ion number order. For the APPROX network, the ion numbers correspond to: neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19]. (see Chapter 7 for the ion types and numbers in the ISE and NSE networks.) Repeated use of this command can set all the elements in the XNWCOMP array in subroutine TTYCOM (which is then used to change the zonal abundances). Mass fractions will be renormalized to sum to unity, and the

Special Purpose Commands (Cont.)

equation of state will be recomputed for the new composition. WARNING --Non-specified abundances are given whatever garbage values may have initially been in XNWCOMP, and multiple use of this command is complicated by the fact that the mass fractions of the current contents of the XNWCOMP array are renormalized to unity after ***each*** use. All old abundance information from these zones is disregarded. Check zonal compositions afterwards using the *"J I"* command.

****CAUTION****

Radically altering the composition in any zone may cause discontinuous changes in its internal energy, pressure, etc. and lead to convergence problems. Take special care in degenerate cases. The **NEWE** command may be useful here. **Note: The user takes full responsibility for any misleading and/or unphysical results that may be produced due to the use of this command.**

COMPSURF *FIRSTION# MFRAC1* [*MFRAC2 MFRAC3 ..... MFRAC10*]

' compsurf 1 0. .7 0. 0. .28 0. .02 '

Starting with its *FIRSTION#* th entry, set the values of the COMPSURF array in KEPCOMS equal respectively to *MFRAC1, MFRAC2, MFRAC3,* etc. At least one, and up to 10 such values can be given on each command line. Repeated use of this command can thus set all the elements of the COMPSURF array. These elements represent respectively the mass fractions of neutrons[1], H1 [2], photodisintegration protons [3], He3 [4], He4 [5], C12 [6], N14 [7], O16 [8], Ne20 [9], Mg24 [10], Si28 [11], S32 [12], Ar36 [13], Ca40 [14], Ti44 [15], Cr48 [16], Fe52 [17], Fe54 [18], and Ni56 [19] that are used to set the composition of the surface zones added by the **ADDSURF** command. Note that this array is stored in the restart dump for later use.

CUTSURF *NSURF*

' cutsurf 3 '

Remove *NSURF* zones from the surface of the star. PBOUND (P 69) and TBOUND (P 68) are automatically reset to correspond to the innermost zone removed. This option is sometimes useful in removing essentially "frozen" outer layers of the star so that available zones can be concentrated on core processing or to remove high velocity surface zones that are trying to form a stellar wind.

DECAYNI

Convert all Ni56 to Fe54 in such a way as to conserve mass, but with no energy generation.

Special Purpose Commands (Cont.)

DET *JDET0 JDET1 ENDET*

' det 1 30 7.867E+17 '

Add *ENDET* ergs/g to the specific energies of zones *JET0* to *JDET1*, inclusive, to simulate the passage of a detonation wave through these zones. Also change detonated zones to Ni56. This command should be used only for zones using the APPROX network, and is normally used in conjunction with setting TIMEX0 (P 38) to the current problem time (TIME, P 2), so that the decay energy from this "newly formed" Ni56 is appropriately deposited in the star (see P 38).

DUMP *DUMPVAR RATZDUMP RATIODEZ RATIOADZ*

' dump convect .1 -1. 0. '

Add dump variable *DUMPVAR* to the list of variables to be dumped to the qq post-processor dump file or change its dump parameters if it is already in the dump list. *DUMPVAR* may be any zonal edit variable listed in Chapter 7, and in addition it may take the values:

parm -- to dump the values of the changeable ('p') parameters, or

qparm -- to dump the values of the edit ('q') parameters.

The associated dump parameters which must be given for each variable are:

RATZDUMP -- the maximum allowed fractional change between dumps of the specified zonal dump variable.

RATIODEZ -- the minimum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is dezoned.

RATIOADZ -- the maximum fractional change of this zonal dump variable allowed between two adjacent dump grid points before the dump grid for the variable is adzoned.

In the case of **parm** and **qparm** the values of *RATIOADZ* and *RATIODEZ* are ignored but must be given. Note that the **DUMP** command for new variables is usually given in the problem generator file (see Chapter 2).

GENBURN *NAMEBG*

' genburn sol160bg '

Read BURN generator, *NAMEBG*, and begin BURN co-processing. Note that this command is usually given in the problem generator file (see Chapter 2).

LINK *NAMELINK*

' link linkwlsn '

Read and execute the LINK file named *NAMELINK*. The link file contains the information

Special Purpose Commands (Cont.)

needed to link the results of specialized core collapse calculations or parameterized models back to KEPLER in order to follow the subsequent explosion and nuclear processing. See the LINK subroutine and Chapter 6.

LISTA

List all aliases, including those not yet defined (which are denoted by "null").

MIX *NZMIN NZMAX DELMASS*

' mix 293 507 0.5 '

Mix composition outwards starting with zone *NZMIN* and ending with zone *NZMAX* in mass increments of *DELMASS* (solar masses). Reset the equation of state in mixed zones. Used for light-curve calculations to simulate Rayleigh-Taylor mixing.

NEWDUMPS

Reset all dump-file names and delete all old dump variables.

NEWE

Calculate new internal energies from current densities and temperatures. This is *usually* wise when changing EOS's in the middle of a problem via code modifications or changing EOS parameter settings. Note that total energies are also readjusted so that the resulting "virtual " energy nonconservation is not reflected in the energy edits.

NEWQNAME

Reset the names of the expected qq-file and qlib-file to reflect the current problem name.

NEWSTART

Reinitialize the problem by making an edit and restart dump of the current status of the problem, putting out output files, and storing dumps. This command is obsolescent and should not be used on UNIX machines without careful checking of the coding involved.

STORE *NSDIRECT*

' store /usr/leo/weaver/s25s2a '

Set the directory into which ASCII output files and labeled restart dumps will be written to *NSDIRECT*. If *NSDIRECT* is set to **'no-store'** (the default), output files will be placed in the current

Special Purpose Commands (Cont.)

working directory. The name of *NSDIRECT* may be up to 48 characters long.

SYSTEM *"COMMAND-STRING"*

' system "cd /usr/leo/weaver" '

Execute the system command, *COMMAND-STRING* (which must be enclosed in double quotes and be less than than 72 characters long). Note that the entire system command may not exceed 80 characters and may not, itself, be comma-delimited.

UNALIAS *NAMEA*

' unalias t1 '

Remove the previously defined alias *NAMEA*. If *NAMEA* is "all", then all aliases are removed, including those defined in the generator.

ZEROTIME

Set the problem time, TIME (P 2), to 0. Add the old value of TIME to TOFFSET (P 315). Also reset the **timen** array and take a small time step if BURN co-processing is being done.

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CHAPTER 6

LINK INPUT FILE

LINK input files allow information derived from other codes (especially detailed core collapse calculations) or from parameterized models to be introduced into KEPLER. Typically this information specifies that a certain mass at the center of the star is to be removed and replaced with a time dependent inner boundary condition whose motion and neutrino emission acts like a "piston" to explode the outer layers of the star. The format conventions in LINK file command lines (called "cards" for historical reasons) and those for generator cards are identical (see Chapter 2).

A link input file named *NAMELINK* is read into KEPLER when the command **LINK** *NAMELINK* (e.g.: ' **link linkwlsn** ') is issued from the terminal (see Chapter 5). Allowed LINK file cards are listed below.

LINK INPUT CARDS

CUT *JCORE*
' cut 57 '
Core Cut Card (optional).
Remove the inner *JCORE* zones from the center of the star. Add their mass to SUMM0 (P 61), the boundary condition parameter giving the mass inside the inner boundary of the calculation.

APPROX *JLO JHI*
' approx 1 9 '
APPROX Network Card (optional).
Change zones between *JLO* and *JHI* to the APPROX network (if not already using it). The code

assumes that non-APPROX zones are either NSE or ISE zones and repacks the abundance array appropriately to put it into APPROX format. Since the ISE abundance array does not store information on (the usually very small) abundances of ions **h1, he3, c12, n14,** and **ne20,** these end up being zeroed in going to APPROX. Also, isotopes more neutron rich than ^{54}Fe (e.g. ^{56}Fe) are stored as **fe52** in such a way as to conserve mass (but not Y_e -- also see the **"YESET"** command below). This command should not be used (or be rewritten) if the resulting abundance of **"fe52"** is significant. In its current form, it is intended to be used to transform relatively unneutronized zones containing newly synthesized ^{56}Ni and/or ^{54}Fe which the APPROX network is able to deal with sensibly. Remember to turn on low-temperature ^{56}Ni decay (if desired) by resetting TIMEX0 (P 38), and, if desired, TIME (P 2).

PST *TIME(I)* *INNER-RADIUS(I)*
' pst 0. 1.0072e+7
pst 1.e+10 1.0072e+7 '

Piston Cards (Optional, but at least two required if any are specified).
This card specifies the radius of the inner boundary of the problem, *INNER-RADIUS(I),* in cm at time, *TIME(I),* in seconds. A series of such cards with monotonically increasing values of *TIME(I)* are used to build up a discrete time history of the inner problem boundary, which the code uses to get intermediate values by interpolation. If the *INNER-RADIUS(I)* given is 0., this serves as a flag for the code to reset its value to RADIUS0 (P 60), so that a higher precision value can given. This is sometimes useful in treating compact configurations such as surface layers on neutron stars. The range of times covered must exceed the range of times for which the problem is to be run and at least two piston cards must be specified. The code does not remember data from **"PST"** cards in any previously read LINK decks, but *does* remember this current **"PST"** data in restart dumps. Currently, a maximum of NPISTZ = 300 **"PST"** cards are allowed. (Here, NPISTZ is a FORTRAN parameter set in KEPCOMS).

NFLUX *TBOUNCE FLUXNU0 A0 CHI0 A1 CHI1 A2 CHI2*
' nflux 0.21569 9.e+24 2.5e-8 8.0e+7 0.25e-8 8.0e+8 0.4e-8 2.2e+9 (typical) '
' nflux 0.223 0. 0. 0. 0. 0. 0. 0. (no flux) '

Neutrino Flux Card (optional).
This card contains the fitting coefficients for the "reduced" neutrino momentum flux, FLUXNU, in the form:

FLUXNU (TIME, R0) = *FLUXNU0* / ((1. + EXP (-*A0* * (CHI - *CHI0*))) *

(1. + EXP (-*A1* * (CHI - *CHI1*))) * (1. + EXP (+*A2* * (CHI - *CHI2*))),

where CHI = C * (TIME - *TBOUNCE*) - R0 , C is the speed of light (cm/sec), TIME is the current problem time (P 2) in seconds, and R0 is the radius in cm. (See REGESS). Here *TBOUNCE* has units of seconds; CHI, *CHI0, CHI1,* and *CHI2* have units of cm; *A0, A1,* and *A2* have units of cm^{-1}; and FLUXNU and *FLUXNU0* have units of cm**3 / sec**2. Note the positive coefficient of *A2* in this fit.

Basically, this fit represents the neutrinos as a wave that propagates outward from the inner boundary without significant attenuation. In a typical case, such as that given in the example, this wave turns on exponentially near retarded time *CHI0,* peaks about retarded time *CHI1,* and decays away exponentially near retarded time *CHI2.* The acceleration of the matter due to scattering with this neutrino wave is then given by ABAR * FLUXNU / R0**2 cm/sec**2, where ABAR is the average atomic weight. This scattering is currently assumed to be elastic, and no thermal energy is deposited. Typically FLUXNU is derived from edits of neutrino-induced acceleration in the inner mantle zones of detailed core collapse calculations, such as that of Wilson and coworkers. [See 7/25/78 KEPLER notes.]

YE	*ARBITRARY*	*INTERIOR-MASS(I)*	*YEQ0(I)*
'ye	**1**	**0.**	**0.48**
ye	**2**	**2.**	**0.50 '**

Y_e Cards for ISE initialization. (Optional, but at least two are required if any are given).

ARBITRARY is an arbitrary, but required, value that is generally used to number the "YE" cards.

INTERIOR-MASS(I) is the interior mass coordinate (in solar masses) for this Y_e point.

YEQ0(I) (moles/g) is the value of Y_e to be used to initialize new ISE zones at this mass coordinate.

A series of such cards with monotonically increasing values of *INTERIOR-MASS(I)* are used to build up a discrete representation of the post-oxygen burning Y_e profile, which the code uses to get intermediate values by linear interpolation (see subroutine SDOT). Out of the range of mass coordinates specified by such a set of "YE" cards, the code uses the minimum of the current (APPROX-generated) value of Y_e and YEMAX (P 323 -- default = 0.498 moles/g) in order to initialize a new ISE zone. The code does not remember data from "YE" cards in any previously read LINK decks, but *does* remember this current "YE" data in restart dumps.

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CHAPTER 7

ZONAL EDIT AND DUMP VARIABLES

GENERAL

This chapter lists the currently defined zonal edit variables by type. An alphabetical summary is given in Appendix C. Any of these variables can be edited in various ways by name (or list of names) or specified as a variable to be included in the post-processor dumps using the **DUMP** command or generator card (see Chapters 5 and 2, respectively). The **V**, **VF**, and **Z** commands are used to make terminal edits of these zonal edit variables. Periodic edits to the Ascii output file can be made automatically while the problem is running by using the **ZEDIT** command, while edits on demand to the output file are made in various formats by the **VED**, **VEDF**, and **ZED** commands. In addition, X-Window and Postscript plots can be made of the current values of these variables using the **MONGO** or **MON** commands, while a color-coded 'timemap' of each variable's space-time history can be made on Silicon Graphics workstation monitors using the **TIMEMAP** or **TM** commands.

The list of zonal edit variables given here is easily extensible, as indicated in the sections on EDITCOM and miscellaneous edit variables below. In addition, KEPLER will automatically incorporate changes in the BURN and ISE isotope networks into the lists of isotopes and ISE-quantities that can be edited.

KEPCOM ZONAL INTERFACE ARRAY VARIABLES

ym..... Exterior mass coordinate (g).
rn..... Radius of outer zone boundary (cm).
rd..... Calculated change in radius (cm) -- during a cycle;
Radius at last timestep (cm) -- at the end of a cycle.
un..... Velocity of the outer zone boundary (cm/s).
xln..... Calculated non-neutrino luminosity at the outer zone boundary (erg/s).
qln..... Converged non-neutrino luminosity at the outer zone boundary (erg/s).
qld..... Calculated change in converged luminosity (erg/s) -- during a cycle;
Converged luminosity at last timestep (erg/s) -- at the end of a cycle.
difi..... Diffusion coefficient for material mixing due to convection (cm**2/s).

KEPCOM ZONE-CENTERED ARRAY VARIABLES

netnum..... Number of the nuclear network currently used in the zone.
xm..... Zonal mass (g).
dn..... Density (g/cc).
tn..... Temperature (K).
td..... Calculated change in temperature (K) -- during a cycle;
Temperature at last timestep (K) -- at the end of a cycle.
en..... Specific energy density (erg/g).
pn..... Pressure (erg/cc)
zn..... Viscous stress -- including linear and quadratic artificial viscosity (ergs).
etan..... Electron degeneracy parameter (μ_e / kT).
sn..... Total energy generation rate -- including neutrino losses (erg/g/s).
snn..... Nuclear energy generation rate -- excluding neutrino losses (erg/g/s)
abar..... Mean atomic weight (g/mole).
zbar..... Mean atomic charge.
xkn..... Rosseland mean opacity (cm**2/g).
xnei..... Number density of ionized electrons (electrons/cc) -- **not implemented yet.**
stot..... Total zonal entropy (k/baryon).
dsold..... Density at which the energy generation rate was last calculated (g/cc).
tsold..... Temperature at which the energy generation rate was last calculated (K).
snold..... Last calculated energy generation rate (erg/g/s).
snbd..... Last calculated partial derivative of the energy generation rate with respect to density (s*cm**5/g).
snbt..... Last calculated partial derivative of the energy generation rate with respect to temperature (erg/g/s/K).
abarold..... Last calculated value of ABAR
abarnbd..... Last calculated partial derivative of ABAR with respect to density (cc/g).
abarnbt..... Last calculated partial derivative of ABAR with respect to temperature (1/K).
ypbtime..... Last calculated total time derivative of the proton abundance (mole/g/sec).
ynbtime..... Last calculated total time derivative of the proton abundance (mole/g/sec).

KEPCOM BURN COPROCESSOR ARRAY VARIABLES

netnumb..... Number of the BURN isotopic nuclear network used in this zone.

limnuc..... Integer containing the Z and A of the isotope controlling the BURN timestep along with the KEPLER cycle that this zone was last burned coded in the form:

LIMNUC = A + 100*Z + 10000* NCYC

timen..... Time to which the BURN coprocessing in this zone has been updated (sec).

dtimen..... Current timestep for BURN coprocessing in this zone (sec).

dnold..... Density at which BURN coprocessing was last done in this zone (g/cc).

tnold..... Temperature at which BURN coprocessing was last done in this zone (K).

ymb..... Mass interior to the outer boundary of this zone, as last considered by the BURN coprocessor (g).

sburn..... BURN nuclear energy generation rate, excluding neutrino losses (erg/g/s).

etab..... Burn neutron excess (moles/g). The corresponding BURN electron abundance is given by: **yeburn** = 0.5 * (1. - **etab**)

pbuf..... Abundance buffer (internal working array -- see CONVECTB) (moles/g).

ZONAL 'ELEMENTAL' MASS FRACTIONS AND RELATED VARIABLES

The edit or dump variables corresponding to the elemental mass fractions of the 'ions' involved in the APPROX, NSE, and ISE networks take the form, **'ionfe54'**, where **fe54** exemplifies any valid network 'ion' symbol. Valid ion symbols are shown below in **bold-face** letters in the table that follows. The symbol with which each ion's curve is labeled in abundance plots is shown in square brackets, followed by (in the case of ISE or NSE) the isotopes whose mass fractions are explicitly summed to get each 'elemental' mass fraction. A list of the precise isotopes included is given on the next page.

ION#	APPROX Network		ISE and NSE Networks		
1	**nt1**	[n]	**nt1**	[n]	(neutron only)
2	**h1**	[H]	**ye**	[none]	(electron abundance)
3	**pn1**	[p]	**pn1**	[p]	(proton only)
4	**he3**	[^{3}He]	**yq**	[none]	($A \geq 24$ abundance)
5	**he4**	[He]	**he4**	[He]	($2 \leq A \leq 5$)
6	**c12**	[C]	**yf**	[none]	($A > 46$ plus ^{46}Ti abundance)
7	**n14**	[N]	**eb0**	[none]	(binding energy / nucleon)
8	**o16**	[O]	**o16**	[O]	('unburned' ^{16}O only)
9	**ne20**	[Ne]	**fe56**	[^{56}Fe]	(^{56}Fe only)
10	**mg24**	[Mg]	**mg24**	[Mg]	($23 \leq A \leq 28$, ex. ^{28}Si)
11	**si28**	[Si]	**si28**	[Si]	(^{28}Si only)
12	**s32**	[S]	**s32**	[S]	($29 \leq A \leq 35$)
13	**ar36**	[Ar]	**ar36**	[Ar]	($36 \leq A \leq 39$)
14	**ca40**	[Ca]	**ca40**	[Ca]	($40 \leq A \leq 43$)
15	**ti44**	[Ti]	**ti44**	[Ca]	($44 \leq A \leq 47$)
16	**cr48**	[Cr]	**cr48**	[Cr]	($48 \leq A \leq 51$)
17	**fe52**	[^{52}Fe]	**'fe'**	['Fe']	($A \geq 2*Z + 4$ Iron Peak, ex. ^{56}Fe)
18	**fe54**	[Fe]	**fe54**	[Fe]	($A \approx 2*Z + 2$ Iron Peak)
19	**ni56**	[Ni]	**ni56**	[Ni]	($A \leq 2*Z + 1$ Iron Peak)

The distinction between **h1** and **pn1** in the APPROX network is that the former represents unburned hydrogen, while the latter represents protons resulting from photodisintegration. This separation makes inverting the resulting reaction matrix more efficient. Note also that, while not explicitly included in the APPROX network, flows proceeding through the ~~elements~~ Isotopes ^{27}Al, ^{31}P, ^{35}Cl,

^{39}K, ^{43}Sc, ^{47}V, ^{51}Mn, ^{55}Co, ^{53}Fe, and ^{2}H are included implicitly by assuming that their abundances are in steady state with their neighboring nuclei (see WZW78).

For zones using the ISE or NSE networks, the exact list of isotopes whose mass fractions are summed to get the edited values for each 'ion' symbol are as follows:

ionnt1 = **nt1**

ionpn1 = **pn1**

ionhe4 = **h2 + h3 + he3 + he4 + he5 + li5** ($2 \le A \le 5$)

ionmg24 = **na23 + mg24 + mg25 + mg26 + al26 + al27 + al28** ($23 \le A \le 28$)

iono16 = **o16**

ionsi28 = **si28**

ions32 = **si29 + si30 + p30 + p31 + s31 + p32 + s32 + p33 + s33 + s34 + cl35** ($29 \le A \le 35$)

ionar36 = **cl36 + ar36 + cl37 + ar37 + ar38 + ar39 + k39** ($36 \le A \le 39$)

ionca40 = **ar40 + k40 + ca40 + k41 + ca41 + k42 + ca42 + k43 + ca43 + sc43** ($40 \le A \le 43$)

ionti44 = **ca44 + sc44 + ti44 + sc45 + ti45 + ca46 + sc46 + ti46 + sc47 + ti47 + v47** ($44 \le A \le 47$)

ioncr48 = **ca48 + sc48 + ti48 + v48 + cr48 + sc49 + ti49 + v49 + cr49 + ti50 + v50 + cr50 + ti51 + v51 + cr51 + mn51** ($48 \le A \le 51$)

ion'fe' = **ti52 + v52 + cr52 + v53 + cr53 + v54 + cr54 + mn54 + cr55 + mn55 + cr56 + mn56 + mn57 + fe57 + mn58 + fe58 + co58 + fe59 + co59 + fe60 + co60 + ni60 + fe61 + co61 + ni61 + fe62 + co62 + ni62 + co63 + ni63 + co64 + ni64 + ni65 + ni66** ($A \ge 2*Z + 4$ Iron Peak)

ionfe54 = **mn52 + mn53 + fe54 + fe55 + co56 + co57 + ni58 + ni59** ($A \approx 2*Z + 2$ Iron Peak)

ionni56 = **fe52 + fe53 + co54 + co55 + ni56 + ni57 + cu59 + zn60** ($A \le 2*Z + 1$ Iron Peak)

ionfe56 = **fe56**

The special cases where the edit variables formed from the 'ion' symbols listed do not correspond to 'elemental' mass fractions are as follows:

ionye..... Electron abundance in any current (non-BURN) network (moles/g).
ionyq..... Total abundance of ISE or NSE isotopes with A $\geq$ 24 (moles/g).
ionyf..... Total abundance of ISE or NSE isotopes with A > 46 plus ^{46}Ti (moles/g).
ioneb0..... Mean binding energy per nucleon of all ISE or NSE isotopes (MeV).

ISE EDIT QUANTITIES

Zonal edit variables for ISE network isotopic mass-fractions, weak rates, and related quantities can be referenced in the form: **'insefe56'** where **'nse'** is a fixed flag, **'fe56'** represents the symbol of an isotope in the ISE network (stored in array NUCSYMD in subroutine QNSE – see below), and **'i'** represents a variable flag depending on which isotopic quantity or rate is desired.

'i' may take the values:

'i' .....to get the isotopic mass fraction,
'w' .....to get the isotopic statistical weight,
'r' ..... to get the total weak interaction rate due to this isotope (moles/g/sec),
'c' ..... to get the electron capture rate due to this isotope (moles/g/sec),
'p' ..... to get the positron emission rate due to this isotope (moles/g/sec),
'b' ..... to get the beta decay rate due to this isotope (moles/g/sec),
'e' ..... to get the total neutrino energy loss due to this isotope (ergs/g/sec),
'k' ..... to get the neutrino energy loss due to e^- capture and e^+ decay on this isotope (erg/g/sec),
'x' ..... to get the energy stored in the excited states of this isotope (MeV/nucleus).

