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New Version of the Energy-Deposition Code E-DEP-1: Better Stopping Powers

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Materials Modification and Analysis Branch
Condensed Matter and Radiation Sciences Division

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This new version of the E-DEP-1 program uses improved stopping powers that have been developed since the original program appeared. The stopping-power cross sections in the original paper were taken from Lindhard, Scharff, and Schiott and were based on the Thomas-Fermi interatomic potential. The present version uses the elastic stopping power of Wilson, Haggmark, and Biersack, which is based on a much more realistic interatomic potential, and for the inelastic stopping power the phenomenological fit of Land and Brennan. In addition, we have made some minor corrections, we have extended the range to higher energies, and added three dummy routines with full sets of common statements to allow the user to use the data as he or she sees fit. The present version is consistent with FORTRAN IV and has been tested with both DEC FORTRAN 66 and FORTRAN 77. The Fortran program is included in the report, and the output is given for the sample run used in the original version, but now using this version. Figures show a comparison between the two.

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NEW VERSION OF THE ENERGY DEPOSITION CODE E-DEP-1: BETTER STOPPING POWERS

INTRODUCTION

The main purpose of this new version of E-DEP-1 is the employment of improved stopping powers that have been developed since the original program appeared [1-4]. The new stopping power for elastic collisions is described in the second section of this report, while that for inelastic collisions is described in the third section. In addition, we have taken this opportunity to include several minor corrections and improvements; these are discussed in the fourth section of this report. This adaptation gives the user new options that are selected by the input data; the sixth section is the updated description of the input data cards, and the seventh section compares the results of using the same data on both the older version and the newer version. The section on programs on tapes and discs indicates where tape and disc-storage can be obtained for those who would like to run the program.

ELASTIC STOPPING POWER

In the original program, the stopping power cross sections for elastic atomic collisions are that of Lindhard et al. (LNS) [5], which are based on the Thomas-Fermi interatomic potential. The present adaptation uses the cross sections of Wilson et al. (WHB) [6], which are based on a much more realistic interatomic potential. The present adaptation modifies subroutine TFXS and FTOH so that either the LNS cross sections or the WHB cross sections can be used. (TFXS is called by JOGIBB in the calculation of $S_n(E)$ of Eq. (4) of Ref. 1, and FTOH is called by REPLAC in the calculation of $S_L(E)$ of Eq. (6) of Ref. 1.

Throughout the previous version of EDEPI, ϵ refers to the reduced energy;

$$\epsilon = \frac{E}{E_L}, \tag{1}$$

where E is the ion beam energy and E_L is the Lindhard energy [5,7],

$$E_L(keV) = 0.030735721\ Z_1\ Z_2\ Z_L^{1/3} \left(\frac{A_1 + A_2}{A_2}\right) \tag{2}$$

with

$$Z_L = Z_1^{2/3} + Z_2^{2/3}\ . \tag{3}$$

However, Wilson et al. [6] use the different reduced energy due to Firsov [8], in which Z_L in the above formulas is replaced by Z_F, defined by

$$Z_F^{1/2} = Z_1^{1/2} + Z_2^{1/2}\ . \tag{4}$$

When choosing the WHB cross sections, and in the subroutines TFXS and FTOH only, the ϵ used in the present adaptation is that of Firsov rather than Lindhard.

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With ϵ so defined, the quantities calculated in TFXS, i.e., $S_n(\epsilon)$ and $W(\epsilon)$ are taken from WHB as

$$S_n(E) = \frac{A \ln (B\epsilon)}{B\epsilon - (B\epsilon)^{-c}} \tag{5}$$

and

$$W(\epsilon) = \frac{1}{4 + A'\epsilon^{-B'} + C'\,\epsilon^{-D'}}, \tag{6}$$

where

A = 0.56258, A′ = 0.37492,
B = 1.1776, B′ = 1.6119,
C = 0.62680, C′ = 4.9822, and
D′ = 1.0965.

These expressions are Eqs. (14) and (16) of Ref. 6 for the case of their average interatomic potential.

FTOH is used by REPLAC to calculate $d\sigma(T)$ of Eq. (6) of Ref. 1. For the WHB calculation, it uses Eq. (18) of Ref. 6 which is

$$f(t^{1/2}) = A\,\frac{X^{1+C} - 1 - (1+C)\ln X}{X^{2+C} - 2X + X^{-C}}, \tag{7}$$

where $X \equiv Bt^{1/2} \equiv B\epsilon \sin \frac{1}{2}\theta$ in which θ is the scattering angle in the center of mass coordinate frame, and A, B, and C are the constants used in Eq. (5).

By selection of a setting in the input data deck, the user may direct EDEP1 to use the LNS cross sections instead of the WHB cross sections. The printout indicates which of the two cross sections is being used.

INELASTIC STOPPING POWER

The original program uses the inelastic stopping law of Lindhard et al. (LSS) [7]:

$$s_e(\epsilon) = k\,\epsilon^{1/2}, \tag{8}$$

with

$$k = 0.07952506\ Z^{1/6} \left(\frac{Z_1 Z_2}{Z_L}\right)^{1/2} \frac{A_2}{A_0^{3/2}} \tag{9}$$

where ϵ and Z_L are previously defined and

$$A_0 = \frac{A_1 A_2}{(A_1 + A_2)}. \tag{10}$$

In practice, it is found that Eq. (8) is a good approximation, while Eq. (9) can be very poor. In the present work, the approximation of Eq. (8) is retained, and the approximation of Eq. (9) is replaced by the phenomenological fit given by Land and Brennan (LB) [9] as shown in the tables of Ref. 10. By selection of settings in the input data deck (Card 6), the user may direct EDEP1 to use any of three different k values: the LB k-value, the k-value of LSS, or a numerical value supplied by the user in the data deck. For the case where the LB k-values have been selected, these tables do not cover

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instances where $Z_1 < 6$, $Z_1 > 92$, or $Z_2 > 102$. When the LB option is selected, the code supplies for these Z values the k-value given by the LSS Eq. (9) above. For each $Z_1 - Z_2$ combination, the printout indicates the source of that k-value: Land-Brennan tables, LSS Eq. (9), or user supplied.

In evaluating the inelastic losses that occur in a cascade, one needs an average k-value to represent collisions between target atoms. This is the quantity k_s in Eq. (7) of Ref. 1. This quantity was originally evaluated by using the above Eq. (9) where Z_1 as well as Z_2 were set to a substrate-average ZAVE and A_1 and A_2 were set to a substrate average AAVE. In the new version of the code, k_s is evaluated as

$$k_s = \frac{\sum_{i,j=1}^{r} k_{ij} N_i N_j}{\sum_{i,j=1}^{r} N_i N_j} \tag{11}$$

where the sum is taken over the r atomic species that are present in the target, N_i is the atomic density of the ith target species, and k_{ij} is the k-value for Eq. (8) for an atom