The symbols of the 125 isotopes comprising the ISE (and NSE) network are:

n1	**h1**	**h2**	**h3**	**he3**	**he4**	**he5**	**li5**	**c12**	**o16**	(1-10)
ne20	**na23**	**mg24**	**mg25**	**mg26**	**al26**	**al27**	**al28**	**si28**	**si29**	(11-20)
si30	**p30**	**p31**	**s31**	**p32**	**s32**	**p33**	**s33**	**s34**	**cl35**	(21-30)
cl36	**ar36**	**cl37**	**ar37**	**ar38**	**ar39**	**k39**	**ar40**	**k40**	**ca40**	(31-40)
k41	**ca41**	**k42**	**ca42**	**k43**	**ca43**	**sc43**	**ca44**	**sc44**	**ti44**	(41-50)
sc45	**ti45**	**ca46**	**sc46**	**ti46**	**sc47**	**ti47**	**v47**	**ca48**	**sc48**	(51-60)
ti48	**v48**	**cr48**	**sc49**	**ti49**	**v49**	**cr49**	**ti50**	**v50**	**cr50**	(61-70)
ti51	**v51**	**cr51**	**mn51**	**ti52**	**v52**	**cr52**	**mn52**	**fe52**	**v53**	(71-80)
cr53	**mn53**	**fe53**	**v54**	**cr54**	**mn54**	**fe54**	**co54**	**cr55**	**mn55**	(81-90)
fe55	**co55**	**cr56**	**mn56**	**fe56**	**co56**	**ni56**	**mn57**	**fe57**	**co57**	(91-100)
ni57	**mn58**	**fe58**	**co58**	**ni58**	**fe59**	**co59**	**ni59**	**cu59**	**fe60**	(101-110)
co60	**ni60**	**zn60**	**fe61**	**co61**	**ni61**	**fe62**	**co62**	**ni62**	**co63**	(111-120)
ni63	**co64**	**ni64**	**ni65**	**ni66**						(120-125)

```
                                #  Normally, this parameter is used to reset certain parameter
                                #  values following carbon depletion.

o16odep     /-1.d+99/           #(p 332) If the central oxygen abundance is .le. O16ODEP and the central
                                #  temperature is  .ge. TQSELIM (P 184), then make a restart dump
                                #  labeled '#odep', execute the alias-defined "odep" command, and
                                #  reset O16ODEP to -1.E+99.
                                #  Normally, this parameter is used to reset certain parameter
                                #  values at oxygen depletion.

tempchar    /1.d+99/  [K]       #(p 333) If the central temperature is .ge. TEMPCHAR,
                                #  then make a restart
                                #  dump labeled with '#tn' and the current cycle number, reset

                                #  TEMPCHAR to 1.E+99, and finally execute the alias-defined
                                #  "tnchar" command.
                                #  Note that the user -defined "tnchar" command can change
                                #  the value of TEMPCHAR in such a way as to cause the "tnchar"
                                #  command to be issued recursively (i.e., by using the command:
                                #  "P  N  DELTA  ADD" -- see Chapter 5).

denchar     /1.d+99/  [g/cc]    #(p 334) If the central density is .ge. DENCHAR, then make a restart
                                #  dump labeled with '#dn' and the current cycle number, reset

                                #  DENCHAR to 1.E+99, and finally execute the alias-defined

                                #  "dnchar" command.
                                #  Note that the user -defined "dnchar" command can change
                                #  the value of DENCHAR in such a way as to cause the "dnchar"
                                #  command to be issued recursively (i.e., by using the command:
                                #  "P  N  DELTA  ADD" -- see Chapter 5).

abarchar    /1.d+99/            #(p 335) If the central mean atomic weight (ABAR) is .ge. ABARCHAR,
                                #  then make a restart dump labeled with '#ab' and the current
                                #  cycle number, reset ABARCHAR to 1.E+99, and finally execute

                                #  the alias-defined "abchar" command.
                                #  Note that the user -defined "abchar" command can change
                                #  the value of ABARCHAR in such a way as to cause the "abchar"
                                #  command to be issued recursively (i.e., by using the command:
                                #  "P  N  DELTA  ADD" -- see Chapter 5).

tshock      /1.d+99/  [sec]     #(p 343) If the problem time is .ge. TSHOCK, then make a restart dump
                                #  labeled '#shock', reset TSHOCK to 1.E+99, and finally execute
                                #  the alias-defined "tshock" command.
                                #  Normally, this command is used to reset certain parameter values
                                #  and/or make edits at the time of the piston-induced bounce of the
                                #  collapsing iron core that creates an out-going shock wave.

tnucleo     /1.d+99/  [sec]     #(p 344) If the problem time is .ge. TNUCLEO, then make a restart dump
                                #  labeled '#nucleo', reset TNUCLEO to 1.E+99, and finally
                                #  execute the alias-defined "tnucleo" command.
                                #  Normally, this command is used to reset certain parameter
                                #  values and/or make edits at a time just after explosive
                                #  nucleosynthesis is complete.

tenvel      /1.d+99/  [sec]     #(p 345) If the problem time is .ge. TENVEL, then make a restart dump
                                #  labeled '#envel', reset TENVEL to 1.E+99, and finally execute
                                #  the alias-defined "tenvel" command.
                                #  Normally, this command is used to reset certain parameter
                                #  values and/or make edits just before the supernova shock wave
                                #  breaks through the surface of the presupernova star.


%c....Other Execution-Control Parameters
#**********|*********|********|*************************************************************************

iautoout    /0/                 #(p 159) Send out two copies of the ASCII output if IAUTOOUT>1.
                                #  Also send out two copies of the graphics output if
                                #  IAUTOOUT>2.  Note:  No output files are destroyed.
                                #  (CRAY only! -- this is an obsolescent parameter that should
                                #  not be used on UNIX machines without recasting.)

fraccore    /1.1/               #(p 161) The effective number of zones used in REGESS (JMCALC)
                                #  shall be the minimum needed to contain the inner
                                #  FRACCORE mass-fraction of the initial mass of the star.

jmcalc      /jmz/               #(p 162) Effective number of zones used in subroutine REGESS.
                                #   JMCALC is  internally calculated from FRACCORE  and
                                #   should not be changed.
jpause      /-1/                #(p 192) Pause the code at the end of the calculation for zone

                                #  J = JPAUSE  in REGESS ("PAUSE 1") and in
                                #  UPDATE ("PAUSE 2").  Do not pause if JPAUSE < 0.
                                #  Type a carriage return to continue.


#**************************|*************************************************************************
***General Edit Par          /edit par/    Parameters  EDIT:
```

```
%c....General Edit Control Parameters
#**********|*********|********|*************************************************************************

nedit      /20/                #(p 16) Number of cycles between ASCII edits.


dtedit     /0./       [sec]    #(p 17) Time between ASCII edits (0. = infinity)  (sec).


npixedit   /50/                #(p 64) Graphics edits to the monitor are made every NPIXEDIT
                               #  KEPM-hER cycles (if P 127 > 0).

abunlim    /1.d-3/             #(p 128) Least elemental mass fraction plotted or listed in a
                               #  terminal ion edit.

nnewoutf   /2000/              #(p 197) Start a new labeled ASCII output file every NNEWOUTF cycles.

npage      /53/                #(p 268) Number of lines printed per "page" of ASCII output.
                               #  The value 53 causes zone lists to be printed in 50-zone blocks.

scalem     /1.9892d+33/ [g]    #(p 273) Mass unit used for the mass coordinate employed in making
                               #  ASCII and terminal edits (g).

neditz1    /10/                #(p 274) Make an ascii edit of primary zonal quantities every
                               #  NEDITZ1*NEDIT (P 16) cycles.

neditz2    /20/                #(p 275) Make an ascii edit of secondary zonal quantities every
                               #  NEDITZ2*NEDIT (P 16) cycles.

nedita     /10/                #(p 243) Make an elemental abundance edit every NEDITA*NEDIT
                               #  (P 16) cycles.

neditp     /50/                #(p 278) Make an ascii edit of all changeable parameters every
                               #  NEDITP*NEDIT (P 16) cycles.

medit      /0/                 #(p 276) Flag determining the minimum amount of information printed in
                               #  an ascii cycle edit regardless of the settings of other edit
                               #  parameters:
                               #    .le. 0  means minimum is a 1 page "short" edit;
                               #    .ge. 1  means minimum includes a primary zonal edit;
                               #    .ge. 2  means minimum includes a secondary zonal edit;
                               #    .ge. 3  means minimum includes an ion abundance edit;
                               #    .ge. 4  means minimum includes an ISE abundance edit;
                               #    .ge. 5  means minimum includes a BURN isotope edit;
                               #    .ge. 6  means minimum includes a BURN isotope edit for all zones;
                               #    .ge. 7  means minimum includes a parameter edit.

meditfin   /7/                 #(p 277) Effective value of MEDIT (P 276) used in determining the scope
                               #  of the final edit made when the problem is finished.


#**************************|*************************************************************************
****ISE_Edit_Par             /ised_par/   Parameters  ISEEDIT:
#**********|*********|********|*************************************************************************


%c....ISE Edit Parameters
#**********|*********|********|*************************************************************************

njeditq    /10/                #(p 168) Make a ISE edit every NJEDITQ zones.

neditq     /20/                #(p 180) Make a detailed edit of the ISE zones every NEDITQ
                               #  general numerical edits.

xthres     /1.d-4/             #(p 183) Edit only those ISE isotopes with mass fractions exceeding
                               #  XTHRES.

neditq1    /5/                 #(p 198) Make an ISE edit for the central zone every NEDITQ1 * NEDIT
                               #  (P 16) cycles.


#**************************|*************************************************************************
****Burn_Edit_Par            /bned_par/   Parameters  BURNEDIT  BURN:
#**********|*********|********|*************************************************************************


%c....Burn Edit Parameters
#**********|*********|********|*************************************************************************

neditb     /5/                 #(p 241) Make a BURN isotopic abundance edit every NEDITB*NEDIT
                               #  (P 16) KEPLER cycles.

jmeditb    /1/                 #(p 244) Edit only zones whose zone number is .le. JMEDITB during

                               #  normal BURN isotopic abundance edits.

neditall   /100/               #(p 245) Make a BURN isotopic abundance edit for all zones every
```

```
abunlimb    /1.d-5/             #(p 272) Edit only those BURN isotope mass-fractions whose values
                                #  exceed ABUNLIMB in making terminal edits (including
                                #  isotopic mass-fraction sums over zones).

ncomp       /999999/            #(p 250) Make a complete ASCII edit of the nuclear processes in all
                                #  zones considered by the BURN coprocessor every NCOMP cycles.

ncent       /999999/            #(p 251) Make an ASCII edit of the nuclear processes in the central zone
                                #  considered by the BURN coprocessor every NCENT cycles.

nedt        /999999/            #(p 252) Make an ASCII edit of the nuclear processes involved every nedt
                                #  BURN coprocessor matrix inversions (debugging only).


#**************************|*********************************************************************
****Dump_Par                 /dump_par/   Parameters  DUMP  CYCLE:
#**********|*********|********|*********************************************************************


%c....Restart Dump Control Parameters
#**********|*********|********|*********************************************************************

ndump       /10/                #(p 18) Number of cycles between restart dumps.

nsdump      /10/                #(p 156) Save every NSDUMP restart dumps.

nsavez      /24/                #(p 269) Total number of nonBURN zonal arrays to save in restart dumps.
                                #  These arrays are listed in KEPCOMS, starting with YM and
                                #  numbering NZONEI + NZONEC in total.    NSAVEZ  must be
                                #  at least 14 and no greater than NZONEI + NZONEC.  Saving
                                #  more than the minimum number of arrays needed to restart the
                                #  problem is often useful for edit purposes.

nsaveb      /10/                #(p 270) Total number of BURN zonal arrays to save in restart dumps.
                                #  These arrays are listed in KEPCOMS, starting with NETNUMB
                                #  and numbering NZONEB in total. NSAVEB  must be at least 6 and
                                #  no greater than NZONEB.  Saving more than the minimum number of
                                #  arrays needed to restart the problem is often useful for edit
                                #  purposes.

#....NOTE: Restart dumps with special labels (made when special conditions occur)
#....      can be specified by parameters in the "Special Command Execution and
#....      Dump Parameters" section of the Program_Management_Par group.


%c....Post-Processor-Dump Control Parameters
#**********|*********|********|*********************************************************************

ncycqq      /5/                 #(p 299) Number of KEPLER cycles between post-processor dump
                                #  cycles (i.e.. calls to DUMPQ).

lenqmax     /3000000/           #(p 44) Maximum length of a post-processor dump file (bytes).

niondump    /40/                #(p 164) Number of dump cycles between forced dumps of all
                                #  dump-grid points of all 'ions' specified as dump variables.


nisodump    /400/               #(p 165) Number of dump cycles between forced dumps of all
                                #  dump-grid points of all 'BURN 'isotopes' specified as dump
                                #  variables.

nzondump    /40/                #(p 166) Number of dump cycles between forced dumps of all
                                #  dump-grid points of all  arrays specified as dump variables
                                #  except 'ions' and 'isotopes.'

dscalem     /solmass/ [g]       #(p 297) Mass units used for the internal mass coordinate, YMASS,
                                #  used for dumping purposes (g). -- See subroutine DUMPQ.

ngridmin    /10/                #(p 298) Minimum number of points allowed in a dump grid.
                                #  See DUMPQ.

lentrack    /16384/             #(p 300) Length of the track(s) assigned to each dump variable in the
                                #  post-processor dump(s) (bytes).  See DUMPQ.

backfacq    /0.5/               #(p 303) If the fractional change in a dump variable since the last
                                #  dump cycle exceeds BACKFAC*RATZDUMP(IDAT), then also
                                #  dump the old value of that variable at the previous (dump cycle)
                                #  time point, where RATZDUMP(IDAT) is the (previously
                                #  specified) maximum allowed fractional change between
                                #  dumps of this zonal dump variable (indexed by IDAT).
                                #  See Chapter 2 on Generator Input.

nfirstq     /0/                 #(p 346) Default value of the first cycle to be read or plotted in
                                #  making post-processor edits, time plots, or timemaps.   Note that
                                #  this parameter is reset by the NEWDUMPS command to the
                                #  current value of NCYC+NCYCQQ-MOD(NCYC,NCYCQQ)
                                #  so that KEPLER will not try to read old dumps.
```

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#**************************|*******************************************************************
****Boundary_Condition_Par    /edge_par/   Parameters  REGESS  UPDATE  ACCRETE:
#**********|*********|********|*******************************************************************


%c....General Boundary Condition Parameters
#**********|*********|********|*******************************************************************

radius0     /0./       [cm]     #(p 60) Radius of inner boundary (cm).

summ0       /0./       [g]      #(p 61) Mass inside inner boundary (g).

xlum0       /0./       [erg/s]  #(p 62) Luminosity emerging from inner surface (erg/s).

tbound      /0./       [K]      #(p 68) Temperature at outer boundary (K).

pbound      /0./       [erg/cc] #(p 69) Pressure at outer boundary (erg/cc).

vloss       /1.d+99/   [cm/sec] #(p 70) Remove the outer zone if its velocity exceeds VLOSS, but do not
                                 #  change the previous values of PBOUND (P 69) or TBOUND
                                 #  (P 68)  (cm/sec).


%c....Accretion Parameters
#**********|*********|********|*******************************************************************

accrate     /0./    [Msun/yr]   #(p 211) Mean rate at which mass in the form of new zones is added
                                #  to the surface of the star (solar masses per year).   The
                                #  accumulated mass is stored in XMACRETE (P 212)
                                #  until it is large enough to be added as a whole zone.  The
                                #  surface boundary pressure is gradually increased at a rate
                                #  proportional to ACCRATE until a mass (in XMACRETE)
                                #  equal to that in the current outer zone is reached.  Then a
                                #  new zone, the mirror image of the old outer zone, is added.
                                #  Accretion composition is set by the COMPSURF command
                                #  in TTYCOM.  This prescription will work best for
                                #  coarse and roughly equal surface zoning.

xmacrete    /0./       [g]      #(p 212) Mass of phantom outer zone used to mediate mass
                                #  accretion (g).  (See P 211).


%c....General Mass-Loss Parameters
#**********|*********|********|*******************************************************************

xmloss0     /0./    [Msun/yr]   #(p 221) Nominal mass loss rate from the surface of the star (solar
                                #  masses/year).   This constant mass loss rate is added to
                                #  whatever de Jager-prescription mass loss may have been

                                #  specified by XMLOSSM (P 220).

totm0       /0./       [g]      #(p 222) The original total mass of the star (g).  This is set during
                                #  generation and is used in interpreting edit, dump, and rezoning
                                #  parameters involving stellar mass fractions rather than the
                                #  current mass of the star (TOTM) which may change
                                #  due to mass loss, accretion, etc.    Normally, the internally set
                                #  value of TOTM0 should not be changed by the user.

fracdez     /0.5/              #(p 223) Dezone the mass-losing zone if its mass drops below
                                #  FRACDEZ times the average mass of the zones on
                                #  either side of it.

xfracml     /0.01/             #(p 225) Subtract any "surface" mass loss specified by XMLOSSM
                                #  (P 220) or XMLOSS0 (P 221) from the  zone closest to the
                                #  surface that still has more than XFRACML*TOTM0 (P 222)
                                #  grams of material overlying it.   This should be set so that
                                #  mass is not extracted from zones too near the surface in order to
                                #  avoid excessive dezoning, small timesteps, and luminosity
                                #  fluctuations.

# xmratbak  /0.2/               #(p 224) Redo the timestep ("backup") if the fractional change of
                                #  mass in the mass-losing zone exceeds XMRATBAK.
                                #NOTE: xmratbak is specified in the "Backup Control Parameters" section
                                #  of the Time_Step_Par group.


%c....de Jager Mass-Loss Parameter(s)
#**********|*********|********|*******************************************************************

xmlossm     /0./               #(p 220) Multiplier on the de Jager mass-loss rate.  (See CYCLE and
                                #  Ann. Rev. Astron.Astrophys.  24, 336 (1986)).


%c....Binary Mass-Loss Parameters
#**********|*********|********|*******************************************************************

binm10      /0./       [Msun]   #(p 348) The initial mass of the star being evolved (primary) in solar
                                #  masses that is used in calculating the possibility of mass loss to a
                                #  binary companion, following the formalism of Podsiadlowski,
```

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                                #  its radius exceeds its Roche radius, with a power-law cutoff to
                                #  avoid numerical discontinuities.  The formalism also involves
                                #  parameters 349 - 354, defined below.   See subroutine CYCLE.
                                #  NOTE: Set to totm0/solmass in the generator.

binm20      /0./       [Msun]   #(p 349) The initial mass of the binary companion star (in solar masses)
                                #  used in calculating the possibility of binary mass transfer.
                                #  No mass transfer is performed if BINM20 .le. 0.  See P 348.

binalp      /1./                #(p 350) PJH's alpha parameter, related to the angular momentum of the

                                #  mass lost in binary transfer. See P 348.

binbet      /1./                #(p 351) PJH's beta parameter.  Fraction of the total mass spilling
                                #  over from the Roche lobe of the primary that is
                                #  transferred to the secondary rather than being lost from
                                #  the system.   BINBET equals 1. for conservative binary
                                #  mass transfer.

bina0       /2./       [AU]     #(p 352) Initial binary separation in AU used in calculating the
                                #  possibility of binary mass transfer.    See P 348.

binmdt     /1.0d-03/ [Msun/yr]  #(p 353) Mass loss rate due to binary mass transfer assumed when the
                                #  primary stars exceeds its Roche radius (solar masses per year).
                                #  See P 348.

rocher      /1.d+99/   [cm]     #(p 354) Current Roche radius (cm).  This is a calculated quantity and
                                #  should normally not be changed by the user.  See P 348.


%c....Obsolescent Mass-Loss Parameters
#**********|*********|********|*************************************************************************

nsurfz      /-10/               #(p 217) If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic
                                #  ramp in zonal mass of the NSURFZ zones at the surface of the
                                #  star, where fracsz0    /1.  is twice the desired mass-fraction
                                #  of the surface zone and FRACSZ1 (P 219) is twice the desired
                                #  mass-fraction of the NSURFZth zone from the surface.
                                #  Otherwise, NSURFZ has no effect. (See REZONE.)
                                #  This is an obsolescent parameter involving an old mass-loss
                                #  scheme and should not be used without a careful check of the
                                #  detailed coding in REZONE.

fracsz0     /1./                #(p 218) Inner surface zoning parameter (see REZONE and the
                                #  discussion under P 217).   This is an obsolescent parameter
                                #  involving an old mass-loss scheme and should not be used
                                #  without a careful check of the  detailed coding in REZONE.

fracsz1     /1./                #(p 219) Outer surface zoning parameter (see REZONE and the
                                #  discussion under P 217).   This is an obsolescent parameter
                                #  involving an old mass-loss scheme and should not be used
                                #  without a careful check of the  detailed coding in REZONE.



#**************************|*************************************************************************
****Viscosity_Par            /visc_par/   Parameters  REGESS  UPDATE:
#**********|*********|********|*************************************************************************


%c....Artificial Viscosity Parameters
#**********|*********|********|*************************************************************************

q2fac       /4./                #(p 4) Quadratic artificial viscosity (Q) factor.  Shock transitions
                                #  are spread over about 2*SQRT(Q2FAC) zones. (see WZW78)

q1fac       /.1/                #(p 13) Linear artificial viscosity factor.  Helps damp sound waves
                                #  during hydrostatic evolution.  Should be set to 0. during
                                #  hydrodynamic phases.    Normally set to 1000. in the
                                #  generator until the star settles down onto the zero-age main
                                #  sequence (from an initially rather arbitrary configuration), at
                                #  which point it is reset to 0.1.

artv1       /1./                #(p 107) Multiply Q1FAC by ARTV1 in zone J if JARTV1.le.J<JARTV2.

artv2       /1./                #(p 108) Multiply Q1FAC by ARTV2 in zone J
                                #  if JARTV2.le.J<JM-JARTV3.

artv3       /1./                #(p 109) Multiply Q1FAC by ARTV3 in zone J
                                #    if J.ge.MAX(JARTV1,JARTV2,JM-JARTV3)

jartv1      /1000/              #(p 110) (See P 107-109).

jartv2      /1000/              #(p 111) (See P 107-109).

jartv3      /1000/              #(p 112) (See P 107-109).

#q1faczms   /0.1/               #(p 310) Reset the value of Q1FAC (P 13) to Q1FACZMS at the time
                                #  specified by TIMEZMS (P 308).
                                # NOTE: q1faczms is specified in the "Parameter Change Parameters"
```

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#**************************|*********************************************************************
****Equation_of_State_Par     /eos_par/   Parameters  EOS:
#**********|*********|********|*********************************************************************


%c....Equation-of-State Parameters
#**********|*********|********|*********************************************************************

pimult     /1./                #(p 34) Ion energy and pressure multiplier.

prmult     /1./                #(p 35) Radiation energy and pressure multiplier.

pemult     /1./                #(p 36) Electron energy and pressure multiplier.


xipot      /13.6053/ [eV]      #(p 56) Ionization potential (eV) --see subtoutine ES.

dzero      /0.1/     [g/cc]    #(p 57) Characteristic density for pressure ionization (g/cc).


npflag     /1/                 #(p 58) Pairs are included in EOS calculation only if NPFLAG>0.

etaconv    /1.d-5/             #(p 92) Relative convergence required in calculating the electron Fermi
                               #  degeneracy parameter, ETA.


xmimult    /1./                #(p 149) The mass used in calculating ion degeneracy is XMIMULT
                               #  times the mass of a neutron.

eionmult   /1./                #(p 196) 1.      Multiplier on the contribution of ionization potential
                               #  energy to the equation of state.  (See subroutine ES).

wilsonmt   /-1./               #(p 199) Multiplier on the Wilson-based nuclear EOS (except for the

                               #  thermal ion component) if it is .ge.0. Otherwise, the old

                               #  non-relativistic, partial degeneracy model for the ion EOS
                               #  is used.  WARNING...setting this parameter .ge.  0 appears
                               #  to cause anomalous contributions to the pressure and energy
                               #  at densities far below nuclear density and probably should

                               #  not be used without revision. (See subroutine ES).

t11cut     /1./      [E+11 K]  #(p 200) Upper bound on the temperature used to calculate the energy
                               #  in nuclear excited states and nuclear partition functions

                               # (E+11 K units).  (See subroutines ES and SDOTQ).

coulmult   /1.0/               #(p 215) Multiplier on the Wigner-Seitz Coulomb corrections to the ion
                               #  energy and pressure (See Clayton, p. 152, and ES).


icalcne    /0/                 #(p 337) Calculate more accurate electron densities in partially
                               #  ionized regions if ICALCNE > 0 using Lisa Ensman's multiple-ion,
                               #  Saha equilibrium subroutine, CALCNE.   Generally this
                               #  more accurate, but very time-consuming routine is
                               #  turned on just before shock-breakout while doing supernova
                               #  light-curve calculations.

xneconv    /1.d-5/             #(p 338) Maximum allowable fractional convergence error in the electron
                               #  density calculated by subroutine CALCNE (see P 337).

ionflag    /0/                 #(p 339) If  IONFLAG .le. 0 and the density and temperature have changed
                               #  by a fraction less than DDSFRAC (P 153) and DTSFRAC (P 154),
                               #  respectively, since the last iteration, then extrapolate the
                               #  value of the electron density from its partial derivatives with
                               #  respect to density and temperature instead of calling CALCNE
                               #  (when ICALCNE > 0 -- see p 337), unless this is the first
                               #  iteration.
                               #  Otherwise call CALCNE all the time, provided ICALCNE > 0.

xnemin     /1.d-5/             #(p 340) Minimum mass fraction for which an element is included in
                               #  the calculation of Saha ionization equilibrium done in
                               #  subroutine CALCNE (see P 337).


#**************************|*********************************************************************
****Opacity_Par               /opac_par/   Parameters  OPAC:
#**********|*********|********|*********************************************************************


%c....Opacity Parameters
#**********|*********|********|*********************************************************************

transm     /1./                #(p 37) Multiplier on diffusive heat transport.

           /1.d-50/ [cm**5/g**2/(E+7 K)**4]  #(p 40) Opacity will be no lower than
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                                #  where RHO is the density in g/cc, T7 = Temperature/(10**7 K),
                                #  and XKMIN (p 50) is defined below.   (cm**5/g**2/(E+7 K)**4 units.)

xkmin       /1.d-10/ [cm**2/g] #(p 50) Least upper opacity bound (cm**2/g). (see P 49 and KAPPA)

zbound      /0.1/              #(p 91) Mass fraction of heavy elements above which IBEN1 opacities
                               #  are used.

xk1mt       /1./               #(p 29) Multiplier on IBEN1 opacity.

xk2mt       /1./               #(p 30) Multiplier on IBEN2 opacity.

xk3mt       /1./               #(p 31) Multiplier on Christy opacity.

xk4mt       /1./               #(p 32) Multiplier on Compton opacity.

rxkcmt      /1./               #(p 33) Multiplier on conductive opacity.


#**************************|*********************************************************************
****Convection_Par           /conv_par/   Parameters  REGESS  UPDATE:
#**********|*********|********|*********************************************************************


%c....General Convection Parameters
#**********|*********|********|*********************************************************************

xmlen       /1./               #(p 19) Ratio of the convective mixing length to the pressure
                               #  scale height.

fudgc       /.01/              #(p 20) Fudge factor for convection (about 0.01).  Reduces convective
                               #  efficiency for very small departures from adiabatic gradients
                               #  and thus makes the numerical onset of convection less
                               #  abrupt and unstable.   (see subroutines REGESS and UPDATE)

difim       /1./               #(p 21) Multiplier for the rate of convective mixing.

fracneut    /.05/              #(p 59) If the semiconvective test parameter, W, is less than zero
                               #  but greater than -FRACNEUT*ABS(LOG(T1/T0)), then
                               #  the zonal interface is flagged convectively neutral ("NEUT"
                               #  or ",").  (see subroutine UPDATE)

frcsound    /1.d+99/           #(p 146) Don't do convection if the absolute value of the zone velocity
                               #  exceeds FRCSOUND times the local sound speed.
                               # NOTE:  Historical default value was 0.1.

convlim     /1./               #(p 147) Limit the convective velocity to a fraction CONVLIM of
                               #  the local sound speed.

xltaucon    /0./               #(p 209) Don't allow the convective velocity to increase by a factor
                               #  greater than EXP (DT/(XLTAUCON*TAUCONV)) in one
                               #  timestep, where DT is the current timestep and TAUCONV
                               #  is the timescale for convective mixing (see REGESS and
                               #  UPDATE).   Useful in modeling detonations.  (See P 214
                               #  for studying deflagrations).

noqsecon    /0/                #(p 210) Don't force zones that are convectively coupled to ISE zones
                               #  to go to ISE if NOQSECON > 0.   This parameter should be
                               #  kept zero unless you really  understand what you're doing.


%c....Semiconvection and Overshoot Parameters
#**********|*********|********|*********************************************************************

drmult      /.1/               #(p 24) Semi-convective mixing will be slower than thermal transport by
                               #  at least DRMULT (about 0.1) in zones with mean atomic
                               #  weight, ABAR,  is  .ge. ABARSEMI (P 324). (See sub.UPDATE)
                               #  (Also see DRMULTLO (P 325), WOVERSHT (P 148),
                               #  and WOVERSLO (P 326)).

dtsmult     /1.d+99/           #(p 75) The fractional amount of semiconvective mixing that can occur
                               # in one timestep is limited to approximately DTSMULT.

woversht    /0.01/             #(p 148) The semiconvective test parameter, W, is taken to be
                               #  W = WOVERSHT*ABS(LOG(T1/T0)) for the special
                               #  overshoot semiconvective zones where W would otherwise
                               #  be less than 0 and when ABAR .ge. ABARSEMI (P 324).
                               #  Overshoot mixing occurs at a rate calculated
                               #  from this value of W, but limited by the thermal diffusion
                               #  timescale as in normal semiconvection. (see UPDATE & WZW78).
                               #  If WOVERSHT    /0 no overshoot mixing is done.
                               #  (Also see WOVERSLO -- P 326).

abarsemi    /4./               #(p 324) Value of the zonal mean atomic weight, ABAR, used to divide
                               #  the star into two regions with separately specifiable values of the
                               #  semiconvective mixing rate and the overshoot mixing coefficient
                               #  (g/mole).   (See the definitions of DRMULT (P 24),
                               #  WOVERSHT (P 148), DRMULTLO (P 325), and WOVERSLO (P 326)).
```

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                                #  atomic weight, ABAR,  is below ABARSEMI (P 324).
                                #  (See UPDATE and discussion of DRMULT (P 24),
                                #  WOVERSHT (P 148), and WOVERSLO (P 326)).

woverslo    /woversht/          #(p 326) The semiconvective test parameter, W, is taken to be
                                #  W=WOVERSLO*ABS(LOG(T1/T0)) for the special
                                #  overshoot semiconvective zones where W would otherwise
                                #  be less than 0 and when ABAR < ABARSEMI (P 324).
                                # Overshoot mixing occurs at a rate calculated from
                                #  this value of W, but is limited by the thermal diffusion
                                #  timescale as in normal semiconvection. (see UPDATE & WZW78).
                                #  If WOVERSLO=0 no overshoot mixing is
                                #  done.  (Also see WOVERSHT -- P 148).


#**************************|*********************************************************************
****Nuclear_Reaction_Par      /sdot_par/   Parameters  SDOT  SDOTQ:
#**********|*********|********|*********************************************************************


%c....General Nuclear Reaction Parameters
#**********|*********|********|*********************************************************************

sneutmt     /1./                #(p 101) Neutrino energy loss rate multiplier (APPROX only).

snucmt      /1./                #(p 102) Non-neutrino nuclear energy generation rate multiplier
                                #  (APPROX only).

c12agmlt    /1./                #(p 208) Multiplier on the overall C12(a,g) rate (APPROX only).
                                # This parameter is obsolescent.   It is better to use E1MLTC12
                                # P 227) and E2MLTC12 (P 228).

e1mltc12    /1./                #(p 227) Multiplier on the E1 part of the C12(a,g) cross-section
                                #  (affects both APPROX and the the BURN coprocessor,
                                #  but currently has no effect on the C12(a,g) rate used to calculate
                                #  photodisintegration flows in ISE.)

e2mltc12    /1./                #(p 228) Multiplier on the E2 part of the C12(a,g) cross-section.
                                #  (affects both APPROX and the the BURN coprocessor,
                                #  but currently has no effect on the C12(a,g) rate used to calculate
                                #  photodisintegration flows in ISE.)


tnucmin     /0./       [K]      #(p 65) Don't calculate nuclear burning in APPROX if the temperature
                                #  is less than TNUCMIN (K).   Note that unless the hydrogen
                                #  burning rate is significant, no APPROX network

                                #  calculations will be done below 1.E+7 K, even if
                                #  TNUCMIN <  1.E+7 K.  (See P 89).

dypmin      /1.d-10/ [moles/g] #(p 89) Minimum amount of potential hydrogen burn in the present
                                #  timestep needed to trigger the use of any reaction network
                                #  (moles/g).   (APPROX only).

dymgmin     /1.d-10/ [moles/g] #(p 90) Minimum amount of Mg24 production required in the last
                                #  timestep to trigger the use of the full reaction network
                                #  (moles/g). (APPROX only).


ipup        /1/                #(p 28) Abundance update parameter. Update abundances only if IPUP.ne.0.


timex0      /-1.d+99/ [sec]    #(p 38) Time at which any Ni56 present in low temperature regions (as
                                #  determined by P 89 and P 65) of the star is assumed to have
                                #  been produced and begun to decay, first to Co56 and then to
                                #  Fe56 (sec).   If TIMEX0 .ge. -1.E+50 and the zonal Ni56
                                #  abundance, YNI,  .ge. 3.E-5, then the nuclear energy
                                #  generation is take equal to that generated by an initial Ni56

                                #  abundance YNI after having decayed for a time interval
                                #  TIME (P 2) -TIMEX0.   Note that the value of YNI in the
                                #  abundance array is not changed by this "decay", and always
                                #  represents the initial amount produced.
                                #  DO NOT set TIMEX0 > TIME (P 2).

xkapgam     /0.054/ [cm**2/g]  #(p 341) Assumed effective opacity (cm2/g) for the deposition of gamma
                                #  ray energy from the radioactive decay of Ni56 and Co56, as
                                #  controlled by TIMEX0 (P 38).

egamp       /0.60/             #(p 342) Dimensionless correction factor used in calculating the
                                #  escape of gamma rays from the radioactive decay of Ni56
                                #  and Co56, as controlled by TIMEX0 (P 38).  See subroutine
                                #  SDOT for details.


irnet       /0/                #(p 63) If IRNET=0, use APPROX network.  If IRNET=1,  use
                                #  SDOT1 (H and He burning network).  Otherwise use
                                #  SDOT2 (NOVA network).  Note that SDOT1 and SDOT2
                                #  are replaced by dummy routines in the current version of
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                                #  being used again.

dsnum       /1.d-6/             #(p 103) Fractional density and temperature perturbations used to get
                                #  nuclear energy generation rate derivatives (APPROX only).

ddsfrac     /.01/               #(p 153) Maximum fractional change in density since the last iteration
                                #  for which ABAR changes and energy generation rates
                                #  can be extrapolated from their previous values (APPROX only).

dtsfrac     /.001/              #(p 154) Maximum fractional change in temperature since the last
                                #  iteration  for which ABAR changes and energy
                                #  generation rates can be extrapolated from their previous
                                #  values (APPROX only).

iudflag     /0/                 #(p 155) Extrapolate energy generation rates and ABAR changes in
                                #  cases of small temperature and density change only if
                                #  IUDFLAG is also .le.0.

iupdflag    /1/                 #(p 163) Don't calculate derivatives in subroutine SDOT when called

                                #  from subroutine UPDATE if IUPDFLAG .ge. 0 (APPROX only).

iflgabar    /0/                 #(p 160) The mean atomic weight, ABAR, calculated in subroutine
                                #  SDOT is implicitly coupled to the ion equation of state only if
                                #  IFLGABAR.ne.0 and the normal APPROX network (IN=1)
                                #  is being used.  (This is an obsolescent parameter and the
                                #  coding should be carefully rechecked if it is set .ne.0).


#***************************|*********************************************************************
****Carbon_Deflagration_Par   /cdef_par/   Parameters  SDOT  REGESS  UPDATE  CYCLE:
#***********|*********|********|*********************************************************************


%c....Carbon Deflagration Parameters
#***********|*********|********|*********************************************************************

# xltaucon  /0./                #(p 209) Don't allow the convective velocity to increase by a factor
                                #  greater than EXP (DT/(XLTAUCON*TAUCONV)) in one
                                #  timestep, where DT is the current timestep and TAUCONV
                                #  is the timescale for convective mixing (see REGESS and
                                #  UPDATE).   Useful in modeling detonations.  (See P 214
                                #  for studying deflagrations).
                                # NOTE: xltaucon is specified in the "General Convection Parameters"
                                #  section of the Convection_Par group.


flamerad    /0./      [cm]      #(p 214) Characteristic flame radius for carbon deflagration studies
                                #  (cm).  If XLTAUCON (P 209)> 0 and FLAMERAD > 0, multiply
                                #  the convective timescale, TAUCON, used to calculate the

                                #  maximum allowed rate that the convective luminosity
                                #  can increase (see P 209) by an additional factor of
                                #  FLAMERAD/RFLAME, where RFLAME is the maximum
                                #  radius at which a temperature above 2.E+9 K exists.
                                #  This parameter effectively varies the velocity at which a
                                #  deflagration can propagate and should be used only   when
                                #  studying carbon detonations.   Note that larger values of
                                #  FLAMERAD imply slower deflagration speeds, and that
                                #  the relationship is not linear.


flamva      /0./              #(p 279) If FLAMVA .ne. 0., the current problem is a study of a carbon
                                #  deflagration in a white dwarf.   The current radius of the
                                #  deflagration flame is taken as the radius of the outermost zone
                                #  where the temperature exceeds 2.E+9 K and is edited as JFLAM (P 283)
                                #  by KEPLER.   The outward speed of the flame is
                                #  controlled by adjusting the opacity for heat conduction between
                                #  zones JFLAM and JFLAM + 1 up or down by a factor,
                                #  XKAPFLAM (P 284), between 0. and 1.   Such "gating" is

                                #  performed in KAPPA and UPDATE and sets the velocity of
                                #  advance of the 2.E+9 K temperature front to a comoving value
                                #  that averages:
                                #  VFLAME = VCOND * ( RFLAME / XLAMBMIN )**( FLAMVB - 2. ),
                                #  where:      XLAMBMIN = 4p * VCOND**2 / GEFF  and
                                #  VCOND is FLAMVC (P 281) times the heat conduction
                                #  velocity, RFLAME is the current radius of the flame front, and
                                #  GEFF is FLAMVA times the acceleration of gravity at the flame

                                #  front.  The calculated flame velocity is bounded below by
                                #  VCOND ^Aand above by FLAMVD (P 282) times the speed of
                                #  sound behind the flame front.
                                #     Basically the flame front wrinkles as it propagates in a fractal
                                #  manner and the extra area it thus enjoys causes the flame to
                                #  burn the entrained material more rapidly.   See CYCLE for more
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                              #  corresponding to a 20% delta-rho/rho across the burning front
                              #  to study "plausible" carbon deflagrations using this model.

flamvb      /2.0/             #(p 280) Fractal exponent helping determine the relationship between
                              #  the velocity of heat conduction and the velocity of the
                              #  carbon deflagration flame based on its degree of "wrinkling."
                              #  FLAMVB is equivalent to the fractal dimension of the burning
                              #  front which is 2. for a smooth surface, 2.7 corresponds to fully
                              #  developed turbulence, and 3. corresponds to filled space.

flamvc      /92./             #(p 281) Multiplier on the heat conduction velocity used to calculate
                              #  the velocity of the carbon deflagration front.   See the discussion
                              #  given for FLAMVA (P 279) for a more detailed explanation of
                              #  its use.   The default value of 50 corresponds to the laminar
                              #  flame speed in a 50/50 carbon-oxygen mixture at 2.E+9 g/cc.

flamvd      /1./              #(p 282) The velocity of the carbon deflagration flame front is limited
                              #  to FLAMVD times the local sound speed.  (See the discussion for
                              #  FLAMVA (P 279)).

jflam       /0/               #(p 283) The zone where the carbon deflagration flame is currently
                              #  located.  This parameter is internally set by KEPLER to be
                              #  the outermost zone whose temperature exceeds 2.E+9 K and
                              #  its value should not be changed by the user.

xkapflam    /0.001/           #(p 284) Carbon deflagation opacity gating factor.  Must be > 0. and
                              #  <1.  See the discussion given for FLAMVA (P 279) for a
                              #  more detailed explanation of its use.

xmflam      /0./^C     [g]    #(p 285) The mass in the current carbon deflagration flame-front zone
                              #  JFLAM (P 283) that has already been burned (g).  This
                              #  parameter is set internally by KEPLER and should not be
                              #  changed.  When the entire mass of zone JFLAM (P 283) has
                              #  been burned the opacity coupling it to zone JFLAM + 1 is
                              #  changed from being divided by XKAPFLAM (P 284) to being
                              #  multiplied by it.  This causes the flame front to advance to the
                              #  next zone.  See the discussion given for FLAMVA (P 279).

flamve      /0.805/           #(p 347) Density power dependence of the heat conduction velocity
                              #  used in calculating the velocity of nuclear deflagrations in
                              #  Type I supernovae.  (0.805 for C/O, 1.06 for Ne/O)
                              #  See P 279-285 and subroutine CYCLE for details.

#**************************|*********************************************************************
****ISE_Transition_Par      /iset_par/   Parameters  SDOT  SDOTQ:
#**********|*********|********|*********************************************************************

%c....ISE Network Transition Parameters
#**********|*********|********|*********************************************************************

tqselim     /1.5d+9/  [K]     #(p 184) A sufficient condition to change a zone from the APPROX to
                              #  ISE network is if its temperature exceeds TQSELIM (K),
                              #  its O16 mass fraction is less than O16LIM, its iron peak
                              #  mass fraction exceeds QN56LIM, and its density exceeds
                              #  DQSELIM.

o16lim      /.04/             #(p 185) (See P 184).

qn56lim     /0./              #(p 186) (See P 184).

siqselim    /1.d-3/           #(p 189) A sufficient condition to change a zone from the ISE to the
                              #  NSE network is for the sum of the silicon and sulfur "group"
                              #  elemental mass fractions to be less than or equal to SIQSELIM.

dqselim     /1.d+5/   [g/cc]  #(p 203) Nominal minimum density for changing a zone from
                              #  the APPROX to the ISE network (g/cc). (See P 184).


# noqsecon   /0/              #(p 210) Don't force zones that are convectively coupled to ISE zones
                              #  to go to ISE if NOQSECON > 0.   This parameter should be
                              #  kept zero unless you really  understand what you're doing.
                              # NOTE: noqsecon is specified in the "General Convection Parameters"
                              #  section of the Convection_Par group.

noiland     /1/               #(p 290) If NOILAND > 0, prevent separated islands of zones employing
                              #  the ISE network from developing by not letting zone J go to ISE
                              #  unless zone J - 1 has already done so.


jqse        /0/               #(p 106) Change all APPROX network zones with J<JQSE to the
                              #  ISE network.

jnse        /0/               #(p 188) Change all ISE zones with J<JNSE to the NSE network.
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#**********|*********|********|*************************************************************************

%c....ISE Network Physics Parameters
#**********|*********|********|*************************************************************************

y56gessm    /1.d-4/             #(p 201) Initial guess made in SDOT for the Y56 abundance when
                                #  initializing a new ISE zone (moles/g).  If Y56GESSM is
                                #  within 1.E-3 of 1., the temperature is greater than
                                #  TQSEMIN, and  J > 1, then the initial guesses for the
                                #  proton, neutron, and Fe56 abundances used in the ISE
                                #  iteration are taken equal to their values in the next innermost
                                #  zone (which typically is already in ISE).

yemax       /0.498/             #(p 323) Maximum value of Ye allowed when initializing a new  ISE
                                #  zone (moles/g).   This simulates the small amount of

                                #  neutronization that usually occurs before the end of oxygen
                                #  burning.

yemin       /.02/               #(p 41) No further changes in YE are allowed for YE < YEMIN
                                #  (moles/g).

tqsemin     /2.d+9/    [K]      #(p 105) Floor on the temperature used in the ISE calculation (K).


snuwmult    /1./                #(p 187) Multiplier on neutrino energy losses from weak processes
                                #  on nuclei and nucleons.  (ISE only)

bethemt     /0./                #(p 137) Multiplier on fudged Co63 electron decay rate as suggested by
                                #  Gerry Brown and Hans Bethe (11/89).


iexciteh    /1/                 #(p 171) Include excited states in ISE calculations only if IEXCITEH>0.


# t11cut    /1./      [E+11 K]  #(p 200) Upper bound on the temperature used to calculate the energy
                                #  in nuclear excited states and nuclear partition functions

                                # (E+11 K units).  (See subroutines ES and SDOTQ).
                                # NOTE: T11CUT is specified in the Equation_of_State_Par group.


isi30brn    /1/                 #(p 202) Neutron-rich-silicon-burning flows are included in the ISE
                                #  network if ISI30BRN .ge. 1. (See  subroutine SDOTQ)

iflagye     /1/                 #(p 167) The electron EOS is implicitly coupled to nuclear-burning-
                                #  induced changes in the electron abundance, YE, provided
                                #  IFLAGYE.ne.0 and the ISE or NSE network is being used.


%c....ISE Network Convergence Parameters
#**********|*********|********|*************************************************************************

itermh      /1000/              #(p 172) Maximum number of iterations allowed in ISE calculation.

ypconvh     /1.d-8/             #(p 173) Allowed relative convergence error in the proton abundance in
                                #  the ISE calculation.

ynconvh     /1.d-8/             #(p 174) Allowed relative convergence error in the neutron abundance in
                                #  the ISE calculation.

ysiconvh    /1.d-8/             #(p 175) Allowed relative convergence error in the Si28 abundance in
                                #  the ISE calculation.

cnseh       /1./                #(p 176) Increment the proton, neutron, and Si28 abundances by a
                                #  fraction CNSEH of that calculated by the Newton-Raphson
                                #  method for an ISE iteration.

fyph        /.05/               #(p 177) Maximum allowed relative change in proton abundance during
                                #  an ISE iteration.

fynh        /.05/               #(p 178) Maximum allowed relative change in neutron abundance during
                                #  an ISE iteration.

fysih       /.15/               #(p 179) Maximum allowed relative change in Si28 abundance during
                                #  an ISE iteration.

xiter1qe    /.5/                #(p 181) If the relative change of the proton, neutron, or Si28
                                #  abundance is opposite in sign and more than XITER1QE
                                #  in magnitude with respect to the corresponding change
                                #  during the previous ISE iteration cycle, then cut the current
                                #  step size in half if more than ITER1NSE iterations have
                                #  been done.

iter1qe     /10/                #(p 182) (See P 181).

# iqerrflg  /1/                 #(p 207) Fatal errors in QBURN encountered during a normal
                                #  REGESS iteration will cause KEPLER to back-up if
                                #  IQERRFLG .ge. 1, or to terminate if IQERRFLG < 1.
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dtqnum      /1.d-4/              #(p 169) Relative temperature change used in calculating numerical
                                 #  derivatives in SDOTQ.

ddqnum      /1.d-4/              #(p 170) Relative density change used in calculating numerical
                                 #  derivatives in SDOTQ.


#**************************|*********************************************************************
****BURN_Control_Par          /bcon_par/   Parameters  CYCLE  CYCLEB  ZBURN:
#**********|*********|********|*********************************************************************


%c....Burn Co-processing Control Parameters
#**********|*********|********|*********************************************************************

inburn      /0/                  #(p 267) BURN coprocessing and related edits are done only if
                                 #  INBURN > 0.    Note that INBURN is set to 1 by subroutine
                                 #  GENBURN if a BURN generator deck has been specified in the
                                 #  regular generator deck or by command GENBURN.   It is an
                                 #  internal flag and should not be changed by the user, except to
                                 #  permanently turn off BURN coprocessing in a problem.

dtfrac      /1.d-2/              #(p 230) When BURN coprocessing is initiated (or when the

                                 #  ZEROTIME or RESET commands are given), (re)set the zonal

                                 #  timesteps used by the BURN coprocessor to
                                 #  DTFRAC*DTNEW (P 1).


netmax      /1/                  #(p 240) BURN coprocessing is skipped if a zones's network number,
                                 #  NETNUM, is greater than NETMAX.

bmassmin    /-1./      [g]       #(p 231) BURN coprocessing is skipped if a zone's exterior mass
                                 #  coordinate is less than BMASSMIN (g).

bmassmax    /1.d+99/   [g]       #(p 232) BURN coprocessing is skipped if a zone's exterior mass
                                 #  coordinate is greater than BMASSMAX (g).

btempmin    /1.d+6/    [K]       #(p 233) BURN coprocessing is skipped if a zone's temperature
                                 #  is less than BTEMPMIN (K).

btempmax    /1.d+99/   [K]       #(p 234) BURN coprocessing is skipped if a zone's temperature
                                 #  is greater than BTEMPMAX (K).

snucmin     /1.d-99/ [erg/g/s]   #(p 235) BURN coprocessing is skipped if the absolute value of a
                                 #  zone's normal nuclear energy generation rate (SNN)
                                 #  is less than SNUCMIN (erg/g/s).
bdenmin     /1.d-99/   [g/cc]    #(p 236) BURN coprocessing is skipped if a zone's density
                                 #  is less than BDENMIN (g/cc).
bdenmax     /1.d+99    [g/cc]    #(p 237) BURN coprocessing is skipped if a zone's density
                                 #  is greater than BDENMAX (g/cc).


nupdate     /100/                #(p 229) Do a forced update of BURN isotopic abundances in
                                 #  every zone every NUPDATE cycles.


tchange     /.02/                #(p 238) Force a zone to be updated by the BURN coprocessor if
                                 #  its fractional temperature change since its last BURN

                                 #  processing exceeds TCHANGE.

dchange     /.05/                #(p 239) Force a zone to be updated by the BURN coprocessor if
                                 #  its fractional density change since its last BURN

                                 #  processing exceeds DCHANGE.

nsubcycm    /1/                  #(p 264) Number of coupled BURN coprocessing / BURN isotope

                                 #  convection subcycles per KEPLER cycle.


#**************************|*********************************************************************
****BURN_Physics_Par          /burn_par/   Parameters  CYCLE  CYCLEB  ZBURN:
#**********|*********|********|*********************************************************************


%c....BURN CO-processing Physics Parameters
#**********|*********|********|*********************************************************************

mazful      /1/                  #(p 265) Use Fuller et. al.'s weak rates in the BURN coprocessor
                                 #  if MAZFUL=1, otherwise use the old rates of Mazurek
                                 #  and Hansen.

taunu       /0./       [sec]     #(p 286) Time scale for the neutrino pulse considered by the BURN
                                 # coprocessor in calculating neutrino-induced nucleosynthesis
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enu53       /3./ [E+53 erg]    #(p 287) Total energy (in units of 10**53 ergs)  for the neutrino pulse
                               #  considered by the BURN coprocessor in calculating neutrino-
                               #  induced nucleosynthesis after core collapse.

tmunu       /8./       [MeV]   #(p 288) Temperature of the mu and tau neutrinos in the neutrino pulse
                               #  considered by the BURN coprocessor in calculating neutrino-
                               #  induced nucleosynthesis after core collapse (MeV).

tenu        /4./       [MeV]   #(p 289) Temperature of the electron neutrinos in the neutrino pulse
                               #  considered by the BURN coprocessor in calculating neutrino-
                               #  induced nucleosynthesis after core collapse (MeV).


%c....Burn Co-processing Zonal Burn Control Parameters
#**********|*********|********|*************************************************************************

ileqs       /1/                #(p 258) Choice of matrix inverter to use in the BURN Co-Processor:
                               #    If ileqs .le. 0 use modified Gaussian elimination (SLEQSZ).
                               #    If ileqs .ge. 1 use FLEQS - harwell sparse matrix inverter
                               #      coded by Frank Timmes.

delchi      /.15/              #(p 247) Maximum desired fractional change of an isotopic abundance
                               #  used in determining the zonal timestep used in the BURN
                               #  coprocessor.

chimin      /1.d-6/ [moles/g]  #(p 246) Minimum isotopic abundance that affects the calculation
                               #  of the zonal timestep in the BURN coprocessor (moles/g).

al26mult    /1.0d+02/          #(p 266) Decrease the abundance threshold for Al26 to affect the BURN
                               #  coprocessor zonal timestep from CHIMIN (P 246) to
                               #  CHIMIN/AL26MULT.

fdtn        /2./               #(p 248) Maximum factor by which the zonal timestep in the BURN
                                 coprocessor can be increased in one zonal cycle.


nzro        /1/                #(p 253) Set newly calculated negative BURN isotope abundances to 0.
                               #  if NZRO not equal to 0.
amaglim     /0./       [?]     #(p 254) Minimum absolute magnitude of a BURN matrix element
                               #  for which Gauss-Jordan elimination is carried out in solving
                               #  for changes in isotopic abundances.

ninv        /0/                #(p 255) Total number of BURN-coprocessor matrix inversions so far
                               #  (internally incremented).


dtbkup      /.5/               #(p 249) Back up to the previous zonal cycle in the BURN
                               #  coprocessor if the new zonal timestep is less than DTBKUP
                               #  times the previous timestep.

bkupmass    /1.d-13/ [moles/g] #(p 261) Minimum absolute magnitude of a negative isotopic abundance
                               #  (except of protons) that can cause a zonal backup in the BURN
                               #  coprocessor (moles/g).

bkupdiv     /10./              #(p 260) Factor by which to reduce the BURN coprocessor zonal

                               #  timestep when a negative isotopic abundance backup occurs.

bkupmp      /1.d-19/ [moles/g] #(p 262) Minimum absolute magnitude of a negative proton abundance
                               #  that can cause a zonal backup in the BURN coprocessor
                               #  (moles/g).

nbkupmax    /10/               #(p 263) Maximum number of consecutive negative isotopic abundance
                               #  backups allowed in the BURN coprocessor before quitting.

nbkup       /0/                #(p 256) Total number of BURN-coprocessor backups so far (internally
                               #  incremented).

negbkup     /0/                #(p 259) Cumulative number of BURN coprocessor backups due to
                               #  encountering negative isotopic abundances (incremented internally).


ntty        /6/                #(p 257) FORTRAN I/O unit number for ZBURN messages sent to the
                               #  user's terminal.

#**************************|*************************************************************************
****Neutrino_Deposition_Par   /neut_par/   Parameters  EOS  SDOT  SDOTQ:
#**********|*********|********|*************************************************************************


%c....Neutrino Deposition Parameters
#**********|*********|********|*************************************************************************

jshell0     /1/                #(p 93) Innermost zone in which there is neutrino deposition.

jshell1     /1000/             #(p 94) Outermost zone in which there is neutrino deposition.
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texplode    /1.d+99/   [sec]    #(p 96) Time of neutrino deposition (sec).

tauexp      /1.d-2/    [sec]    #(p 97) Time scale for neutrino deposition (sec).

p0core      /0./       [cgs]    #(p 98) Artificial neutrino core pressure is given by:
                                #  PCORE = P0CORE*D**D0POWER*EXP(-D0CORE/D),
                                #  where D is the density in g/cc, PCORE is in erg/cc,
                                #  and P0CORE is in appropriate cgs units.

d0core      /3.d+11/  [g/cc]    #(p 99) Core density cutoff (g/cc) -- (see P 98 ).

d0power     /1./               #(p 100) Core pressure density dependence exponent.  (See P 98).


#**************************|*********************************************************************
****Rezoning_Par              /zone_par/   Parameters  CYCLE  REZONE  REZONEB:
#**********|*********|********|*********************************************************************


%c....General Rezoning Parameters
#**********|*********|********|*********************************************************************

izonef      /1/                #(p 86) Rezoning Flag:  .le.0 means no rezoning (including dezoning);
                                #  =1 means normal rezoning;
                                #  =2 means rezoning with before and after edits;
                                #  =3 means stop after hydrostatic adzoning.

idzonef     /1/                #(p 87) Dezoning Flag:  .le.0 means no dezoning;
                                #  =1 means normal dezoning;
                                #  =2 means dezoning with before and after edits;
                                #

# izonezms  /1/                #(p 309) Reset the value of IZONEF (P 86) to IZONEZMS at the time
                                #  specified by TIMEZMS (P 308).
                                # NOTE: IZONEZMS is specified in the "Parameter-Change Parameters"
                                #  section of the Problem_Management_Par group.


jmmin       /10/               #(p 85) Minimum number of zones allowed after dezoning.

irzopt      /1/                #(p 216) Rezoning Option Flag.
                                #  IRZOPT = 1 or .ge. 3:  Modify the density gradient considered
                                #  in adzoning by the factor (ZBAR+1)/ABAR

                                #  in order to suppress runaway adzoning of the density

                                #  discontinuities that sometimes form at composition interfaces

                                #  (esp. H/He).
                                #  Note that  for a nondegenerate, perfect gas this is equivalent

                                #  to considering the gradient in the matter pressure instead of
                                #  in the density when adzoning.  Dezoning is not affected.
                                #  IRZOPT .ge. 2:  Don't adzone across the boundaries of fully
                                #  convective regions.
                                #  IRZOPT .le. 0.   Normal rezoning.
                                #  (See REZONE).

jlcalc      /0/                #(p 190) Remove the inner JLCALC zones from the problem and
                                #  reset the inner boundary conditions on radius (RADIUS0
                                #  (P 60)) and mass (SUMM0 (P 61)), but don't change the
                                #  central luminosity (XLUM0 (P 62) -- note default is 0.).

etacut      /10./              #(p 136) Electron degeneracy parameter, ETA, above which to use
                                #  temperature interpolation in ADZONE.


%c....Physical Rezoning Parameters
#**********|*********|********|*********************************************************************

rnratmax    /.25/              #(p 76) Maximum fractional radius change allowed between zones
                                #  before adzoning.

rnratmin    /.1/               #(p 77) Minimum fractional radius change allowed between zones
                                #  before dezoning.

tnratmax    /.25/              #(p 78) Maximum fractional temperature change allowed between
                                #  zones before adzoning.

tnratmin    /.1/               #(p 79) Minimum fractional temperature change allowed between zones
                                #  before dezoning.

dnratmax    /.25/              #(p 80) Maximum fractional density change allowed between zones
                                #  before adzoning.
dnratmin    /.1/               #(p 81) Minimum fractional density change allowed between zones
                                #    before dezoning.
```

```
rnmax       /1.d+99    [cm]     #(p 88) Maximum radius for which rezoning is considered (cm).

tnmin       /1./       [K]      #(p 83) Minimum temperature for which adzoning is considered (K).

dnmin       /1.d-99/   [g/cc]   #(p 84) Minimum density for which adzoning is considered (g/cc).


%c....Mass-Fraction-Based Rezoning Parameters
#**********|*********|********|*************************************************************************

fracrz0     /-1./                #(p 193) (See P 138 and P 150).

fracrz1     /1./                 #(p 138) The effective values of the density, temperature, and radius
                                 #  gradients used to determine the necessity for adzoning or
                                 #  dezoning are multiplied by:
                                 #  RZMULTM if FRACM .le. FRACRZ0,
                                 #  RZMULT0 if FRACRZ0 < FRACM .le. FRACRZ1,
                                 #  RZMULT1 if FRACRZ1 < FRACM .le. FRACRZ2, and
                                 #  RZMULT2 if FRACM > FRACRZ2,
                                 #  where FRACM is the cumulative mass fraction measured
                                 #  from the center of the star.  (See also P 104 and P 150).

fracrz2     /1./                 #(p 139) (See P 138 and P 150).


rzmultm     /1./                 #(p 194) (See P 138).

rzmult0     /1./                 #(p 140) (See P 138).

rzmult1     /1./                 #(p 141) (See P 138).

rzmult2     /1./                 #(p 142) (See P 138).


fmaxm       /1./                 #(p 195) (See P 150).

fmax0       /1./                 #(p 150) Always adzone if the total mass fraction of any pair of zones
                                 #  exceeds:
                                 #  FMAXM if FRACM .le. FRACRZ0,
                                 #  FMAX0 if FRACRZ0 < FRACM .le. FRACRZ1,
                                 #  FMAX1 if FRACRZ1 < FRACM .le. FRACRZ2, and
                                 #  FMAX2 if FRACM > FRACRZ2,
                                 #  where FRACM is the cumulative mass fraction measured
                                 #  from the center of the star.

fmax1       /1./                 #(p 151) (See P 150).

fmax2       /1./                 #(p 152) (See P 150).


zonemmin   /1.d-99/    [g]       #(p 336) ZONEMMIN is the minimum mass (g) that a zone may have and

                                 #  still be allowed to be adzoned (as part of a zone pair).

# fmaxmcig  /1./                 #(p 313) Reset the value of FMAXM (P 195) to FMAXCIG when the

                                 #  central temperature specified by TEMPCIG (P 311) is reached.
                                 # NOTE: FMAXMCIG is specified in the "Parameter-Change Parameters"
                                 #  section of the Problem_Management_Par group.

# fmax0cig  /1./                 #(p 314) Reset the value of FMAX0 (P 150) to FMAX0CIG when the

                                 #  central temperature specified by TEMPCIG (P 311) is reached.
                                 # NOTE: FMAX0CIG is specified in the "Parameter-Change Parameters"
                                 #  section of the Problem_Management_Par group.


abarrat0    /2./                 #(p 143) The effective values of the density, radius, and temperature
                                 #  gradients used for adzoning are formed by multiplying the
                                 #  actual gradients by the factor:
                                 #  (1.+ABARRATM*ABARRAT0*ABARRAT /
                                 #     (ABARRAT0+ABARRAT));
                                 #  and for dezoning by the factor:
                                 #  (1.+1.5*ABARRATM*ABARRAT0*ABARRAT /
                                 #       (ABARRAT0+ABARRAT),
                                 #  where ABARRAT is the average relative ABAR change
                                 #  between adjacent zones.
                                 #  Do this for adzoning only if the sum of the masses in the
                                 #  involved zones divided by the total mass of the star exceeds
                                 #  FRACMLIM.

abarratm    /1.3/                #(p 144) (See P 143).

fracmlim    /.01/                #(p 145) (See P 143).


tcorefac    /1./                 #(p 104) Increase the rezoner's sensitivity to temperature gradients
                                 #  by a factor of TCOREFAC in the region where FRACM, the
                                 #  culmulative mass fraction measured from the center of the
```

```
#c....Mass-Loss-Connected Rezoning Parameters
#**********|*********|********|*************************************************************************

# vloss     /1.d+99/   [cm/sec] #(p 70) Remove the outer zone if its velocity exceeds VLOSS, but do not
                                #  change the previous values of PBOUND (P 69) or TBOUND
                                #  (P 68)  (cm/sec).
                                # NOTE: VLOSS is specified in the "General Boundary Condition
                                #  Parameters" section of the Boundary_Condition_Par group.


# fracdez   /0.5/              #(p 223) Dezone the mass-losing zone if its mass drops below
                                #  FRACDEZ times the average mass of the zones on
                                #  either side of it.
                                # NOTE: FRACDEZ is specified in the "General Mass-Loss Parameters"
                                #  section of the Boundary_Condition_Par group.


# nsurfz    /-10/              #(p 217) If NSURFZ > 0 and IZONEF (P 86) > 0, maintain a logarithmic
                                #  ramp in zonal mass of the NSURFZ zones at the surface of the
                                #  star, where fracsz0    /1.  is twice the desired mass-fraction
                                #  of the surface zone and FRACSZ1 (P 219) is twice the desired
                                #  mass-fraction of the NSURFZth zone from the surface.
                                #  Otherwise, NSURFZ has no effect. (See REZONE.)
                                #  This is an obsolescent parameter involving an old mass-loss
                                #  scheme and should not be used without a careful check of the
                                #  detailed coding in REZONE.
                                # NOTE: NSURFZ is specified in the "Obsolescent Mass-Loss Parameters"
                                #  section of the Boundary_Condition_Par group.

# fracsz0   /1./               #(p 218) Inner surface zoning parameter (see REZONE and the
                                #  discussion under P 217).   This is an obsolescent parameter
                                #  involving an old mass-loss scheme and should not be used
                                #  without a careful check of the  detailed coding in REZONE.
                                # NOTE: FRACSZ0 is specified in the "Obsolescent Mass-Loss Parameters"
                                #  section of the Boundary_Condition_Par group.

# fracsz1   /1./               #(p 219) Outer surface zoning parameter (see REZONE and the
                                #  discussion under P 217).   This is an obsolescent parameter
                                #  involving an old mass-loss scheme and should not be used
                                #  without a careful check of the  detailed coding in REZONE.
                                # NOTE: FRACSZ1 is specified in the "Obsolescent Mass-Loss Parameters"
                                #  section of the Boundary_Condition_Par group.


#**************************|*************************************************************************
****Miscellaneous_Par         /misc_par/   Parameters  CYCLE  SETUP  REGESS  UPDATE:
#**********|*********|********|*************************************************************************


%c....Miscellaneous Parameters
#**********|*********|********|*************************************************************************

hstatm      /1./             #(p 43) Multiplier on the inertial terms in the momentum balance
                             #  equation.  Nominally forces hydrostatic equilibrium for
                             #  for HSTATM = 0., but may result in convergence and
                             #  consistency problems.   This parameter should be kept set to
                             #  1. (normal hydrodynamics)  unless the user is prepared to
                             #  make a very careful study of its actual effects (see subroutines
                             #  REGESS and UPDATE).

cenu        /1./             #(p 48) Velocity centering parameter (Range: 0.5,1.):
                             #  0.5 gives exact energy conservation;
                             #  1.0 gives greatest stability.
                             #  Actually, KEPLER only behaves reasonably if CENU=1,
                             #  so the user should NOT change the default value without
                             #  careful study and a willingness to bear full responsibility
                             #  for whatever nonsense may result.

setparm     /14./            #(p 66) Initialize new parameters in RESTART if SETPARM .le. XK.
                             #  XK represents a floating point number used in RESTART

                             #  as an index for the version of KEPLER is which the last set
                             #  new parameters has been introduced.  After such a new
                             #  parameter update is made SETPARM is reset to XK+1.
                             #  This allows restart dumps written by older versions of
                             #  KEPLER with fewer parameters to be used by any later
                             #  version of the code.
                             #  NOTE: The current value of XK+1 is 14.


%c....Obsolete Parameters
#**********|*********|********|*************************************************************************

igridm      /498/            #(p 117) Obsolete.

igridv      /496/            #(p 118) Obsolete.

ivplot      /1/              #(p 129) bsolete.
```

```
edmassl    /1.d-4/            #(p 242) Obsolete.

widthtd    /60./              #(p 295) Obsolete.


#**************************|*********************************************************************
****MONGO_Graphics_Par      /mon_par/   Parameters  PLOTIT  TTYCOM:
#**********|*********|********|*********************************************************************


%c....Device-Control Graphics Parameters
#**********|*********|********|*********************************************************************

itvstart   /0/                #(p 127) Graphics device control parameter.
                              #   =  0 means no graphics processes are active.
                              #   =  1 means start an X-window graphics display and reset
                              #          ITVSTART to 2.
                              #   = -1 means stop the X-window graphics display and reset
                              #          ITVSTART to 0.
                              #   =  2 means keep the X-window display open and display graphs
                              #          and timeplots as requested. (This value is internally set).
                              #   =  3 means initialize a portrait-orientation Postscript File
                              #          and reset ITVSTART to 5.
                              #   =  4 means initialize a landscape-orientation Postscript File
                              #          and reset ITVSTART to 5.
                              #   =  5 means keep the postscript file open for further input (under
                              #          development).
                              #  Note that ITVSTART is reset to zero when a problem is restarted.

# npixedit  /50/              #(p 64) Graphics edits to the monitor are made every NPIXEDIT
                              #  KEPM-hER cycles (if P 127 > 0).
                              # NOTE: NPIXEDIT is specified in the "General Edit Control Parameters"
                              #  section of the General_Edit_Par group.


iwinsize   /10240750/         #(p 42) Size of graphics window to be created in the form xxxxyyyy,
                              #  where xxxx is the number of pixels wide to make the window
                              #  and yyyy is the number of pixels wide it should be.   Be sure to
                              #  include leading zeros if yyyy is less than 4 digits.

iwinloc    /0/                #(p 45) Location of the upper-left-hand corner of the graphics window
                              #  given in the form xxxxyyyy, where yyyy is the number of pixels
                              #  below the top of the screen this corner should be, and xxxx is
                              #  the number of pixels from the left-hand edge of the screen
                              #  it begins.   Be sure to include leading zeros if yyyy is less than
                              #  4 digits.

ibackgnd   /-1/               #(p 296) Graphics window background color is white if IBACKGND .ge. 0
                              #  and black if IBACKGND < 0.    The foreground color is always
                              #  the inverse of the background color.


%c....Plot-Type Graphics Parameters
#**********|*********|********|*********************************************************************

ipixtype   /31/               #(p 113) Graphics picture-type control parameter:
                              #  <0 graphics window is not updated, but is still open.
                              #  =0 only header info is displayed.
                              #  =1 thermodynamics (TD) graph only.
                              #  =2 velocity graph only.
                              #  =3 mass-fraction graph only.
                              #  =4 entropy graph only.
                              #  =5 density-temperature graph only.
                              #  =6 isotopic mass-fraction graph (use the SETISO command
                              #       first to determine the ions to be displayed).
                              #  =7 thru 9: only header info is displayed.
                              #  =10 thru 99: Two graphs will be displayed in split-screen
                              #       fashion with the type of the top graph determined by the value
                              #       of the first digit and the type of the second graph determined
                              #       by the value of second digit as specified above.


%c....'Radial'-Coordinate-Control Graphics Parameters
#**********|*********|********|*********************************************************************

irtype     /3/                #(p 132) Use the interior mass fraction as the independent coordinate
                              #  in all graphs if IRTYPE =2;
                              #  use the interior mass in solar mass units if  IRTYPE=3;
                              #  Otherwise use the radius (in cm).

igridt     /370/              #(p 116) Grid choice for the radial coordinate:
                              #  If IRTYPE = 1, then the radial coordinate will be log10 (radius)
                              #  if IGRIDT > 10 and linear in radius otherwise.
                              #  If IRTYPE .ne. 1, IGRIDT has no effect.

jp0        /1/                #(p 119) Innermost zone to plot. (See P 121).

jp1        /0/                #(p 120) Outermost zone to plot is JM (outermost zone) - JP1.
```

```
rpmin0      /1.d+7/    [cm]      #(p 121) Minimum radius plotted when JP0 < 0  (cm).

rpmax0      /1.d+14/   [cm]      #(p 122) Maximum radius plotted when JP1 < 0  (cm).

yplotmin    /0./                 #(p 134) Minimum mass coordinate plotted (fraction of total mass).

yplotmax    /1./                 #(p 135) Maximum mass coordinate plotted (fraction of total mass).


%c....Thermodynamics-Graph Parameters
#**********|*********|********|*************************************************************************

ymintd      /1./       [g/cc]    #(p 123) Lower bound of thermodynamics graph ordinate shall be no
                                 #  greater than YMINTD (nominally g/cc).

ymaxtd      /1.d+8/    [g/cc]    #(p 124) Upper bound of thermodynamics graph ordinate shall be
                                 #  no less than YMAXTD (nominally g/cc).


sscalem     /1.d-3/              #(p 125) Energy generation rate graph scale multiplier in the TD graph.

pscalem     /1.d-1/              #(p 126) Pressure graph scale multiplier in the TD graph.

vscalem     /1.d-5/              #(p 130) Velocity graph scale multiplier in the TD graph.

rscalem     /1.d-5/              #(p 131) Radius graph scale multiplier in the TD graph.

tscalem     /1.d+7/    [K]          #(p 115) Characteristic temperature for choosing the location of the
                                 #  temperature plotting grid in Thermodynamics graph (K).
                                 #  Equivalent to the temperature plotted at the same ordinate value
                                 #  as a density of 1 g/cc.

convord     /3./       [g/cc]    #(p 133) Ordinate value at which to plot convection sentinels in the TD
                                 #  graph (nominally g/cc).


%c....Velocity and Abundance Graph Parameters
#**********|*********|********|*************************************************************************

vlimset     /-1./      [cm/s]    #(p 191) The ordinate bounds of the velocity graph are M-1VLIMSET if
                                 #  VLIMSET > 0.   Otherwise the ordinate bounds are
                                 #  rescaled automatically.  (cm/s).


# abunlim   /1.d-3/              #(p 128) Least elemental mass fraction plotted or listed in a
                                 #  terminal ion edit.
                                 # NOTE: ABUNLIM is specified in the "General Edit Control Parameters"
                                 #  section of the General_Edit_Par group.

abunminb    /1.d-4/              #(p 316) Lower mass-fraction limit of the isotopic abundance plot.

abunmaxb    /1./                 #(p 317) Upper mass-fraction limit of the isotopic abundance plot.

numiso      /0/                  #(p 318) Number of BURN isotopes to be plotted, starting from the first
                                 #  one listed by the most recent SETISO command.   Normally
                                 #  NUMISO is set to the total number of isotopes listed in the
                                 #  SETISO command at the time that command is processed and
                                 #  does not need to be set by the user.


%c....Graphics Labeling Parameters
#**********|*********|********|*************************************************************************

charsizg    /1.0/                #(p 291) Graphics character size for grid labels (relative to MONGO's
                                 #  default character size).

charsizc    /0.85/               #(p 292) Graphics character size for curve labels (relative to MONGO's
                                 #  default character size).

charsizz    /0.85/               #(p 293) Graphics character size for zone sentinels (relative to MONGO's
                                 #  default character size).

charsizh    /1.0/                #(p 294) Graphics character size for header info (relative to MONGO's
                                 #  default character size).

nplotsym    /8/                  #(p 114) Label each curve with NPLOTSYM character symbols.

# fracneut  /.05/                #(p 59) If the semiconvective test parameter, W, is less than zero
                                 #  but greater than -FRACNEUT*ABS(LOG(T1/T0)), then
                                 #  the zonal interface is flagged convectively neutral ("NEUT"
                                 #  or ",").  (see subroutine UPDATE)
                                 # NOTE: FRACNEUT is specified in the "General Convection Parameters"
                                 #  section of the Convection_Par group.


#**************************|*************************************************************************
****Post-Proc_Graphics_Par    /post_par/   Parameters  CYCLE  DUMPQ  TTYCOM:
#**********|*********|********|*************************************************************************
```

```
#**********|*********|********|*************************************************************************

idtmaxl     /40/                #(p 301) Maximum number of post-processor dump cycles beyond the
                                #  currently-specified dump cycle (LTIME) that READQ will
                                #  search to try to get values for each point in the 'advanced' grid
                                #  formed from dump variable values at or beyond LTIME.
                                #  In PLOTMAP, IDTMAXL is used as a flag for the plot and
                                #  interpolation mode to be used:
                                #     If IDTMAXL = 0, strips of retarded-value rectangles are
                                #        plotted, based on the reconstructed grids (best for very
                                #        discontinuous variables, esp. CONVECT).

                                #     If IDTMAXL = 1, forward and backward facing triangles are
                                #        plotted for each dump point.  These triangles have a uniform
                                #        color determined by the value at their most retarded vertex
                                #        (best for moderately discontinuous variables, such as
                                #        abundances).
                                #     if IDTMAXL > 1, forward and backward triangles are plotted
                                #        for each dump point which are Gouraud-shaded to
                                #        interpolate between the variable values at each corner
                                #        (fastest and smoothest for continuous variables, worst for
                                #        discontinuous variables).

idtlook     /10/                #(p 302) Default number of post-processor dump cycles between LOOK
                                #  plots or prints or reconstructed TIMEMAP grids.


vminmap     /1.d+99/            #(p 328) Minimum value of the timemap variable to be mapped.

                                #  If VMINMAP > 1.E+98, then the actual minimum value of the
                                #  current variable is used as the map limit, except as limited by
                                #  VRATMAP (P 330), below.

vmaxmap     /-1.d+99/           #(p 329) Maximum value of the timemap variable to be mapped.  If
                                #  VMAXMAP < -1.d+98, then the actual maximum value of the
                                #  current variable is used as the map limit.

vratmap     /1.d-99/            #(p 330) Minimum ratio of the minimum timemap variable limit to the

                                #  maximum timemap variable limit in the case when the actual

                                #  minimum value of the current timemap variable would

                                #  otherwise be used as the minimum timemap limit.



%c....Time-Coordinate Graphics Parameters
#**********|*********|********|*************************************************************************

maptime     /2/                 #(p 327) Flag indicating the desired time coordinate in timeplots and
                                #  timemaps (see PLOT and TIMEMAP):
                                #     0 => use cycle number;
                                #     1 => use linear time (sec);
                                #     2 => use negative logarithmic time (-log (sec)).
                                #     3 => use positive logarithmic time (log (sec)).
                                #  Note that the time coordinate is calculated relative to
                                #  TIMEREF (P 319) + TOSETREF (P 320).

timecmin    /0./                #(p 321) Minimum value of the time-coordinate to be plotted in
                                #  timeplots and timemaps (time coordinate units--see P 327).
                                #  If both TIMECMIN (P 321) = 0  and  TIMECMAX (P 322) = 0,
                                #  all available time-points will be plotted.

timecmax    /0./                #(p 322) Maximum value of the time-coordinate to be plotted in
                                #  timeplots and timemaps (time coordinate units--see P 327).
                                # If both TIMECMIN (P 321) = 0  and  TIMECMAX (P 322) = 0,
                                #  all available time-points will be plotted.

timeref     /-1.d+99/ [sec]     #(p 319) Reference time used in calculating the time coordinate in
                                #  timeplots and timemaps (sec).  If TIMEREF < -1.^EE+98, then

                                #  a time 10 timesteps beyond the last time-point is used in its place.

tosetref    /0./      [sec]     #(p 320) Reference offset time used in calculating the time-coordinate
                                #  for timeplots and timemaps (sec).   If TIMEREF < -1.^EE+98,

                                #  then the value of TOFFSET prevailing for the last timestep
                                #  is used for TOSETREF.



#**************************|*************************************************************************
#***End Changeable Parameter List
#**********|*********|********|*************************************************************************


c.... buffer for future changeable parameters

      common dumparm(nparmz-nparm)
```

```
#**************************|*********************************************************************
#   Edit Parameter List (Non-Changeable 'Q' Parameters)
#**********|*********|********|*********************************************************************
#**********|*********|********|*********************************************************************


#**************************|*********************************************************************
****Edit_Parameters           /editparm/   Edit_Par  Saved  CYCLE :
#****************|************|*********************************************************************


%c....CYCLE-related Edit Parameters (q0 - q25)
#***********|****************|*********************************************************************

qdum(0:0)    "iqdum(0:0)"      #(q 0) Dummy Pointer Array.

dt           [sec]             #(q 1) KEPLER timestep (sec).

zjm          "jm"              #(q 2) Number of zones.

dtold        [sec]             #(q 3) KEPLER timestep used for the previous cycle (sec)

zncyc        "ncyc"            #(q 4) KEPLER cycle number.

fcr                            #(q 5) Maximum fractional zonal radius change since the last iteration.

fct                            #(q 6) Maximum fractional zonal temperature change since the last
                               #  iteration.

ziter        "iter"            #(q 7) Number of iterations taken for convergence.

told         [sec]             #(q 8) Time at the beginning of the last timestep (sec).

tfcr                           #(q 9) Total maximum fractional zonal radius change during current cycle


tfct                           #(q 10) Total maximum fractional zonal temperature change during current
                               #  cycle.

fcl                            #(q 11) Maximum fractional zonal luminosity change since the last
                               #  iteration.

tfcl                           #(q 12) Total maximum fractional zonal luminosity change since the last
                               #  iteration.

zidtcon      "idtcon"          #(q 13) Symbol of the ion most limiting the current KEPLER timestep.

zimax        "imax"            #(q 14) Total number of ions in the APPROX network (usually 19).


znnet        "nnet"            #(q 15) Number of ion networks specified (usually 3: APPROX(1), ISE(2),
                               #  and NSE(3))

znumit       "numit"           #(q 16) Total number of ions specified in the generator (usually 19).

totm                           #(q 17) Current total amount of mass in the problem (incl. SUMM0 --P 61)
                               # (g).

znreac       "nreac"           #(q 18) Number of nuclear reactions edited (ions only -- usually 29).

zitert       "itert"           #(q 19) Total number of iterations since problem generation.

zjfcr        "jfcr"            #(q 20) Zone with largest fractional radius change since the last
                               #  iteration.

zjfct        "jfct"            #(q 21) Zone with largest fractional temperature change since the last
                               #  iteration.

zjfcl        "jfcl"            #(q 22) Zone with largest fractional luminosity change since the last
                               #  iteration.

snuc         [erg/g/s]         #(q 23) Current nuclear energy generation rate from last call to
                               #  subroutine SDOT (erg/g/s).  Note that this rate applies only to
                               #  the zone specified in that call.

s0exp        [erg/g]           #(q 24) Neutrino deposition coefficient (erg/g) derived from the
                               #  values of parameters 93 thru 95 (JSHELL0, JSHELL1, and EEXPLODE)
                               #  and the current zonal of the star.

xlumn        [erg/s]           #(q 25) Neutrino luminosity (erg/s).


%c....Total Energy Edit Parameters (q26 - q45)
#***********|****************|*********************************************************************

enini        [ergs]            #(q 26) Total initial internal energy (ergs).

enink        [ergs]            #(q 27) Total  initial kinetic energy (ergs).
```

```
enint       [ergs]          #(q 29) Total  initial energy (ergs) = enini + enink + eninp.

ensc        [ergs]          #(q 30) Total energy deposited so far from input "source" (ergs).
                            #  (See XLUM0 -- P 62).

eni         [ergs]          #(q 31) Total internal energy (ergs).

enk         [ergs]          #(q 32) Total kinetic energy (ergs).

enp         [ergs]          #(q 33) Total potential energy (ergs).

ent         [ergs]          #(q 34) Total current energy (ergs) = eni + enk + enp.

epro        [ergs]          #(q 35) Total net energy produced so far by nuclear reactions less
                            #  neutrino losses (ergs).

enes        [ergs]          #(q 36) Total non-neutrino energy that has so far escaped from the
                            #  star's surface (ergs).

enc         [ergs]          #(q 37) Energy check (ergs).

enscd       [erg/s]         #(q 38) Rate of energy deposition by input "source" (erg/s).
                            #  (See XLUM0 -- P 62).

enid        [erg/s]         #(q 39) Rate of change in the total internal energy (erg/s).

enkd        [erg/s]         #(q 40) Rate of change in the total kinetic energy (erg/s).

enpd        [erg/s]         #(q 41) Rate of change in the total potential energy (erg/s).

entd        [erg/s]         #(q 42) Rate of change in the total energy (erg/s).

eprod       [erg/s]         #(q 43) Total rate of nuclear energy production (erg/s).

enesd       [erg/s]         #(q 44) Total rate of energy escape from the star (erg/s).

encd        [erg/s]         #(q 45) Total rate of change in the energy check (erg/s).


%c....Surface Edit Parameters (q46 - q48)
#***********|*****************|*****************************************************************

xlum        [erg/s]         #(q 46) Surface luminosity in electromagnetic radiation (erg/s).

radius      [cm]            #(q 47) Photospheric radius (cm) corresponding to radius with 2/3
                            #  optical depth.

teff        [K]             #(q 48) Effective surface temperature (K).


%c....BURN-related Edit Parameters (q49 - q58)
#***********|*****************|*****************************************************************

zncycb      "ncycb"         #(q 49) Current cycle number used by the BURN coprocessor.
                            #  (Should be same as ncyc).

zncycbt     "ncycbt"        #(q 50) Number of cycles since BURN co-processing was initiated.
                            #  (Usually = ncyc).

znburnz     "nburnz"        #(q 51) Number of zones co-processed by BURN during current KEPLER cycle.


znburnzt    "nburnzt"       #(q 52) Total number of zones co-processed by BURN since problem
                               generation.

zimaxb      "imaxb"         #(q 53) Number of isotopes in the currently specified BURN network
                             (typically 200).

znnetb      "nnetb"         #(q 54) Number of specified BURN isotopic networks (usually 1).

znumitb     "numitb"        #(q 55) Total number of isotopes specified in the BURN generator
                            #  (typically 200).

zjlm        "jlm"           #(q 56) Number of zones at the end of the last KEPLER cycle.

zjbmax      "jbmax"         #(q 57) Maximum zone number for which BURN co-processing is now being
                            #  done.

dtsub       [sec]           #(q 58) Length of a BURN co-processing/Burn ion convection subcycle.
                            #  (see P 264).


%c....LINK-related Edit Parameters (q59 - q71)
#***********|*****************|*****************************************************************

zjpist      "jpist"         #(q 59) Index of the piston position now being utilized.
                            #  (See Chapter 6 and CYCLE).

zjpistm     "jpistm"        #(q 60) Total number of piston positions specified in the LINK file.
```

```
velocty0    [cm/s]          #(q 61) Velocity of inner problem boundary due to specified piston
                            #  (cm/s). (See Chapt. 6).

tbounce     [sec]           #(q 62) Core bounce time (s).  Set by the NFLUX card in the LINK file
                            #  (See Chapter 6).

fluxnu0     [cm**3/s**2]    #(q 63) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.
                            #  (See Chapt. 6).

fluxnua     [1/cm]          #(q 64) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.
                            #  (See Chapt. 6).

chi0        [cm]            #(q 65) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.

                            #  (See Chapt. 6).

fluxnub     [1/cm]          #(q 66) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.
                            #  (See Chapt. 6).

chi1        [cm]            #(q 67) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.
                            #  (See Chapt. 6).

fluxnuc     [1/cm]          #(q 68) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.
                            #  (See Chapt. 6).

chi2        [cm]            #(q 69) Neutrino flux parameter.  Set by the NFLUX card in the LINK file.

                            #  (See Chapt. 6).

znye        "nye"           #(q 70) Index of the LINK-specified Ye  now being utilized.
                            #  (See Chapter 6 and SDOT).

znyem       "nyem"          #(q 71) Total number of  YE-card -specified Ye  values in the LINK file.

                            #  (See Chapt. 6).


%c....Post-Processing-related Edit Parameters (q72 - q77)
#***********|*****************|*****************************************************************

zidmptim    "idmptime"      #(q 72) Integer index of the next dump time (dump cycle number in
                            #  subroutine DUMPQ).

znylib      "nylib"         #(q 73) Number of distinct mass coordinates used so far in describing
                            #  zoning (ylib entries)

znylib0     "nylib0"        #(q 74) Number of ylib entries (see  nylib -- Q 73) at the end of the
                            #  last qq dump cycle.

zndatq      "ndatq"         #(q 75) Current number of zonal edit variables to be dumped.
                            #  (See subroutines DUMPQ & DUMP)

zlocqnex    "locqnext"      #(q 76) Location of the next open track in the current 'qq' dump file.
                            #  (See subroutine DUMPQ).

zndatl      "ndatl"         #(q 77) Current number of specified 'look' variables.
                            #  (See subroutines READQ and ADDLOOK).

#**************************|*****************************************************************
#***End Non-Changeable Edit Parameter List
#**********|*********|********|*****************************************************************


c.... buffer for future 'q' parameters

      common dumqparm(nqparmz-nqparm)



#**************************|*****************************************************************
****Saved_Small_Arrays      /small_sv/   Saved  ALL:
#****************|****************|*****************************************************************


sdum(1)                         # Dummy Pointer Array.


%c....Piston Position and Ye Initialization Arrays (Read from LINK deck)
#***************|****************|*****************************************************************

tpist(npistz)    [sec]          # Array of times at which the piston position is specified (sec).

rpist(npistz)    [cm]           # Array of piston positions corresponding to the tpist times (cm).

yemass(nyez)     [g]            # Array of interior mass coordinates at which Ye is to be reset (g).

yeq0(nyez)       [moles/g]      # Array of Ye values corresponding to the yemass coordinates
```

```
%c.... Ion Arrays
#****************|****************|*************************************************************
aion(nitz)                          # aion(k) contains the atomic weight for the ion with reference
                                    #  number k.

zion(nitz)                          # zion(k) contains the atomic number for the ion with reference
                                    #  number k.

znumi(nniz)       "numi(nniz)"      # numi(j) contains the number of ions in network number j.

zionn(nhiz,nniz)  "ionn(nhiz,nniz)"  # ionn(i,j) contains the reference number for the ith ion in
                                     #  the jth network
c....               number in.


%c.... Burn Isotope Arrays
#****************|****************|*************************************************************
aionb(nitzb)                        # aionb(k) contains the atomic weight for the isotope with reference
                                    #  number k.

zionb(nitzb)                        # zionb(k) contains the atomic number for the isotope with reference
                                    #  number k.

znumib(nnizb)     "numib(nnizb)"    # numib(j) contains the number of isotopes in BURN network number j.

zionnb(nhizb,nnizb) "ionnb(nhizb,nnizb)"  # ionnb(i,j) contains the reference number for the ith
                                          #  isotope in the jth BURN network.


%c.... Time-step Controller Arrays
#****************|****************|*************************************************************
dtc(ndtz)         [sec]             # dtc(i) contains the time-step needed by the ith type of time-
                                    #  step-controlling physical change (1-radius (dtr), 2-temp (dtt),
                                    #  3-density (dtd), 4-compression (dtq), 5-ion abundances (dtion),
                                    #  6-luminosity (dtl).

zjdtc(ndtz)       "jdtc(ndtz)"      # jdtc(i) contains the zone controlling the time-step of type i.


%c.... Subroutine Timing Array
#****************|****************|*************************************************************
timeused(3,nsubz+1)  [sec]          # Array of subroutine timings.  timeused(k,isub) contains the
                                    #  the time (in seconds) since problem generation by subroutine
                                    #  isub for operation of type k (1=cpu, 2=i/o, 3=sys).
                                    #  The vector of timings corresponding to isub=nsubz+1 gives the
                                    #  total cumulative time used since problem generation for all
                                    #  subroutines.


%c.... Reaction-Rate Arrays
#****************|****************|*************************************************************
totalr(nreacz)    [moles]           # totalr(i) is the total number of reactions of type i
                                    #  since problem generation summed over all zones (moles).

rater(nreacz)     [moles/s]         # rater(i) is the current rate of reactions of type i
                                    #  summed over all zones (moles/s).

qval(nreacz)      [MeV]             # qval(i) is the Q-value of the reaction of type i (MeV).
                                    #  Currently not set or used.

zjrate(nreacz)    "jrate(nreacz)"   # jrate(i) is the zone in which reaction i has its maximum
                                    #  net rate.

rrx(nreacz)       [moles/g/s]       # rrx(i) is the maximum net rate of reaction i in any zone
                                    #  encountered so far in the current cycle (moles/g/sec).


%c.... Accretion Composition Array
#****************|****************|*************************************************************
compsurf(nhiz)                      # Array specifying the composition of the material being accreted
                                    #  or added at the surface of the star.  compsurf(i) gives the mass
                                    #  fraction to be used for the ith ion, assumed to be in network 1.
                                    # Set by the COMPSURF command and internally renormalized.

%c.... Post-processor Dump Arrays (See subroutine DUMPQ and DUMP command.)
#****************|****************|*************************************************************
zlocqz(ndatqz)    "locqz(ndatqz)"   # locqz(idat) is the current (next write) location for dumping the
                                    #  values of the dump variable indexed by idat. It is specified in

                                    #  in bytes since the beginning of the current post-processor file,
                                    #  nameqq.
```

```
                                        # of the post-processor file, nameqq).

ratzdump(ndatqz)                        # ratzdump(idat)...array of the maximum allowed fractional changes
                                        #  between dumps of the zonal dump variables (indexed by idat).

ratiodez(ndatqz)                        # ratiodez(idat)...array of minimum fractional changes in a zonal
                                        #  dump variable (indexed by idat) allowed between two adjacent
                                        #  dump grid points before the dump grid for this variable is
                                        #  dezoned.  No dezoning done  if ratiodez(idat).lt.0.

ratioadz(ndatqz)                        # ratioadz(idat)...array of maximum fractional changes in a zonal
                                        #  dump variable (indexed by idat) allowed between two adjacent
                                        #  dump grid points before the dump grid for this variable is
                                        #  adzoned.  No adzoning done if ratioadz(idat).lt.0.  All current
                                        #  zones are included in the grid for idat if ratioadz(idat)=0.


%c.... User-Specified Zonal Edit Arrays (See subroutine ZEDIT and the ZEDIT command.)
#****************|****************|*************************************************************

zndatzed(nzedz)  "ndatzed(nzedz)" # ndatzed(ized)...number of zonal quantities edited in edit ized.

zncyczed(nzedz)  "ncyczed(nzedz)" # ncyczed(ized)...number of cycles between edits of type ized.

zedmass1(nzedz)  [scalem]         # zedmass1(ized)...lower limit of the interior mass coordinate
                                  #  (in scalem (p273) units) of zones to be edited in edits of
                                  #   type ized.

zedmass2(nzedz)  [scalem]         # zedmass2(ized)...upper limit of the interior mass coordinate
                                  #  (in scalem (p273) units) of zones to be edited in edits of
                                  #  type ized.



#*************************|*************************************************************************
****Saved_Zonal_Arrays        /zone_sav/   Saved  ALL:
#****************|************|*************************************************************


%c.... Saved Zonal Arrays...
#****************|************|*************************************************************

zdum(1)                         # Dummy pointer array.


%c.... Saved Arrays Evaluated at Outer Zonal Interfaces
#****************|************|*************************************************************

ym(0:jmz)        [g]            # Exterior mass coordinate (g).

rn(0:jmz)        [cm]           # Radius of outer zone boundary (cm).

rd(0:jmz)        [cm]           # Calculated change in radius (cm) -- during a cycle;
                                #  Radius at last timestep (cm) -- at the end of a cycle.

un(0:jmz)        [cm/s]         # Velocity of the outer zone boundary (cm/s).

xln(0:jmz)       [erg/s]        # Calculated non-neutrino luminosity at the outer zone boundary (erg/s).

qln(0:jmz)       [erg/s]        # Converged non-neutrino luminosity at the outer zone boundary (erg/s).

qld(0:jmz)       [erg/s]        # Calculated change in converged luminosity (erg/s) -- during a cycle;
                                #  Converged luminosity at last timestep (erg/s)--at the end of a cycle.

difi(0:jmz)      [cm**2/s]      # Diffusion coefficient for material mixing due to convection (cm**2/s).


%c.... Saved Arrays Evaluated at Zone Centers
#****************|************|*************************************************************

znetnum(0:jmz) "netnum(0:jmz)" # Number of the nuclear network currently used in the zone.

xm(0:jmz)        [g]            # Zonal mass (g).

dn(0:jmz)        [g/cc]         # Density (g/cc).

tn(0:jmz)        [K]            # Temperature (K).

td(0:jmz)        [K]            # Calculated change in temperature (K) -- during a cycle;
                                #  Temperature at last timestep (K) -- at the end of a cycle.

en(0:jmz)        [erg/g]        # Specific energy density (erg/g).

pn(0:jmz)        [erg/cc]       # Pressure (erg/cc).

zn(0:jmz)        [ergs]         # Viscous stress -- including linear and quadratic artificial
                                #   viscosity (ergs).

etan(0:jmz)                     # Electron degeneracy parameter (MUe / kT).
```

```
snn(0:jmz)        [erg/g/s]     # Nuclear energy generation rate -- excluding neutrino losses (erg/g/s).

abar(0:jmz)       [g/mole]      # Mean atomic weight (g/mole).

zbar(0:jmz)                     # Mean atomic charge.

xkn(0:jmz)        [cm**2/g]     # Rosseland mean opacity (cm**2/g).

xnei(0:jmz)       [elec/cc]     # Number density of ionized electrons (electrons/cc).

stot(0:jmz)       [k/baryon]    # Total zonal entropy (k/baryon).


%c.... Saved (Zone-Centered) Nuclear Burn Derivative Arrays (APPROX and ISE).
#****************|************|*************************************************************

dsold(0:jmz)      [g/cc]        # Density at which the energy generation rate was last calculated(g/cc).

tsold(0:jmz)      [K]           # Temperature at which the energy generation rate was last
                                #  calculated (K).

snold(0:jmz)      [erg/g/s]     # Last calculated energy generation rate (erg/g/s).

snbd(0:jmz)    [erg-cc/g**2/s]  # Last calculated partial derivative of the energy generation rate
                                #  with respect to density (erg-cc/g**2/s).

snbt(0:jmz)       [erg/g/s/K]   # Last calculated partial derivative of the energy generation rate
                                #  with respect to temperature (erg/g/s/K).

abarold(0:jmz)                  # Last calculated value of ABAR.

abarnbd(0:jmz)    [cc/g]        # Last calculated partial derivative of ABAR with respect to
                                #  density (cc/g).

abarnbt(0:jmz)    [1/K]         # Last calculated partial derivative of ABAR with respect to
                                #  temperature (1/K).

ypbtime(0:jmz)    [mole/g/s]    # Last calculated total time derivative of the proton abundance
                                #  (mole/g/sec).

ynbtime(0:jmz)    [mole/g/sec]  # Last calculated total time derivative of the proton abundance
                                #  (mole/g/sec).


#**************************|*************************************************************
****Ion_Abundance_Array       /abun_ion/   Saved  ALL?:
#****************|************|*************************************************************


%c.... Saved Array of Ion Abundances (Generally Elemental)
#****************|************|*************************************************************

ppn(nhiz*jmz)     [moles/g]     # Ion Abundance Array:  ppn(i,j) = ppn((j-1)*imax+i)


#**************************|*************************************************************
****Saved_BURN_Arrays         /burn_sav/   Saved  CYCLE  CYCLEB  REZONEB:
#****************|************|*************************************************************


%c.... Saved Zonal BURN Co-Processor Arrays
#****************|************|*************************************************************

bdum(1)                         # Dummy pointer array.

znetnumb(0:jmzb) "netnumb(0:jmzb)" # Number of the BURN isotopic nuclear network used in this zone.

zlimnuc(0:jmzb)  "limnuc(0:jmzb)"  # Integer containing the Z and A of the isotope controlling the
                                #  BURN timestep along with the KEPLER cycle that this zone was
                                #  last burned coded in the form:
                                #    LIMNUC  = A + 100*Z + 10000* NCYC

timen(0:jmzb)     [sec]         # Time to which the BURN coprocessing in this zone has been updated
                                #  (sec).

dtimen(0:jmzb)    [sec]         # Current timestep for BURN coprocessing in this zone (sec).

dnold(0:jmzb)     [g/cc]        # Density at which BURN coprocessing was last done in this zone (g/cc).

tnold(0:jmzb)     [K]           # Temperature at which BURN coprocessing was last done in this zone (K).

ymb(0:jmzb)       [g]           # Mass interior to the outer boundary of this zone, as last considered
                                #  by the BURN coprocessor (g).

sburn(0:jmzb)     [erg/g/s]     # BURN nuclear energy generation rate, excluding neutrino losses.
                                #  (erg/g/s).

etab(0:jmzb)      [moles/g]     # Burn neutron excess (moles/g).   The corresponding BURN electron
```

```
pbuf(0:jmzb)      [moles/g]     # Abundance buffer (internal working array -- see CONVECTB) (moles/g).


#**************************|*****************************************************************
****Isotopic_Abundance_Array  /abun_iso/   Saved  CYCLE  CYCLEB  REZONEB:
#***************|***********|*****************************************************************

c.... BURN abundance array:  ppnb(i,j) = ppnb((j-1)*imaxb+i)

      common  ppnb(nburn*jmzb)


c.... i/o buffer

      common ziobuf(iobufz)


c.... temporary storage space

      common scmt(3*(jmz+1)), dbuf(nvar*(nvar+1)*(jmz+2))

c.... mass coordinate library buffer array

      common ylib(nylibz)


      common ends



#**************************|*****************************************************************
****Saved_Character_Common    /charsave/   Saved  :
#***************|***********|*****************************************************************


%c.... Saved common for character variables...

%c.... Names, flags, and id-words
#******************|**************|*************************************************************
c
cdum(1)              character*8    # Dummy pointer array (char*8).

namep0               character*8    # Name under which this problem was last run (char*8).

namec0               character*16   # Name of the code with which this problem was last run (char*16).

iflag80              character*8    # Sequence letter for naming graphics files (char*8).

iqbrnflg             character*8    # Communications flag for subroutine SDOTQ (char*8).

craybox              character*8    # Name of user's computer output box (char*8).

idword               character*8    # ID word specified in the generator--usually user's name (char*8).


%c.... Storage and status info
#******************|**************|*************************************************************

nxdirect             character*16   # Name of storage directory for post-processor and restart dumps.

lastrun              character*16   # String containing the date that this problem was last run.

lastmod0             character*16   # String containing the date that this code was last complied.


%c.... Symbols for ions, isotopes, time-step controlers, and reactions
#******************|**************|*************************************************************

ions(nitz)           character*8    # Array of symbols for ions (char*8).

ionsb(nitzb)         character*8    # Array of symbols for burn isotopes (char*8).

idtcsym(ndtz)        character*8    # Array of symbols for time-step controlers (char*8).

isymr(nreacz)        character*8    # Array of symbols for nuclear reactions (char*8).


%c.... Post-processor file names and arrays (see DUMPQ)
#******************|**************|*************************************************************

nameqq               character*16   # Name of current post-processor dump file (char*16).

nameqlib             character*16   # Name of the file containing the mass coordinate library array
                                    #  ylib, and the array of stored dump times (char*16).

nameolds             character*16   # Name of the old status file (char*16).

namenews             character*16   #  Name of the new status file (char*16).
```

```
labldatq(ndatqz)    character*48   # Array of post-processor dump variable labels (char*48).

%c.... Edit variable names and remembered tty command strings (See TTYCOM)
#******************|**************|*************************************************************

namedzed(nzedz,10)  character*8    # Array of edit variable names for user-specified edits (char*8).

savdcmd0(30)        character*80   # Old array of remembered tty command strings (char*80).

%c.... 'Look' variable arrays and post-processor file names  (See READQ)
#******************|**************|*************************************************************

namedatl(ndatqz)    character*8    # Remembered 'look' post-processing variable names (char*8).

labldatl(ndatqz)    character*48   # Remembered 'look' post-processing variable labels (char*48).

nameqql0            character*16   # Name of first postprocessor('qq') dump file to be read (char*16).

nameqql1            character*16   # Name of last postprocessor('qq') dump file to be read (char*16).

nameqlbl            character*16   # Name of the qlib file associated with the qq-files to be read.
                                   #  (char*16)  normally automatically read from qq-file header.


%c.... Misc. names, symbols, icons and sentinels
#******************|**************|*************************************************************

nsdirect            character*48   # Archival output storage directory (char*48).

isosym(50)          character*8    # Array of the symbols of isotopes to be plotted (char*8).

isoicon(50)         character*16   # Array of the plot icons of isotopes to be plotted (char*16).

savedcmd(ncsavedz)  character*80   # Array of remembered tty command strings (char*80).

icon(0:jmz)         character*8    # Array of zonal convection sentinels (char*8).

#**************************|*********************************************************************
#***End Saved Character Common
#**********|*********|********|*********************************************************************



#**************************|*********************************************************************
%c.... ZBURN Communications Common...
%c
#**********|*********|********|*********************************************************************
****ZBURN_Common              /zbrn/   BURN  ZBURN :
#****************|************|*********************************************************************


%c.... Vectors for sending and receiving info on the subgroups of zones to be burned by ZBURN
#****************|************|*********************************************************************
jalign                        # Dummy integer alignment variable.

jcount                        # Number of zones currently being passed to the BURN coprocessor
                              #  to be burned

yz(nburn*nzburn) [moles/g]    # Vector of isotopic abundances for the zones to be burned by ZBURN
                              #  (moles/g).

jzone(nzburn)                 # Vector of zone numbers for the zones to be burned by ZBURN.

timez(nzburn)    [sec]        # Vector of times to which the zones to be burned by ZBURN have
                              #  already been updated by the BURN coprocessor (sec).

denz(nzburn)     [g/cc]       # Vector of densities for the zones to be burned by ZBURN (g/cc).

tempz(nzburn)    [K]          # Vector of temperatures for the zones to be burned by ZBURN (K).

rnz(nzburn)      [cm]         # Vector of radii of the outer boundaries of the zones to be burned
                              #  by BURN (cm).

sburnz(nzburn)   [erg/g/s]    # Vector of BURN nuclear energy generation rates, excluding neutrino
                              #   losses, for the zones just burned by ZBURN (erg/g/s).

dtimez(nzburn)   [sec]        # Vector of current timesteps for BURN coprocessing for the zones to be
                              #   burned by ZBURN (sec).

etaz(nzburn)                  # Vector of BURN neutron excesses (moles/g) for the zones just burned
                              #  by BURN.  The corresponding BURN electron abundance is given by:
                              #     yeburn = 0.5 * (1. - etaz)

limnucz(nzburn)  [moles/g]    # Vector of time-step-limiting isotopes for the zones just burned by
                              #  ZBURN.  The values of limnucz are integers containing the Z and A of
                              #  the isotope controlling the BURN timestep along with the KEPLER
```

```
%c.... KEPLER parameters and variables passed through to ZBURN under different names
#****************|************|*************************************************************
zbdum(1)                        # Dummy poiner array.

chiminz          [moles/g]      # ZBURN chimin...(p 246) Minimum isotopic abundance that affects the
                                #  calculation of the zonal timestep in the BURN coprocessor (moles/g).

delchiz                         # ZBURN delchi...(p 247) Maximum desired fractional change of an
                                #  isotopic abundanceused in determining the zonal timestep used in
                                #  the BURN coprocessor.

fdtnz                           # ZBURN fdtn...(p 248) Maximum factor by which the zonal timestep in
                                # the BURN coprocessor can be increased in one zonal cycle.

dtbkupz                         # ZBURN dtbkup...(p 249) Back up to the previous zonal cycle in the
                                #  BURN coprocessor if the new zonal timestep is less than DTBKUP
                                #  times the previous timestep.

ncompz                          # ZBURN ncomp...(p 250) Make a complete ASCII edit of the nuclear
                                #  processes in allzones considered by the BURN coprocessor every
                                #  NCOMP cycles.

ncentz                          # ZBURN ncent...(p 251) Make an ASCII edit of the nuclear processes in
                                #  the central zone considered by the BURN coprocessor every NCENT
                                #  cycles.

nedtz                           # ZBURN nedt...(p 252) Make an ASCII edit of the nuclear processes
                                #  involved every nedt involved every nedt BURN coprocessor matrix
                                #  inversions (debugging only).

nzroz                           # ZBURN nzro...(p 253) Set newly calculated negative BURN isotope
                                #  abundances to 0. if NZRO not equal to 0.

amaglimz         [?]            # ZBURN amaglim...(p 254) Minimum absolute magnitude of a BURN matrix
                                #  element for which Gauss-Jordan elimination is carried out in solving
                                #  for changes in isotopic abundances.

ninvz                           # ZBURN ninv...(p 255) Total number of BURN-coprocessor matrix
                                #  inversions so far(internally incremented).

nbkupz                          # ZBURN nbkup...(p 256) Total number of BURN-coprocessor backups so fa
                                #  (internally incremented).

nttyz                           # ZBURN ntty...(p 257) FORTRAN I/O unit number for ZBURN messages sent
                                #  to the user's terminal.

ileqstpz                        # ZBURN ileqs...(p 258) Choice of matrix inverter to use in the BURN
                                #  Co-Processor:
                                #    If ileqs .le. 0 use modified Gaussian elimination (SLEQSZ).
                                #    If ileqs .ge. 1 use FLEQS - harwell sparse matrix inverter
                                #      coded by Frank Timmes.

negbkupz                        # ZBURN negbkup...(p 259) Cumulative number of BURN coprocessor backups
                                #  due toencountering negative isotopic abundances (incremented
                                #  internally).

nalign                          # Dummy integer alignment variable.

bkupdivz                        # ZBURN bkupdiv...(p 260) Factor by which to reduce the BURN coprocessor

                                #  zonal timestep when a negative isotopic abundance backup occurs.

bkupmasz         [moles/g]      # ZBURN bkupmass...(p 261) Minimum absolute magnitude of a negative
                                #  isotopic abundance (except of protons) that can cause a zonal backup
                                #  in the BURN coprocessor (moles/g).

bkupmpz          [moles/g]      # ZBURN bkupmp...(p 262) Minimum absolute magnitude of a negative proton
                                #  abundance that can cause a zonal backup in the BURN coprocessor
                                #  (moles/g).

nbkupmxz                        # ZBURN nbkupmax...(p 263) Maximum number of consecutive negative
                                #  isotopic abundance backups allowed in the BURN coprocessor before
                                #  quitting.

mazfulz                         # ZBURN mazful...(p 265) Use Fuller et. al.'s weak rates in the BURN
                                #  coprocessor if MAZFUL=1, otherwise use the old rates of Mazurek
                                #  and Hansen.

c12mt1z                         # ZBURN e1mltc12...(p 227) Multiplier on the E1 part of the C12(a,g)
                                #  cross-section (affects both APPROX and the the BURN coprocessor,
                                #  but currently has no effect on the C12(a,g) rate used to calculate
                                #  photodisintegration flows in ISE.)

c12mt2z                         # ZBURN e2mltc12...(p 228) Multiplier on the E2 part of the C12(a,g)
                                #  cross-section (affects both APPROX and the the BURN coprocessor,
                                #  but currently has no effect on the C12(a,g) rate used to calculate
                                #  photodisintegration flows in ISE.)
```

```
                                #  affect the BURN coprocessor zonal timestep from CHIMIN (P 246) to
                                #  CHIMIN/AL26MULT.

imaxbz                          # ZBURN imaxb...maximum number of actual isotopes in any of the BURN
                                #  networks specified in the BURN generator for the current problem.

ncycle                          # ZBURN ncycb...current BURN cycle number (usually same as KEPLER).

btime           [sec]           # Current problem time for the BURN co-processor.  This in generally
                                #  the same as the KEPLER time, except when subcycling is specified.
                                #  See CYCLEB and NSUBCYCM (p 264).

taunuz          [sec]           # ZBURN taunu...(p 286) Time scale for the neutrino pulse considered by
                                #  the BURN coprocessor in calculating neutrino-induced nucleosynthesis
                                #  after core collapse (sec).

enu53z          [E+53 erg]      # ZBURN enu53...(p 287) Total energy (in units of 10**53 ergs) for the
                                #  neutrino pulse considered by the BURN coprocessor in calculating
                                #  neutrino-induced nucleosynthesis after core collapse.

tmunuz          [MeV]           # ZBURN tmunu...(p 288) Temperature of the mu and tau neutrinos in the
                                #  neutrino pulse considered by the BURN coprocessor in calculating
                                #  neutrino-induced nucleosynthesis after core collapse (MeV).

tenuz           [MeV]           # ZBURN tenu...(p 289) Temperature of the electron neutrinos in the
                                #  neutrino pulse considered by the BURN coprocessor in calculating
                                #  neutrino-induced nucleosynthesis after core collapse (MeV).

%c
%c... End ZBURN Communications Common
%c
#**********|*********|********|*******************************************************************************



c.... form fixed point  arrays for parameters
c.... note that iratioz is a machine-dependent parameter indicating
c.... the ratio of the storage length of normally used real numbers
c.... to that of normally used integers (=1 on cray, =2 on mips and sun)

      dimension ipdum(0:(iratioz*(nparmz+1)-1))
      equivalence (pdum(0),ipdum(0))



c.... form reference arrays for edit ('q') parameters

      dimension iqdum(0:(iratioz*(nqparmz+1)-1))
      equivalence (qdum(0),iqdum(0))


c.... form integer reference arrays for the post-processing buffer
c.... note that gridbuf is real*4

      dimension igridbuf(ngridbuf)
      equivalence (igridbuf,gridbuf)

c.... form reference arrays for zonal variables

      dimension izdum(1), ibdum(1)
      equivalence (zdum(1),izdum(1))
      equivalence (bdum(1),ibdum(1))


c.... equivalence ise derivative arrays to approx derivative
c.... arrays in order to save space

      dimension yp00(jmz), ypbtp(jmz), ypbdp(jmz),
     1          yn00(jmz), ynbtp(jmz), ynbdp(jmz)
      equivalence (yp00,snold), (ypbtp,snbt), (ypbdp,snbd)
      equivalence (yn00,abarold), (ynbtp,abarnbt), (ynbdp,abarnbd)


c     endcliche
```

```
c.... some helpful notes on tty interactions for kepler

      subroutine ttycom

      implicit real*8 (a-h,o-z)
      save

      include 'kepcom'

c.... this subroutine performs teletype communications.
c.... it is called by cycle at the beginning of each timestep to
c.... check for messages or, if in stepping mode, to wait for
c.... further instructions. teletype commands may be entered more
c.... than one to a line by using commas as delimitors.
c.... note that words representing input character variables are
c.... truncated to 8 characters, while numerical input is field-
c.... free, subject to an overall limitation of 80 char/line.
c.... floating point numbers must be distinguished from
c.... integers by a decimal point or exponent.

c.... allowed tty commands:

c.... fin.....to terminate the problem
c.... end.....same as fin
c.... s.......to suspend, or to step one cycle
c.... s n.....to step n cycles
c.... g.......to resume normal calculations
c.... ed......to force an edit
c.... ed m....to force an edit with medit (p 276) = m
c.... ted m...to force an acsii edit to the tty with medit (p 276) = m
c....         if no value of m is given, 1 page 'short' edit is made.
c.... edp.....to force a parameter edit
c.... d.......to force a dump
c.... d name..to force a dump on file name
c.... newe....code calculates new internal energies
c.... p n v...to change parameter n to v
c.... p n v add...to add v to the value of parameter n
c.... p n.....to ask the value of paramter n
c.... q n.....to ask for the value of edit ('q') parameter n
c.... t.......to get a time edit on tty
c.... tq......to get a time and general edit on tty
c.... e.......to get an energy edit on tty
c.... j.......to get a zone j edit on tty
c.... j i.....to get ion type edit for zone j
c.... j b.....to get burn ion type edit for zone j
c.... j i sym.to get edit for ion sym in zone j
c.... j b sym.to get edit for burn ion sym in zone j
c.... j q.....to get qburn edit for zone j
c.... tn......to get an edit for all tn reactions
c.... tn sym..to get an edit for tn reaction sym
c.... time....to get an edit of computer time used
      sumi
c.... massi n m......to get an edit of the mass of all ions
c.... sumi                in zones n thru m (in solar masses).
c.... massi n m sym..to get an edit of the mass of ion 'sym'
c.... sumi                in zones n thru m (in solar masses).
c.... massb n m......to get an edit of the mass of all burn isotopes
c.... sumb                in zones n thru m (in solar masses).
c.... massb n m sym..to get an edit of the mass of burn isotope 'sym'
c....                     in zones n thru m (in solar masses).

c.... v arrayname [jmin [jmax]]
c....    to make a tty edit of the variable 'arrayname' from zones
c....    jmin to jmax, inclusive.  if only jmin is specified, jmax is
c....    assumed =jmin.  If neither jmin or jmax is given, then jmin=1
c....    and jmax=jm.  arrayname may be any editable array (see kepdoc
```

```
c....    and the list given in the mongo command below).

c.... vf arrayname [jmin [jmax]]
c....     same as the v command except that edited values are given to
c....     14 decimal places instead of 3.

c.... ved arrayname [jmin [jmax]]
c....     same as the v command except that the edit is written to
c....     the ascii output file instead to the terminal.

c.... vfed arrayname [jmin [jmax]]
c....     same as the v command except that edited values are given to
c....     14 decimal places instead of 3, and the edit is written to
c....     the ascii output file instead to the terminal.

c.... z arrayname1 [arrayname2....arrayname10] [jmin [jmax]]
c....    to make a columnar zonal edit of arrays arrayname1 through
c....    arrayname10 (if requested) for zones jmin through jmax.
c....    if only jmin is specified, jmax is assumed =jmin.
c....    If neither jmin or jmax is given, then jmin=1 and jmax=jm.
c....    arraynamen may be any editable array (see kepdoc
c....    and the list given in the mongo command below).
c....    the first column in the edit gives the convection sentinel
c....    and the zone number, while the second column list the interior
c....    mass in scalem (p 273) units.   values of the requested arrays
c....    start in column 3.   At least one array must be requested, up
c....    to a maximum of 10.  note that 5 array requests fit nicely in
c....    an 80-column screen window while 10 fill an 132 columm edit
c....    page.

c.... zed arrayname1 [arrayname2....arrayname10] [jmin [jmax]]
c....    like the z command except the edit is written to
c....     the ascii output file instead to the terminal.

c.... zedit ized ncyczed arrayname1 [arrayname2...arrayname10]
c....       [ zedmass1 [zedmass2]]
c....    to specify a special multiple column ascii edit of zonal
c....    quantities to be written every ncyczed cycles.
c....    here nzed is an index number (max of nzedz) that
c....    distinguishes requested edits and zedmass1 and zedmass2
c....    specify an optional interior mass range (in scalem (p 273)
c....    units) to edit.  If only zedmass1 is specified a +-1% range
c....    around it is edited, and if no masses are specified an edit
c....    of the whole star is made.
c....    previously specified edits can be changed or terminated by
c....    overwriting them with a new zedit command with the same
c....    index number. (note: setting ncyczed=0 terminates the edit)

c.... dump arrayname ratzdump ratiodez ratioadz
c....      add array 'arrayname' to the list of variables to be dumped
c....      to the qq dump file or change its dump parameter if it is
c....      already in the dump list.  all the arraynames legal in the z
c....      and mon edits are also legal here plus 'parm' (to dump the
c....      values of the changeable('p') parameters) and 'qparm' (to
c....      dump the values of the edit ('q') parameters).
c....      the associated dump parameters are:
c....         ratiodez...array of minimum fractional changes in a
c....                zonal dump variable allowed between two
c....                adjacent dump grid points before the dump grid
c....                for this variable is dezoned.
c....         ratioadz...array of maximum fractional changes in a
c....                zonal dump variable allowed between two
c....                adjacent dump grid points before the dump grid
c....                for this variable is adzoned.
c....         ratzdump...array of the maximum allowed fractional
c....                changes between dumps of the zonal dump variables.
```

```
c....    in the case of 'parm' and 'qparm' the values of ratioadz and
c....    ratiodez are ignored but must be given.


c.... addlook arrayname [delflag]
c....      add array 'arrayname' to the list of ('look') variables to be
c....      read from the qq dump file.  all the arraynames legal in the
c....      'z' and 'mon' edits are also legal here (but not 'parm' or
c....      'qparm').  if the second argument is present and is equal to
c....      'delete', then array arrayname is deleted instead.

c.... plot n
c....    to plot current problem status in graphics window and/or file
c....    (n: 1=thermodynamics plot
c....        2=velocity plot
c....        3=abundance plot
c....        4=entropy plot
c....        5=temperature and density plot
c....        6=isotopic abundance plot
c....        n=12,13,21,23,31,32, etc. gives pairs of the above plots)

c.... setiso isosym1 [isosym2 ... isosym20]
c....    this command sets the detailed isotopic abundances to be
c....    plotted by the "plot 6" or "look 6" commands.  At least 1
c....    and no more than 20 isotopic symbols (ionsym1...ionsym20)  must
c....    be specified in the form: "setiso h1 he4 c12 o16 mg25 al26"

c.... listiso
c....    list the current set of isotopes to be plotted as set by the
c....    "setiso" command.

c.... timeplot timevar [ncyct0 ncyct1 [ndelcyct]]

c.... printl [ n [filename]]
c.... pl     [ n [filename]]    (abbreviated form)
c....       make a postscript plot in landscape orientation on the local
c....    laser printer where n is the plot type defined in the plot
c....    command.  if n is not specified, it is taken to be
c....    ipixtype (p 113).  if a filename is specified, the picture is
c....    also saved in a postscript file with that name (note that n
c....    must also be specified in this case).  if 'k' is given for
c....    file-name, a new file-name is generated automatically in
c....    the form nameprob:ncyc, where nameprob is the current problem
c....    name and ncyc is the current cycle.

c.... printp [ n [filename]]
c.... pp     [ n [filename]]    (abbreviated form)
c....       make a postscript plot in portrait orientation on the local
c....    laser printer where n is the plot type defined in the plot
c....    command.  if n is not specified, it is taken to be
c....    ipixtype (p 113).  if a filename is specified, the picture is
c....    also saved in a postscript file with that name (note that n
c....    must also be specified in this case).  if 'k' is given for
c....    file-name, a new file-name is generated automatically in
c....    the form nameprob:ncyc, where nameprob is the current problem
c....    name and ncyc is the current cycle.

c.... mongo arrayname2 arrayname3...arrayname8 [axisy2 axisy3]
c....       to enter interactive plotting mode with array rbuf from
c....    subroutine plot in data column1, and each array, arraynamei,
c....    in data columni.  at least one and no more than seven
c....    array names can be specified.  they may consist of names of
c....    saved zonal arrays in kepcom: ym, rn, rd, un, xln, qln, qld,
c....    difi, netnum, xm, dn, tn, td, en, pn, zn, etan, sn, snn,
c....    abar, zbar, xkn, xnei, stot, dsold, tsold, snold, snbd, snbt,
c....    abarold, abarnbd, abarnbt, ypbtime, ynbtime, netnumb, limnuc,
```

```
c....    timen, dtimen, dnold, tnold, ymb, sburn, etab, pbuf.
c....    alternately, they may have the form ionfe54 or isoal26, where
c....    fe54 exemplifies any valid approx-network ion symbol and
c....    al26 exemplifies any  valid burn network isotope symbol.
c....    other editable zonal quantities include the variables listed in
c....    the nameedit array (see block data kepdat),the nuclear reaction
c....    flows due to the reactions named in isymr, and the misc.
c....    variables 'mixlen', 'taumix', 'nalim', 'nzlim', 'ncyczb',
c....    'yeburn', 'rhor', 'sneut', 'sgain', 'sloss', and 'convect'.
c....    (see kepdoc).
c....       detailed ise and nse zonal edit qunatities can be referenced
c....    in the form: 'insefe56' where 'nse' is a fixed flag, 'fe56'
c....    represents the symbol of an isotope in the qnse network (stored
c....    in array nucsym). and 'i' represents a variable flag depending
c....    on which isotopic quantity or rate is desired.
c....    'i' may take the values:
c....         'i' .... to get the isotopic mass fraction
c....         'w' .... to get the isotopic statistical weight
c....         'r' .... to get the total weak interaction rate
c....                  due to this isotope (moles/g/sec)
c....         'c' .... to get the electron capture rate due to this
c....                  isotope (moles/g/sec)
c....         'p' .... to get the positron emission rate due to this
c....                  isotope (moles/g/sec)
c....         'b' .... to get the beta decay rate due to this
c....                  isotope (moles/g/sec)
c....         'e' .... to get the total neutrino energy loss due to
c....                  this isotope (ergs/g/sec)
c....         'k' .... to get the neutrino energy loss due to electron
c....                  capture on this isotope (erg/g/sec).
c....         'x' .... to get the energy stored in the excited states of
c....                  this isotope (mev/nucleus).
c....      on entry into mongo, graphs of the first one or two
c....    (if specified) arrays are made automatically vs.the normal mass
c....    coordinate.  For most quantities the ordinate is logarithmic
c....    by default (with negative data values or a small range of
c....    values defaulting the plot instead to linear), but can be
c...     set explicitly by setting axisy2 and/or axisy3 to
c....    'lin' or 'log'.  the code assumes that one 'lin' or
c....    'log' value appended to the command line (after at least one
c....    arrayname) refers to axisy2, the flag for plotting arrayname2.
c....    if two 'log' or 'lin' values are appended, they are intepreted
c....    as axisy2 and axisy3, the flags for ploting arrayname2 and
c....    arrayname3, respectively.  the flag 'same' can also be used as
c....    the last word on the command line to set the axis type for
c....    plotting arrayname3 to be the same as arrayname2, except that
c....    the axis limits are expanded to cover the extremes of both
c....    variables  The 'same' flag can be proceeded by at most one
c....    'lin' or 'log' flag specifying the common axis type.  If an
c....    axis type is not given, a default value is chosen according to
c....    the character of the data.
c....      type 'curses' to get mouse coordinate display, corresponding
c....    to the values of the last-defined axes.
c....    type 'end' to quit interactive mongo.

c.... mon arrayname2 arrayname3...arrayname8 [axisy2 axisy3]
c....          abreviation for the 'mongo' command described above.

c.... setlib  [nametlib [ncyct0 [ncyct1 [ncyctdel [ncycqqt [lentdmpt
c....           [niymaxt]]]]]]]
c....    this command sets the dump library file and associated
c....    parameters to be used in making time-plots.  here:
c....      nametlib--name of desired dump library file. default is
c....        the one for the current job.
c....      ncyct0--the first dump cycle to be read and plotted.
c....        (default=0)
```

```
c....      ncyct1--the last dump cycle to be read and plotted.
c....        (default=last cycle in dump library)
c....      ncyctdel--the interval in dump cycles beteen dump library
c....         reads.  (default=ncycqq)
c....      ncycqqt--number of cycles beteen dump library dumps.
c....         (default=ncycqq).
c....      lentdmpt--length of each time dump in nametlib.
c....         (default=384)
c....      niymaxt--maximum number of iy coordinate values in nametlib.
c....         (default=20000)
c....   if setlib is not called, the default values are set when
c....   'timeplot' ('tp') is first called.  calling 'setlib' without
c....   arguments resets all these variables to their default values if
c....   they have previously been changed by a 'setlib' command.

c.... timeplot timevar2 timevar3...timevar8 [axisy2 axisy3]
c.... tp       timevar2 timevar3...timevar8 [axisy2 axisy3]  (alt. form)
c....       to enter interactive plotting mode with the array of
c....    log10(time-timeref) values derived from dump library
c....    nametlib (set in setlib) in data column 1,
c....    and the corresponding time sequences for
c....    the time variable, timevari, in data column i.
c....    here timeref is time(n)+10.*(time(n)-time(n-1)), where time(n)
c....    is the time corresponding to the last cycle read and time(n-1) c....    is the
c....    at least one and no more than seven time variables must be
c....    specified from the following list (see kepdoc for definitions):
c....    'ncyc',      'jdtc',     'iter',     'jm',       'jmcalc',
c....    'nylib',     'ndatq',    'dt',       'radius',   'teff',
c....    'xlum',      'dn1',      'tn1',      'xlumn',    'ensc',
c....    'eni',       'enk',      'enp',      'ent',      'epro',
c....    'enes',      'enc',      'enscd',    'enid',     'enkd',
c....    'enpd',      'entd',     'eprod',    'enesd',    'encd',
c....    'snuc',      'sn1',      'snn1',     'pn1',      'eta1',
c....    'ye1',       'sig1',     'cmptime',  'd1',       'd2',
c....    'd3',        'd4',       'd5',       'd6',       'd7',
c....    'd8',        'd9'.
c....      On entry into mongo, graphs of the first one or two
c....    (if specified) variables are made automatically
c....    vs. the log10(time-timeref) time coordinate.
c....    For most quantities the ordinate is logarithmic
c....    by default (with negative data values or a small range of
c....    values defaulting the plot instead to linear), but can be
c...     set explicitly by setting axisy2 and/or axisy3 to
c....    'lin' or 'log'.  the code assumes that one 'lin' or
c....    'log' value appended to the command line (after at least one
c....    arrayname) refers to axisy2, the flag for plotting arrayname2.
c....    if two 'log' or 'lin' values are appended, they are intepreted
c....    as axisy2 and axisy3, the flags for ploting arrayname2 and
c....    arrayname3, respectively.  the flag 'same' can also be used as
c....    the last word on the command line to set the axis type for
c....    plotting arrayname3 to be the same as arrayname2, except that
c....    the axis limits are expanded to cover the extremes of both
c....    variables  The 'same' flag can be proceeded by at most one
c....    'lin' or 'log' flag specifying the common axis type.  If an
c....    axis type is not given, a default value is chosen according to
c....    the character of the data.
c....      Type 'curses' to get mouse coordinate display, corresponding
c....    to the values of the last-defined axes.
c....    Type 'help' to get a list of interactive mongo commands.
c....    Type 'end' to quit interactive mongo.

c.... setq [nameqql0 [nameqql1]]
c....    this command sets the names of the qq-files to be post-
c....    processed, where nameqql0 and nameqql1 are the first and
c....    last members of the sequence of qq-files to be read.
c....    used without argumements setq implies that all
```

```
c....    the qq files for the current problem in the current
c....    working directory are to be used.  note that this is the
c....    default situation and that setq only has to be used in this
c....    mode to restore the specified qq-files to this default.
c....    if only nameqql0 is specified, all available qq-files in
c....    the sequence starting with nameqql0 will be read.
c....    note that qq-file names can be up to 16 characters long.

c.... look n ncycl0 [ncycl1 [ndelcycl]]
c....    this command makes a movie of plot type n starting as closely
c....    as possible to cycle ncycl0 and ending as closely as possible
c....    to cycle ncycl1 at intervals as close as possible to ndelcycl
c....    using information from the qq-files specified by setq or
c....    (by default) those available for the current problem.
c....    plot types and output modes are as specified in the 'plot'
c....    command and by the values of itvstart (p 127).  Plot limits
c....    are assumed the same as those displayed for the current cycle
c....    by 'plot' for this plot type, which can be adjusted using the
c....    usual graphics parameters.  if not specified, ncycl1 is assumed
c....    to be the last cycle for which information is available in the
c....    qq-files specified by 'setq,' and ndelcycl is assumed to be
c....    the cycle interval between post-processor dump writes
c....    multiplied by idtlook (p 302).

c.... l n ncycl0 [ncycl1 [ndelcycl]]
c....     abbreviated form of the 'look' command described above.

c.... lprint1 n ncycl0 [ncycl1 [ndelcycl]] [file-name]
c.... lpl n ncycl0 [ncycl1 [ndelcycl]] [file-name]  (abbreviated form)
c....       make a postscript plot of plot-type n at cycle ncycl0 in c....    landscape
c....    defined in the plot command and use is made of information from
c....    the qq-files specified by setq or (by default) those available
c....    for the current problem.   if a file-name is specified, the
c....    picture is also saved in a postscript file with that name.
c....    if ncycl1, or both ncycl1 and ndelcycl, are given (before
c....    file-name, if any is specified), then a series of prints will
c....    be produced starting at look cycle ncycl0 and continuing to
c....    look cycle ncycl1 at intervals of ndelcycl.  A ':' followed
c....    by the current look cycle number will be appended to the
c....    file-name specified (but limited to a total of 16 characters).

c.... lprintp n ncycl0 [file-name]
c.... lpp     n ncycl0 [file-name]  (abbreviated form)
c....       make a postscript plot of plot-type n at cycle ncycl0 in c....    portrait c
c....    defined in the plot command and use is made of information from
c....    the qq-files specified by setq or (by default) those available
c....    for the current problem.   if a file-name is specified, the
c....    picture is also saved in a postscript file with that name.
c....    if ncycl1, or both ncycl1 and ndelcycl, are given (before
c....    file-name, if any is specified), then a series of prints will
c....    be produced starting at look cycle ncycl0 and continuing to
c....    look cycle ncycl1 at intervals of ndelcycl.  A ':' followed
c....    by the current look cycle number will be appended to the
c....    file-name specified (but limited to a total of 16 characters).

c.... test a j t d...to get an edit of quantity (a) for the
c....                materials of zone j, but at temperature t (deg k)
c....                and density d (g/cc).  (a) may be any of the
c....                following:
c....                   k.....opacity (cm2/g)
c....                   s.....energy production rate (ergs/g/s)
c....                   p.....pressure (ergs/cc)
c....                   e.....energy (ergs/g)

c.... link namel......read link deck namel
```

```
c.... genburn namebg..read burn generator, namebg, and begin
c....                 burn co-processing

c.... cutsurf nsurf.....remove nsurf zones from the surface of the
c....                   problem and set pbound and tbound to
c....                   correspond to innermost zone removed.

c.... check.............type out number of fxrad file errors since
c....                    the last restart (nioerr).

c.... decayni56.........convert all ni56 to fe54 in such a way as to
c....                    conserve mass, but with no energy generation.

c.... box v98...........change output box number to v98 or any other
c....                    specified box.

c.... eostrans transmlt...add transmlt times the energy in nuclear
c....                     excited states to all zonal specific energies

c.... newstart..........reinitialize problem by putting out i/o,
c....                    storing dumps, and finning and restarting
c....                    controllees.

c.... version...........type out information about the dates on which
c....                    the current code muldules were last modified.

c.... store nsdirect......set the directory into which ascii output
c....                    files and labeled restart dumps will be
c....                    written to nsdirect.  if nsdirect is set to
c....                    'no-store' (default), output files will be
c....                    placed in the current working directory.

c.... newqname..........reset the names of the expected qq-file and
c....                    qlib-file to reflect the current problem
c....                    name.

c.... tval n val1 val2 val3 ... val10
c....    set tz(n),tz(n+1)...etc. equal respectively to the subsequently
c....    listed values val1, val2 ...etc.  at least one
c....    and up to ten values can be given on each line.
c....    this command can be used to set or change the tz array so that
c....    it contains the ntemp eos table temperature points (in kev)
c....    needed by eoswrite, immediately followed by the nrho density
c....    points (in g/cc) required (see eostable command).  attempts to
c....    write beyond tz(ntempz) will generate an error message.

c.... eoswrite jtab jj ntemp nrho neosm (no longer supported)
c.... see version .tw:kepn:kepn3/25 for old coding
c....    this command writes an eos table set identified by
c....    eos # jtab based on the composition of zone jj,and having ntemp
c....    temperature points and nrho density points.  this table set is
c....    written after the last entry in file eoskep.
c....    if eoskep does not yet exist, it is created with a
c....    sufficiently large size to contain neosm table sets.
c....    before the eostable command is used, the tz array must be
c....    set via the tval command so that it contains first the ntemp
c....    temperature points (in kev), immediately followed by the
c....    nrho density points (in g/cc).  nrho and ntemp can sum to at
c....    most ntempz.

c.... eostable jj tlow thi ntemp dlow dhi nrho
c....    using the composition from zone jj a table of eos and
c....    opacity information is written on the kepler output medium
c....    for a logrithmic grid of temperatures (from tlow
c....    to thi with nt+1 grid points) and density (from dlow to
c....    with nd+1 grid points)
```

```
c.... det jdet0 jdet1 endet
c....    add endet ergs/g to the specific energies of zones
c....    jdet0 through jdet1 inclusive to simulate
c....    the passage of a detonation wave.
c....    also change detonated zones to ni56.

c.... compsurf n mfrac1 mfrac2 ..... mfrac10
c....    set compsurf(n), compsurf(n+1)...etc. equal respectively to
c....    the values mfrac1, mfrac2...etc. at least one and up to
c....    ten such values can be given on each
c....    command line.  repeated use of this command can thus
c....    set all the elements in the compsurf array. these
c....    elements respectively represent the mass fractions of neutrons,
c....    h1,photodisintegration protons,he3,he4,c12(6),n14,o16,ne20,
c....    mg24,si28(11),s32,ar36,ca40,ti44,cr48(16),fe52,fe54,and ni56
c....    used to set the composition of the surface zones added by
c....    the addsurf command.

c.... addsurf nsurf tmsurf tempsurf rhosurf velsurf
c....    add nsurf zones of equal mass totaling tmsurf (g) with
c....    temperature tempsurf (degk), density rhosurf (g/cc),
c.....   velocity velsurf (cm/s), and the composition last
c....    specified by the compsurf command.
c....    note that each time addsurf is called, the
c....    sum of the mass fractions in the compsurf array is
c....    normalized to unity.


c.... chngcomp l m n mfrac1 mfrac2 .... mfrac8
c....    change composition in zones l thru m to mass fractions
c....    specified.
c....    at least 1 and up to 8 such values can be given on each control
c....    line. repeated use of this command can set all the elements in
c....    the nwcomp array starting at element number n. see instructions
c....    for compsurf command for ordering. mass fractions will be
c....    renormalized to sum to unity and equation of state will be
c....    recomputed using the new composition.
c....                        *** caution ***
c....    radically altering the composition in any zone may cause
c....    discontinuous changes in its internal energy,pressure,etc.
c....    causing convergence problems.

c.... burn co-processor-related commands:

c.... jump ncycnew...to reset the burn cycle number, ncycb, to ncycnew
c.... offset deltat ncycnew...to add deltat to all zonal times
c....                          and change ncycb to ncycnew
c.... zerotime.....set time (p2) to 0.  add the old time to
c....              toffset (p315) and call reset if burn coprocessing
c....              is being done.
c.... reset........reset the timen array and take a small time step


c.... the teletype message is in ttymsg.
c.... ttymsg is limited to 80 ascii characters, but may
c.... contain any possible number of comma-delimited command lines,
c.... which are moved one at a time into line for translation
c.... ncmd is the total number of comma-delimited command lines
c....   in the current message (ttymsg)
c.... nsym is the number of symbol(s)/word(s) in the current command
c....   line which is limited to a maximum of 60

c.... each command line symbol/word is read as if it were a character,
c.... integer, or floating-point variable and the resulting values
c.... are stored in the following arrays (in positions 1 to nsym):
```

```
c.... xxx.........array of floating point values of the words found
c....                  (xxx(k) is set to 0. if word k is not a number).
c.... iii.........array of fixed point values of the words found
c....                  (iii(k) is set to 0 if word k is not a number)
c.... jjj.........array containing the first eight characters
c....                  of each word found (in ascii)
c.... kkk.........array containing the first 80 characters
c....                  of each word found (in ascii)
c.... iwtype......array of word types (0=integer, 1=float, 2=char)
```

ADD-ON

TO KEPLER MANUAL VERSION 1 MAY 1991

OCTOBER 8, 2004

BY ALEXANDER HEGER

Contents

1 Undocumented Parameters (by value)

P	name	default	description
355	xlanger1	0.0d+0	
356	xlanger2	0.0d+0	
357	iburnye	0	If 1 initialize ISE zones with ye taken from the BURN network.
358	relmult	0.0d0	
359	geemult	1.0d0	
350	grbparm	0.0d0	
351	swmult	0.0d0	
352	tsharp	0.0d0	

2 New Parameters (by value)

P	name	default	description
137	`nadapb`	0	turns on adaptive BURN network adjustment if `1`, off if `0`.
363	`xmlossn`	0.0D0	multiplier on Niewenhuijzen & de Jager mass loss rate
364	`nangmix`	0	turn rotational mixing on (1) or off (0)
365	`angfmu`	1.0D0	molecular weight sensitivity of rotational mixing processes; affects Eddington-Sweet circulation and Goldreich-Schubert-Fricke instability; If a negative sigh is added, these instabilities are completely switched off when the "μ-current" exceeds the destabilizing circulation velocity, otherwise they are just reduced by a factor of one plus the ratio of the two circulation velocities.
366	`angfc`	1.0D0	efficiency of chemical mixing by rotational instabilities
367	`angfjc`	1.0D0	efficiency of angular momentum transport by (semi)convection
368	`angrcrit`	2.5D+03	critical Reynolds number (affects secular shear instability)
369	`angric`	2.5D-1	critical Richardson number (do noch change)
370	`angfjdsi`	1.0D0	general efficiency multiplier for dynamical shaer instability
371	`angfjshi`	1.0D0	general efficiency multiplier for Solberg-Høiland instability
372	`angfjssi`	1.0D0	general efficiency multiplier for secular shear instability
373	`angfjez`	1.0D0	general efficiency multiplier for Eddington-Sweet circulation
374	`angfjgsf`	1.0D0	general efficiency multiplier for Goldreich-Schubert-Fricke instability
375	`fmin`	1.0D0	under-relaxation factor on the corrections taken each iteration in the Henyey-solver. The maximum number of iteration is now `itmax (p 5)/fmin`.
376	`ncnvout`	0	write out (1) or not (0) the STERN convection plot file

377	`kaptab`	1	select opacity table: 0: old 1: OPAL'96
378	`fkapz`	1.0D0	multiplier on metallicity used in OPAL opacities
379	`zfakexp`	0.5D0	metallicity-dependence of the mass loss: $\kappa = \kappa_0 \cdot (Z/Z_\odot)^{\texttt{zfakexp}}$ • For non-WR stars all metals (everything but H and He) are considered. • For WR stars only the Fe and Ni abundance is considered.
380	`angsmt`	1.0D0	secular rotational mixing processes may not change by more than that per time-step
381	`nangsmg`	2	smooth some gradients used for computation of the rotational instabilities over that much grid points on either side. A Gaussian smoothing profile is used
382	`angsml`	1.0D-3	secular rotational mixing processes may change by at least that fraction for the local zonal diffusion time-scale
383	`angsmm`	1.0D-3	secular rotational mixing processes may change by at least that fraction of the total diffusion coefficient
384	`ipapsize`	6120792	paper size in points (inch/72). First 4 digits give width, last 4 digits give height. A value of 0 selects DIN A4 paper size. The default value is letter paper size.
385	`hstatxm`	1.D99	interior mass coordinate (g) above which hydrostatic stratification is assumed.
386	`hstatym`	-1.D99	surface mass coordinate (g) above which hydrostatic stratification is assumed
387	`xmlossw`	0.0D0	multiplier on WR mass loss rate
388	`iold`	0	set to 1 to use old physics
389	`rhotrans`	1.0D-7	Some SNIa stuff. *Ask Stan.*
390	`nwndout`	0	write out wind data to wind file PROBNAME.wnd every nwndout cycles. Set to zero to turn off.
391	`kapverb`	0	verbostiy of opacity subroutine. Zero gives no messages.
392	`xl0limf`	4.0D0	multiplier on limiting flux in radiation flux limiter.

393	`xl0limk`	0.0D0	limiting flux multiplied by $\exp\left\{\frac{4\pi\ \mathtt{rn}^2\ \mathtt{xl0limk}}{\kappa\ \mathtt{xm}}\right\}$.
394	`llimout`	1	limit to radiative flux of outer zone only if set to 1 (old behavior), otherwise limit to flux of the hotter zone (upper or lower).
395	`nenout`	0	write out total energies in file PROBNAME.ent every nenout cycles. Set to zero to turn off.
396	`ipromin`	1	minimum zone for procuction factor/yield plot
397	`ipromax`	99999	maximum zone for procuction factor/yield plot
398	`iprownd`	1	take into account wind when computing production factors/yields if set to 1, ignore if set to 0.

399 `iproyld` 0 determines the BURN abundance plot type (plot 9). The following plot types are currently supported:

- 0 total decayed mass fractions relative to solar ("production factors") see `profmin` (p 413) and `profmax` (p 414)
- 1 decayed isotope masses in solar masse (yield); see `proymin` (p 402) and `proymax` (p 403)
- 2 undecayed isotope masses in solar masses (yield) see `proymin` (p 402) and `proymax` (p 403)
- 3 decayed isotope mass fraction see `proamin` (p 415) and `proamax` (p 416)
- 4 undecayed isotope mass fraction see `proamin` (p 415) and `proamax` (p 416)
- 5 elemental decayed production factor relative to solar see `profmin` (p 413) and `profmax` (p 414)
- 6 decayed mass of all elements in solar masses (yield) see `proymin` (p 402) and `proymax` (p 403)
- 7 decayed mass fraction of all elements see `proamin` (p 415) and `proamax` (p 416)
- 101 values in `burnamax`, undecayed isotope mass draction
- 102 values in `burnmmax`, mass coordiantes
- 103 values in `ibcmax`, cycle numbers

Stable isotopes are drawn as filled dots, unstable ones a circles.

400 `minapro` -1000 minimum mass number for production factor/yield plot; automatic determination if set LE -99.

401	`maxapro`	-1000	maximum mass number for production factor/yield plot; automatic determination if set LE -99.
402	`proymin`	1.D-10	minimum value for yield in BURN plot types 1, 2 and 6 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
403	`proymax`	1.D3	maximum value for yield in BURN plot types 1, 2 and 6 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
404	`xkdmin`	1.d-20	minimum value for density used in subroutine kappa.
405	`h1hdep`	1.d-2	central hydrogen abundance at which the #hdep dump is made.
406	`he4hedep`	1.d-2	central helium abundance at which the #hedep dump is made.
407	`nenuout`	0	cycle frequency used to write enu data file.
408	`optconv`	2./3.	minimum optical depth below (i.e., outside of) which zone are not allowed to become convective.
409	`rloss`	1.d99	maximum radius beyon which zones are removed from star (similar to vloss, p 271). Isotope masses are added to the wind arrays, `wind` and `windb`.
410	`tloss`	-1.d99	minimum temperature below which zones are removed from star (similar to tloss, p 409). Isotope masses are added to the wind arrays, `wind` and `windb`.
411	`tapprox`	-1.d99	minimum temperature for change to approx network. Operates similar to the `approx` command in link decks.

412	`semilan`	0.0D0	α efficiency parameter for semiconvection according to Langer et al. (1983, A&A 126, 207), generalized for general EOS by replacing in Eq. (10) $\nabla_L - \nabla$ by $\nabla_S - \frac{d\log\rho}{d\log P}(\Gamma_3 - 1)$. For an idial gas with radiation the second term of the new expression is equal to $\nabla - \frac{\phi}{\delta}\nabla_\mu$, giving the original realtion from Langer et al. If `semilan` ≤ 0 the original prescription of Weaver, Zimmerman, & Woosley (1983) is used. Overshooting also is still treated that way.
413	`profmin`	1.D-4	minimum value for production factor in BURN plot types 0 and 5 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
414	`profmax`	1.D3	maximum value for production factor in BURN plot types 0 and 5 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
415	`proamin`	1.D-12	minimum value for the mass fraction BURN plot types 3, 4 and 7 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
416	`proamax`	1.D0	maximum value for the mass fraction BURN plot types 3, 4 and 7 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
417	`yelimb`	0.497D0	minimum value of `yeburn` below which no BURN coprocessing is considered. Use this parameter in conjunction with `netmax` (p 240).
418	`irecb`	0	record maximum abundances in BURN network (and save in the restart dumps) if set to 1. See also new plots and terminal commands.

419	`bmasslow`	-1.D99	mass coordiante below which no BURN coprocessing is considered. This parameter is automatically changed (increased only) if a zone reaches a Y_e value below `yelimb` (p 417) (in the APPROX network) or the network number in the APPROX network rises above `netmax` (p 240). It is then set to just below the upper edger (in interior mass coordiante) of the cell.
420	`si28dep`	1.D-4	central ^{28}Si mass fraction at which the `#sidep` dump is made, if the mass fractions of ^{16}O and ^{4}He are below 0.01.
421	`ivspecl`	0	version of the special rate set to use. Currently `0` gives the lower limit rate set (as used by Hoffman et al. 2000) and `1` uses the NACRE rate set. `2` uses the standard rate set plus the upper bound of ^{22}Ne(α,n) and ^{22}Ne(α,γ) (constant 7% BR) as determined by Wischer (Aug 2000). `3` uses the NACRE rate set plus the upper bound of ^{22}Ne(α,n) as determined by Rayet et al. (2000). `4` uses the standard rate set plus the CF88 ^{22}Ne(α,γ) and ^{22}Ne(α,n) rates. `6` uses the standard rate set plus the ^{22}Ne(α,n) rate from Jaeger et al. (2001) and the ^{22}Ne(α,γ) rate lower limit from Kaepeller, i.e. dropping the 633 resonance, and moving the 828 keV resonance to 832 keV with a strength of 118 meV. `8` is same as above, but uses the *high* limit ^{22}Ne(α,n) rate of Jaeger et al. (2001). `10` is same as above, but uses the *lower* limit ^{22}Ne(α,n) rate of Jaeger et al. (2001).
422	`ivrate`	1	version of the APPROX network rate subroutine to use. Currently `0` gives the WW95 rate set, `1` uses the rath00 rate set including the C12(α,γ) rate form Buchmann et al. (2000) + Buchmann, priv. comm. (Jul 2000), and `2` uses the NACRE rate set. On restart of older programs a value of `0` is initialized. `ivrate` values of `3`, `4`, and `5` use the rath00 rate set but the *adopted*, *high*, and *low* values of Kunz et al. (2002, ApJ). This also selects these rates in the rath00 rate set BURN coprocessing "special" subroutine `specl0` (see `specl.f` and `specl0.f`.

423	magnet	0	magnetic fields according to Spruit (2001), in prep., are included if set to 1. In this case, in semiconvective regions only the N_μ^2 limiting case of Spruit's description is considered. If set to 2, in semiconvective regions the geometric mean between the N_μ^2 limiting case and Schwarzschild convection is assumed (recommended by Spruit). If set to 3, N_μ^2 is multiplied by 0.1. If set to 4 an old buggy case is reproduced in which η_1 does not include the second term in the max statement of equation (36) of Spruit 2002, A&A, 381, 923. If set to 5 an old buggy case is reproduced in which q_1 is missing a factor $(\Omega/N_T)^{1/4}$.
424	nosht	2	convective zones are bound by overshooting layer only of they are at least nosht zones thick. This is to prevent the numerical "spaghetti" instability. Old dumps are restart with the previous standard value of nosht
425	alpth	1.	efficiency factor for thermohaline convection. If set to zero no thermohaline convection is considered. Thermohaline convections occurs in regions with destabilizing composition gradient, but stabilizing temperature gradient (salt finger instability). The implementation in KEPLER is according to Braun (1997, PhD thesis) and Kippenhahn et al. (1980)
426	abarstep	1.d99	no rezoning is performed when the region under consideration contains a step in ABAR of more than abarstep.
427	zbarstep	1.d99	no rezoning is performed when the region under consideration contains a step in ZBAR of more than zbarstep.
428	xmustep	1.d99	no rezoning is performed when the region under consideration contains a step in the mean molecular weight, μ =ABAR/(1+ZBAR) of more than xmustep.
429	netmin	1	minimum APPROX network number until which BURN coprocessing is followed. This is usefull in combination with iburnye so that BURN is still active when switching to QSE.

430	awcorot	-1.0D0	make the outermost ymcorot (p 431) totate with angular velocity awcorot. Off if $< 0.0D0$.
431	ymcorot	-1.0D0	make the outermost ymcorot totate with angular velocity awcorot (p 430). Off if $< 0.0D0$.
432	nstrout	0	write out structure data every nstrout time steps. No data is written if nstrout is 0.
433	mixcycl	0	do mixing at beginning (mixcycl $= 1, 2$) or at end of cycle (mixcycl $= 0$; default behavior). mixcycl > 0 is *extremely* helpful to prevent fatal crashes due do mixing after a too long time step, e.g., off-center burning shells that burn inward. mixcycl $= 1$ uses always the new time step (dt) for mixing, mixcycl $= 2$ uses the old time step (dtold; magnitude of mixing consistent with mixcycl $= 0$) for mixing unless a backup occurs, then also the current time-step of the backup cycle (dt) is used. When a backup occurs, the original mass fractions are restored and the star is re-mixed with the new time-step. Effective diffusion coefficients as used for the mixing are stored in the restart dump.
434	lburn	0	substitute BURN network for APPROX network (including energy generation, $\bar{A}$, $\bar{Z}$, ...). Abundances are mapped to BURN abbundances for plot/edit purposes only.
435	lbbkup	0	
436	rlossmin	1.D0	minimum radius for which to apply vloss (p 271).
437	lcout	0	number of outer layes to be written in light curve output file.
438	xmagfmu	1.D0	multiply μ-gradient by this factor.
439	xmagft	1.D0	multiply T-gradient by this factor.
440	xmagfnu	1.D0	multiply eddy viscosity by this factor.
441	xmagfdif	1.D0	multiply eddy diffusivity by this factor.
442	dxncbkup	1.D-7	backup if abundance change vector dy returned from subroutine burn implies a mass non-conservation larger than dxncbkup.

443	`iplotb`	0	if BURN is used, in abundance plot, PLOT 3, plot BRUN abundaces instead of APPROX/QSE/NSE abundaces. IF set to 1, only plot BURN abunances in the APPROX regime, if set to 2, plot BURN abundances everywhere where BURN is used, i.e., above `bmasslow`, and if set to 3, plot BURN abundances everywhere.
444	`minzone`	0	minimum zone for rezoning; do not rezone zones below `minzone`.
445	`zonemmax`	1.0000E+99	do not dezone zones bigger than `zonemmax`.
446	`tenubar`	-1.D0	electron anti-neutrino temperature (MeV) for core collapse neutrino flux. Use `tenu (p 289)` instead if `tenubar` is negative. **NOT YET IMPELMENTED**
447	`levcnv`	1	number of levels per dex for `cnv` output file.
448	`mingain`	-1	log of minimum energy generation (nuclear + neutrinos) for `cnv` output file.
449	`minloss`	-1	log of minimum energy loss (nuclear + neutrinos) for `cnv` output file.
450	`minnucl`	-1	log of minimum nuclear energy generation for `cnv` output file.
451	`ddmin`	-1.D0	minimum density for dezoning.
452	`iazonef`	1	allow (1) or disallow (0) adzoning.
453	`dynfac`	1.D0	multiplier on dynamic time-scale used to determine whether to treat problem (zones) as "dynamic" or "static" in `subroutine update`. A value of "0.0D0" means that all zones are always treated hydrostatic.
454	`h1hburn`	0.4	hydrogen mass fraction at which to make the `#hburn` dump.
455	`c12heign`	0.01	carbon mass fraction at which to make the `#heign` dump.
456	`he4hebrn`	0.5	helium mass fraction at which to make the `#heburn` dump.
457	`zonermin`	-1.	minimum zone thickness below which no adzoning is allowed.
458	`zonermin`	-1.	maximum zone thickness above which no dezoning is allowed.

459	`xmixnova`	0.	extent (in mass) of a linear composition gradient between substrate and newly accreted material. The surface material is taken from `compsurf/compsurfb`, the substrate material from outermost layer of the hydrogen-free core ($X < 10^{-5}$).
460	`accmass`	0.	set mass of the accreted zones of not zero. Otherwise the mass of the new zone is that of the current outermost zone. The mass of the new zone is, however, limited to not be different from the outermost zone by more than a factor `accmassf (p 461)`.
461	`accmass`	1.4142	The mass of newly accreted zone is may not differ by more than a factor `accmassf` from the current outermost zone. In combination with `accmass (p 460)` this can be used to accrete a "ramp" of changing zone masses. Good either for well resolved interfaces or fine surface zoning.
462	`vinstopm`	1.d99	upper mass (g) limit for which infall velocity is checked to determine whether #presn has been reached.
463	`lowamul`	0	minimum mass number for which weak rates are modified.
464	`pdmult`	1.	multiplier on positron decay/electron capture rate for `lowamul (p 463)`$\leq$`ihwamul (p 466)`.
464	`edmult`	1.	multiplier on electron decay rate for `lowamul (p 463)`$\leq$`ihwamul (p 466)`.
466	`ihwamul`	0	maximum mass number for which weak rates are modified.
467	`kapburn`	0	when set to 1 use BURN abundances to compute opacity.
468	`fackap`	1.	multiply opacity and its derivatives by `fackap`.
469	`awwkloss`	1.D99	remove all outer shells that have an angular velocity `angwwk` times bigger than Keplerian velocity.
470	`lossrot`	0	if set to 1 use Langer's (1998) formular for rotationally enhanced mass loss.

471	`ymjkep`	-1.d99	reduce angular momentum to keplerian angular momentum in the surface layes down to an exterior mass of `ymjkep` (if it excessd keplerian rotation). This is uefule for some accretion problems of for mapping stars with too much rotation into KEPLER, e.g, from merging binaries.
472	`maxzone`	0	Do not rezone outermost `mazxone` zones. The implicit default for old runs was 2, which is used when restarting an old run.

3 Changed Parameters (by value)

P	name	default	description
87	idzonef	1	value changed to flags: 1: do dezoning; 2: write edits; 4: exit on failture
69	pbound	0.0D0	the boundary pressure from the accretion phantom zone is no longer added here. I goes now into pboundac (q 96).
137	bethemt	0.0D0	Disabled and removed. We now use the weak rates from Langanke & Martínez (2000) replaced by nadapb for adaptive BURN network adjustment.
204	abunminx	-1.E-5	Negaive abundance backup now checked for all isotopes in APPROX independent of their abundance. Now only the absolute value of abunminx is considered, i.e., backups are made if and istope mass fraction is less than −ABS(abunminx.
271	vloss	1.d99	zones exceeding vloss are cut off the surface, keeping tbound (p 68) and pbound (p 69). **New:** the APPROX and BURN isotope masses are added to the "wind" arrays.

4 New Edit ('Q') Parameters

Q	name	description
78	`eninr`	initial rotational energy (erg)
79	`enr`	current rotational energy (erg)
80	`anglint`	initial angular momentum (erg·sec)
81	`anglt`	current angular momentum (erg·sec)
82	`xmlossr`	current mass loss rate (g/sec)
83	`zfak`	computed metallicity multiplier on mass loss rate
84	`enn`	total neutrino energy lost from the star (erg)
85	`enpist`	total energy input by the piston (erg)
86	`enpistd`	energy input rate by the piston (erg/sec)
87	`capeff`	opacity at effective radius (cm^2/g)
88	`xmlost`	mass lost in the "wind" (g)
89	`radconv`	radius (cm) outside of which no convection is allowed. This value is determined using optconv (p 408).
90	`zninvl`	number of BURN matrix inversions in last cycle.
91	`ngbkup`	number of negative abundance backups in SDOT for APPROX network
92	`mncbkup`	number mass non-conservation backuos in SDOT for APPROX network
93	`nacbkup`	number of excess abundance change backups in SDOT for APPROX network
94	`isebkup`	number if ISE non-convergence backups in SDOT
95	`enhd`	rate of change of thermal ("heat") energy content = $\int_0^M c_V(T(m,t))\,(T(m,t) - T(m,t-\Delta t))\,dm\,/\,\Delta t$.
96	`pboundac`	boundaty pessure due to accretion; this is not added to pbound any longer

5 New Terminal Commands

`fin`
`end`
`exit`
`stop`
`bye`
`quit`
`halt`
Because I am tired of having to remember all the different commands for program termination for the different programs all these commands do the same: just terminating.

`pulsedit` [*FILENAME*]
write out a pulsation edit file needed by Isabelle Baraffe's and Jeremiah Murphey's code. This file contains several thermodynamical quantities and hard-to-compute derivatives. If no filename *FILENAME* is given the generic name *PROBNAME-CYCLENUMBER* is used.

`pulsednr` [*FILENAME*]
write out a pulsation edit file needed by Jeremiah Murphey's code. This file contains several thermodynamical quantities and hard-to-compute derivatives. If no filename *FILENAME* is given the generic name *PROBNAME=CYCLENUMBER* is used.

`closewin`
closes the graphics window.

`kapedit` *GRID TLOW THI NTEMP DLOW DHI NDENS EPS*
makes a kappa edit to the screen. *GRID* is the cell number the composition for evaluation of the opacities is taken from, *TLOW* the lower bound temperature, *THI* the upper bound temperature, *NTEMP* the number of temperature grid points, *DLOW* the lower bound temperature, *DHI* the upper bound temperature, *NDENS* the number of density grid points, and *EPS* the relative change in temperature and density, respectively, used for numerical derivatives. The output is a list of temperature, density, opacity, analytical derivative of the opacity for temperature and density, respectively, numerical derivative of opacity for temperature and density, respectively, and, finally, the deviations between the numerical and analytical determinations of the derivatives.

`solidrot`
brings the star to solid body rotation.

`setspin` *VALUE* [`mult`]
If the optional keyword `mult` is present, multiply the rotation rate the factor *VALUE*, otherwise set the **total** angular momentum to *VALUE*, keeping the relative distribution of the angular momentum profile. To enforce rigid rotation afterwards, use the `solidrot` command.

`mode`
echos whether KEPLER is in interactive mode or not. This is used for an IDL interface I wrote.

`datapath` [*PATH*]
sets the "data path" (variable "datapath") where KEPLER looks for data files if they cannot be found in the local directory. If *PATH* is omitted the current value of "datapath" is displayed. If *PATH* is set to *CLEAR* the variable "datapath" is erased. If the environment variable "KEPLER_DATA" is set, KEPLER will also look in the path specified in the variable for data file if they cannot be found in the local directory or the directory specified in "datapath" (if set). This allows for a machine-dependent setting of the data path and is probably the better way in most cases when general/global files are to be used. However, the "datapath" allows to give the location of specialized files (maybe as relative path). In both cases, "datapath" and "KEPLER_DATA" the character "$\sim$" (tilde) is replaced by the value of the system variable "HOME", allowing for machine-independent specification of paths.

`wind`
`windb`
write the wind / windb data to the screen.

`core` [*COREXLIM* [*COREFELM*]]
writes the different core sizes to the screen. The values given are the shell number (j), interior mass (zm), radius (rn), exterior binding energy (ybind), and total entropy at the core boundary (stot). These values are displayed for the center of the star, the ye-jump (ye drops below 0.49), the boundary of the approx network, the O shell (maximum in energy generation by O burning), the iron core (defined by the mass fraction of heavy elements with mass number > 46 exceeding 1/2), the Si core (Si mass fraction $>$*COREFELM* and Si mass fraction bigger than O mass fraction), the

Ne/Mg/O core (C mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*), the C/O core (He mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*), and the helium core (H mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*).

`copycomp` *JGRID*
copy the composition of shell *JGRID* into the internal array `XNWCOMP`.

`prncomp`
print the internal composition array `XNWCOMP`.

`setcomp` *IFIRST ABUN1 ABUN2 ...*
set the values of the internal composition array `XNWCOMP` are to *ABUN1*, *ABUN2* ..., starting with index *IFIRST*. See original documentation for the index/isotope relation.

`newnetb` *FILENAME*
generate new BURN network from file *FILENAME*. Currently only the `net`, `netw`, `p`, and `c` cards are supported. The new network(s) has to include *all* isotopes of the previous network(s)! This command can also be used in aliases and link files.

`pf` | `yd` | `y` | `YD` | `Y` | `pfe` | `ye` | `YE` [`approx` | `burn` | `wind` | *NSTART* [*NEND*]]
makes abundance plots according to the command chosen:

`pf`	production factor of all stable isotopes relative to solar
`Y`	mass of all isotopes (in solar masses)
`YD`	decayed mass of all stable isotopes (in solar masses)
`y`	mass fraction of all isotopes
`yd`	mass fraction of all stable isotopes
`pfe`	elemental decayed production factor relative to solar
`YE`	decayed mass of all elements (in solar masses)
`ye`	decayed mass fraction of all elements

If `approx` is given everything in the APPROX network plus the wind is summed up. If `burn` is given everything that is processed by the BURN network, i.e., that has a mass coordinate at the base of the zone bigger than `bmasslow` (`p 419`), plus the wind is summed up. If `wind` is given only the wind is summed up. *NSTART* and *NEND* indicate the lower and upper zone number limit for summing abundance. If *NEND* is not given, it is assumed equal to *NSTART*; if it is bigger than `jm` (`q 2`) the wind data is plotted.

Negative values of *NSTART* and/or *NEND* indicate zones counted from the surface (i.e., 0 corresponds to the surface zone, -1 to the zone below the surface zone and so forth). If (and only if) *NSTART* and/or *NEND* are bigger than `jm` (`q 2`; e.g., 99999) the wind is added. So, to see everything in star above a given shell number but excluding the wind, 0 (zero) should be chosen as upper boundary!

`killburn`
turns off and removes the burn co-processing. `inburn` and `imaxb` are set to zero.

`burnamax`
prints the maximum abundances reached in the BURN network (only if `irecb` (p 418) is set to 1).

`burnaplt`
plots the maximum abundances reached in the BURN network.

`burnaclr`
reset the recording of maximum abundances of BURN network.

`arange` [*NSTART NEND*]
set the mass number range for BURN isotope plots. The edit parameters `minapro` and `maxapro` are set to the values given. If no values are specified they are set to their default values (-1000).

`k`
`kill`
immediately terminates KEPLER without the usual "shutdown logging".

`rateb` *TEMPERATURE DENSITY*
edit the BURN reaction rates (here: the `sig` array) for temperature *TEMPERATURE* and density *DENSITY*.

`ratenub` *R9 TIME*
edit the BURN neutrino reaction rates (here: the `signun` and `signuc` arrays, and some special reaction rates) for radius *R9* at time *TIME* after bounce. If *TIME* is omitted, 0 is assumed.

`weightb` *TEMPERATURE*
edit the BURN statistical weights (here: the g and `w` arrays) for temperature

TEMPERATURE.

`flowb` *ZONE TEMPERATURE DENSITY TIMESTEP* [*RADIUS*] [*FILENAME* | `matrix`]
edit the BURN flows, abundances, partition functions, and reaction rates of zone *ZONE* for temperature *TEMPERATURE* (in K), density *DENSITY* (in $\mathrm{g\,cm^{-3}}$), and time step *TIMESTEP*. For neutrino exposure the radius *RADIUS* (in cm) is used or 10^{99} cm if omitted. The output is written to the file *FILENAME* or the screen if omitted. The filename "-" is used to indicate the current log file as output destination. If the flag "`matrix`" is given, a diagnostic of the non-zero matrix elements is printed to the screen. If *TEMPERATURE* or *DENSITY* are set to "-" the current values of zone *ZONE* are used. If *TIMESTEP* is set to "-" the new time-step "`dtnew (p 1)`" is used.

`alliso`
generates a BURN network that contains *all* isotopes from the `bdat` file (plus `p`, `n`, and ^{4}He). Useful for debugging purposes. For real simulations use the adaptive network instead.

`edep` [*STARTZONE* [*ENDZONE*]] *DELTA_E*
add *DELTA_E* to zones *STARTZONE* – *ENDZONE*. Same code as the `det` command except that the composition remains unchanged. Same treatment of zone numbers as with the `z` command.

`eostab2` *ZONE TLOW THI NTEMP DLOW DHI NRHO*
write out EOS table Type II for zone *ZONE* with *NTEMP* steps in temperature between *TLOW* and *THI DTEMP* steps in density between *DLOW DHI*. Similar to the `eostab2` command, but T, ρ, P, P_T, P_ρ, e, e_T, e_ρ, κ, and S are tabulated.

`mixcycle` [*0* | *1*]
perform mixing/diffusion operation using current coefficients and new time step (`dtnew`) if `mixcycl (p 433)` = 0. If the optional parameter is not set or not zero then the diffusion coefficients are zeroed to prevent additional mixing when the run is continued.

`burn` *DATAFILE*
do BURN processing of zone 1 according to history in *DATAFILE*. (not yet implemented)

`bstat`
output some BURN statistics

`![#]`
`!` re-executes the last command. If the number # is specified (no space between the `!` and the number) the command issued that many times earlier is re-executed. Currently # must be less than 100, since the history is limited to 100. The history is not saved to restart dumps.

`!!`
lists the last commands, last command last, and their number in the list to be used with the `!` command. The rest of the input line is ignored.

`pulsar` [*PSRMB*]
prints out estimated pulsar rotation rate. Optionally, the pulsar baryonic mass (*PSRMB*; in solar masses) can be specified. *(may need more documentation)*

`mapburn`
maps BURN abundaces to APPROX in all APPROX zones.

`compsurf` [*ZONE* — `show` | `clear` | *ABUN ion* | *IDXSTART ABUN1 ... ABUNN*]
`compsurb` [*ZONE* — `show` | `clear` | *ABUN ion* | *IDXSTART ABUN1 ... ABUNN*]
set APPROX (`compsurf`) and BURN (`compsurb`) accretion abundances.
Without parameter the abundance vector is copied from the outermost zone.
Here, `compsurf` copies both the APPROX and BURN abundances while `compsurb` copies only the BURN abundances. IF *ZONE* is specified, zone *ZONE* is used instead if the outermost zone.
If `show` is specified, the abundance vector is printed to the screen.
If `clear` is specified, the abundance vector is initialized to zero.
If abundance *ABUN* and *ion* the abundance of that isotope is set in the abundance vector is set to the specified value.
A series of n subsequent isotopes starting at index *IDXSTART* in the abundance vector can be set to the values *ABUN1 ... ABUNN*.
Note that by default the abundances of the outermost zone are copied in the surface composition vectors on problem generation so that, if this is desired, no additional `compsurf` *or* `compsurb` *command is required.*

6 Changed Terminal Commands

p *NAME* | *NUMBER* [*VALUE* [`add` | `mul` | `div` | `sub`]]
p *NUMBER1* − *NUMBER2*
p *NUMBER1* .. *NUMBER2*
Display or change parameters. The second and third form print the values of a range of parameters (*NUMBER1* may be smaller or larger than *NUMBER2*).

q *NAME* | *NUMBER*
q *NUMBER1* [− | ..] *NUMBER2*
Display edit parameters. The second form prints the values of a range of parameters (*NUMBER1* may be smaller or larger than *NUMBER2*).

`z`
`zed`
`v`
`vf`
`ved`
`vfed`
The treatment of grid-point numbers has been improved: Grid number 0 counts for the surface, and negative grid numbers are taken to be the corresponding negated grid point counted from the surface of the star. If two numbers are given, they are ordered by size automatically after, after negative grid-point numbers have been reinterpreted – so don't worry to give the upper bound grid-point number first.

`z`
`zed`
Instaed of integer grid numbers now floats are accepted as well an interpreted as the interior mass coordinate in units of solar masses.

`cutsurf` *NSURF*
Now also adds the mass of the isotopes of the zones "cut off" to the arrays "wind" and "windb". Same for the corresponding link command `cutsurf`. If *NSURF* is negative, the zones -*NSURF* and above are removed.

`editiso`
is now prepared to work with arbitrary networks. It reads the solar abundances from the data file *solabu.dat* and the decay data / branch ratios from *decay.dat*. The yields and production factors are now given including the

wind and additionally yields and production factors are given for the wind by itself. The data formats of the files *decay.dat* and *solabu.dat* are given at the beginning of the existing sample files.

`chngcomp` *JMIN JMAX* [*IFIRST ABUN1 ABUN2 ...*]
changes the zonal composion of given range. If *JMIN* or *JMAX* are integer values (containing no ".") they are interpreted as zone numbers. If they are float values, they are interpreted as mass coordinates (in solar masses).
If *IFIRST*, *ABUN1*, *ABUN2* ... are given, the values of the internal composition array `XNWCOMP` are set to *ABUN1*, *ABUN2* ..., starting with index *IFIRST*. See original documentation for the index/isotope relation.
See also addon documentation for `copycomp`, `prncomp`, and `setcomp`.

`test` *TESTVAR J T D*
is now enhanced to allow the *TESTVAR* `d` to print the degeneracy parameter η and its derivatives. *J*, *T*, and *D* are the zone from which the composition is taken, the desired temperature and density, respecrively.

`mlim`
if only one argument is given, the maximum value is set to this and the minimum value to `summ0`. Then the plot is redone.

`sumi`[`g`|`sun`] [*JMIN JMAX*] [*ISOTOPE*]
`sumi`[`g`|`sun`] [*ISOTOPE*] [*JMIN JMAX*]
`sumb`[`g`|`sun`] [*JMIN JMAX*] [*ISOTOPE*]
`sumb`[`g`|`sun`] [*ISOTOPE*] [*JMIN JMAX*]
sums up and prints the total mass of a isotope *ISOTOPE* from zone *JMIN* to zone *JMAX*. `sumi` sums up isotopes in the APPROX network, `sumb` sums up isotopes in the BURN network. *ISOTOPE* must not contain a leading "`iso`" or "`ion`". If *ISOTOPE* is not given, all isotopes with masses greater than `abunlim` (`p 128`) or `abunlimb` (`p 272`), respectively, are printed. If *JMIN* and *JMAX* are not given, `1` and `jm` (`q 2`) are assumed. If *JMIN* or *JMAX* is less than one, the (unsigned) zone number is counted from the surface, i.e., `0` (zero) corresponds to the surface zone. If *JMIN* or *JMAX* is greater than `jm` (`q 2`) the wind is included. Note that *JMIN* and *JMAX* are sorted internally for the bigger and the smaller values, so that they are accepted in arbitrary order. The `sumb` and `sumi` forms return mass fractions, the `sumbg` and `sumig` return absolute masses in grams, and the `sumbsun` and `sumisun` forms return absolute masses in solar masses.

`mix` *NZMIN NZMAX DELMASS* [*FLAG*]

mix zone by zone from zone *NZMIN* up to zone *NZMAX* over a mass "window" of *DELMASS*. Now also mixes BURN isotopes. If an additional forth parameter is given, `pbound (p 68)` and `tbound (p 69)` are not changed.

`addsurf` [*MSURF* | *NSURF MSURF TEMPSURF RHOSURF VELSURF*
If *no* parameter is given, the mass of the current "phantom zone" `xmacrete (p 212)` will be added as a new zone to the problem and `xmacrete (p 212)` will be set to zero.
If *one* parameter is given a mass of this zone will be accreted and `xmacrete (p 212)` will be reduced by this amount or set to zero if the result is negative.
If *five* parameters are given, *NMAX* zones with total mass of *MSURF*, temperature *TEMPSURF*, density *RHOSURF* and velocity *VLESURF* will be accreted.

`compsurf` see *new terminal commands*

7 Changed Generator Commands

The generator card g has been enhanced in order to allow for the addition of rotation on generation of the problem. The new format is

g *ZONE EXTMASS NETW TEMP RHO* [*OMEGA* [*VEL*]]

where *ZONE* is the zone number (starting at 0), *EXTMASS* is the exterior mass coordinate in g, *NETW* the network number, *TEMP* the temperature in K, and *RHO* the density in g/cm^3. The argument *OMEGA* is optional and a default value of 0 is supplied if *OMEGA* is given for none of the cards. However, if only some are missing, they are interpolated. *I.e.*, to generate an initial model with constant gradient in the rotational velocity (or a rigidly rotating model), only for the innermost and the outermost zone values for *OMEGA* have to be supplied. The radial velocity is set by the optional argument *VEL*.

`cutsurf`
see terminal commands.

8 New Generator Commands

`linkfile` *FILENAME*
Generate a stellar model from file *FILENAME*. When this command is used, no further generator cards are allowed nor needed.

`rigidl` *VALUE*
This card allows to give the star the angular momentum *VALUE* (erg·sec) at startup and distribute it such that the star is rigidly rotating.

bounce JCUT TMIN RMIN RMAX ALPHA [`cut`] [`scut`] [`accel`]
This card generates a piston that moves inward from the outer boundary radius of zone *JCUT* to the radius *RMIN* in a time *TMIN*. The radius as a function of time is fit by quadric with the initial slope being the velocity at the outer boundary of zone *JCUT*. After *TMIN* the piston moves outwards with the (negated) free fall velocity from a point at radius *RMAX* in a gravitational field that is *ALPHA* times that of the mass enclosed by the outer boundary of zone JCUT. When the maximum position of the piston is reached, the movement of the piston is stopped.
If the optional keyword `cut` is given, the innermost *JCUT* zones are cut away (see `cut` command). If *JCUT* is a floating point number, it is interpreted as the Y_e value where to locate the pison. If the keyword `scut` is set, it is interpreted as the entropy value where to locate the piston. If the keyword `accel` is set then *TMIN* is interpreted as the acceleration for the piston infall. The time of bounce than becomes variable. If the piston is generated successfully, `tshock (p 343)` is set accordingly. This is particularly useful if `accel` is used

`newnetb` *FILENAME*
see terminal commands.

`rescalem` *SCALE* [`msun`] [`mult` | `div`]
scale the mass coordinate by *SCALE*. If `msun` is given the scaling factor is multiplied by $M_\odot/g$. If `div` is given, the mass coordinate is divided by the scale factor, otherwise it is multiplied by the scale factor. The flag `mult` has no effect but must not be given together with `div`. This command allows to adopt a generator file with a given mass grid to a different mass.

`killpist` reset/terminate piston.

9 New BURN Generator Cards

gg *NETW COMP*
Sets *all* zones to BURN network number *NETW* and BURN composition *COMP*. Otherwise similar to the g command. The important difference is that now the same generator can be used independent of the number of zone in the problem generator file!

`netw` *NETW EL {ASTART AEND}*
Adds the isotopes *ASTART – AEND* of element *EL* to BURN network *NETW*. Several ranges *ASTART – AEND* can be given in the same line. Otherwies similar to the `net` command.

10 New plots and plotting commands

New plot types are number are (p 113 ipixtype):

7 shows the angular velocity (ω), specific angular momentum (j) and total diffusion coefficient for mixing of chemical species.

8 shows the angular velocity (ω), specific angular momentum (j) contributions of the different rotationally induced mixing coefficients and the total diffusion coefficient for mixing of chemical species.

9 shows the production factor/yield for the different isotopes from the BURN co-processing network. Refer to parameters **p 396** to **p 403** for details of the plot adjustment.

New multiplicities of plots supported are (p 113 ipixtype):

3 – To get three plots of equal size, placed vertically below each other use the format `ABC00`, where `A`, `B`, and `C` are the numbers of the individual plots.

– To get three plots, the first of which is larger and the other two are smaller, use the format `ABC`, where `A`, `B`, and `C` are the numbers of the individual plots.

4 To get fours plots of equal size, placed in the corners of the window, use the format `ABCD`, where `A`, `B`, `C`, and `D` are the numbers of the individual plots.

This is now determined in subroutine `setplottype`.

New types and handling of y-axis (p 132 irtype):

1 log radius (cm)

2 interior mass fraction

3 interior mass (solar masses)

4 radius (cm)

5 moment of inertia coordinate ($M_\odot\ R_\odot^2$)

6 zone number

7 log interior mass ($M_\odot$) using `jp0` and `jp1`

8 interior mass ($M_\odot$) using `jp0` and `jp1`

9 log exterior mass ($M_\odot$) using `jp0` and `jp1`

10 exterior mass ($M_\odot$) using `jp0` and `jp1`

11 log column density (g cm^{-2}) using `jp0` and `jp1`

12 column density (g cm^{-2}) using `jp0` and `jp1`

Notes:
For y-axis types 2 and 3 the diffusion coefficients in plot types 7 and 8 are shown in mass units, as it is most useful for investigating mixing of chemical species, for y-axis types 1 and 4 they are radius mass units, and for y-axis type 5 they are given in moment of inertia coordinates, as it is most useful if transport of angular momentum is considered.
For flot types 9 - 12 the surface of the star is to the left.

11 New Edit Quantities

name	description
angj	specific angular momentum (erg·sec)
angi	specific moment of inertia (cm^2)
angw	angular velocity (1/s)
angv	rotational velocity (cm/s)
ange	specific rotational energy (erg/g)
angp	rotational period (s)
angvk	Keplerian rotational velocity (cm/s)
gamed	Eddington Gamma
angwc	critical angular velocity (1/s)
angwwc	angular velocity / critical velocity
angvvc	rotational velocity / critical velocity
angwk	Keplerian angular velocity (1/s)
angek	specific Keplerian energy (erg/g)
angwwk	angular velocity / Keplerian velocity
angvvk	rotational velocity / Keplerian velocity
angeek	rotational energy / Keplerian energy
stotd	old specific entropy (erg/g/K)
eg	specific gravitational energy generation rate (erg/g/s)
gamma1	adiabatic exponent Γ_1
gamma2	adiabatic exponent Γ_2
gamma3	adiabatic exponent Γ_3
enbtn	$(\partial$ en / ∂ tn $)_{dn}$ (erg/g/K)
enbdn	$(\partial$ en / ∂ dn $)_{tn}$ (erg cm^3 g^{-2})
pnbtn	$(\partial$ pn / ∂ tn $)_{dn}$ (dyn/K)
pnbdn	$(\partial$ pn / ∂ dn $)_{tn}$ (dyn cm^3/g)
angri	Richardson number
angdg	total rotational diffusion coefficient (cm^2/s)
angd0	diffusion coefficient for convective processes (cm^2/s)
angd1	diffusion coefficient for dynamical shear instability (cm^2/s)
angd2	diffusion coefficient for Solberg-Høiland instability (cm^2/s)
angd3	diffusion coefficient for secular shear instability (cm^2/s)

angd4	diffusion coefficient for Eddington-Sweet circulation (cm^2/s)
angd5	diffusion coefficient for Goldreich-Schubert-Fricke instability (cm^2/s)
mu	mean molecular weight (g/mol)
tau	optical depth
zm	interior mass coordinate (g)
xbind	binding energy of zone (erg)
ybind	exterior binding energy (erg)
zbind	interior binding energy (erg)
uesc	local escape velocity (cm/sec)
magvcc	arsinh(mag. VC criterion*1.17) according to Henk Spruit (ask him for details)
snt	∂ sn / $\partial\ T$ (erg/g/s/K)
snd	∂ sn / $\partial\ \rho$ (erg $cm^3/g^2/s$)
sneut	sneut (erg/g/s)
sneutbt	∂ sneut / $\partial\ T$ (erg/g/s/K)
sneutbd	∂ sneut / $\partial\ \rho$ (erg $cm^3/g^2/s$)
snuc	snuc (erg/g/s)
snucbt	∂ snuc / $\partial\ T$ (erg/g/s/K)
snucbd	∂ snuc / $\partial\ \rho$ (erg $cm^3/g^2/s$)
snuw	snuw (erg/g/s)
snuwbt	∂ snuw / $\partial\ T$ (erg/g/s/K)
snuwbd	∂ snuw / $\partial\ \rho$ (erg $cm^3/g^2/s$)
snubps	snubps (erg/g/s)
snubpsbt	∂ snubps / $\partial\ T$ (erg/g/s/K)
snubpsbd	∂ snubps / $\partial\ \rho$ (erg $cm^3/g^2/s$)
snlt	∂ ln sn / ∂ ln T
snld	∂ ln sn /∂ ln ρ
sneutlt	∂ ln sneut / ∂ ln T
sneutld	∂ ln sneut /∂ ln ρ
snuclt	∂ ln snuc / ∂ ln T
snucld	∂ ln snuc / ∂ ln ρ
snuwlt	∂ ln snuw / ∂ ln T
snuwld	∂ ln snuw / ∂ ln ρ

`snubpslt`	∂ ln snubps / ∂ ln T
`snubpsld`	∂ ln snubps / ∂ ln ρ
`xmag...`	magnetic quantities (Spruit 2002)

12 New Variables

which are saved to the restart dump file:

name	description
`angj`	array(0:jmz) specific angular momentum (erg·sec)
`angdg`	array(0:jmz) total rotationally induced diffusion coefficients (cm^2/sec)
`angd`	array(0:jmz,1:nangmd) rotational diffusion coefficients separated for processes (cm^2/sec) 1: dynamical shear instability 2: Solberg-Høiland instability 3: secular shear instability 4: Eddington-Sweet circulation 5: Goldreich-Schubert-Fricke instability
`datapath`	CHARACTER*(80) contains a search path for data files
`wind`	array(nitz) stores the APPROX abundances removed from the star
`windb`	array(nitzb) stores the BURN abundances removed from the star
`burnamax`	array(nburn) stores the maximum abundances reached in the BURN network
`burnmmax`	array(nburn) stores the mass coordiantes where the maximum abundances in the BURN network were reached
`ibcmax`	array(nburn) stores the cycle numbers of when the maximum abundances in the BURN network were reached

13 New auto-linked aliases

`hdep`
execued when central hydrogen drops below 1 %.

`hedep`
execued when central helium drops below 1 %.

`&`
executed after each cycle.

14 All New: Environment Variables

KEPLER_DATA
sets the "data path" (see also: variable "datapath") where KEPLER looks for data files if they cannot be found in the local directory.
If the environment variable "KEPLER_DATA" is set, KEPLER will look in the path specified in the variable for data files if they cannot be found in the local directory or the directory specified in "datapath" (if set). This allows for a machine-dependent setting of the data path and is probably the best way in most cases when general/global files are to be used. The character "~" (tilde) is replaced by the value of the system variable "HOME", better utilizing the machine-independent specification of paths.

KEPLER_MAIL
KEPLER_USER
If both variables are set, KEPLER will send an email to the address specified in KEPLER_USER using the mail program specified in KEPLER_MAIL when it terminates. Useful when several instances of KEPLER are run simultaneously.

15 MONGO Environment Variables

FONTDAT
where to find `fonts.dat`

FONTNEW
where to find `fonts.vis`

HELPFILE
where to find `help.dat`

MONGOPS
where to find MONGO postscript files.

Sample code for tcsh

```
setenv FONTDAT $HOME/kepler/mongo_dp64/fonts.dat
setenv FONTNEW $HOME/kepler/mongo_dp64/fonts.vis
setenv HELPFILE $HOME/kepler/mongo_dp64/help.dat
setenv MONGOPS $HOME/kepler/mongo_dp64/postscript/
```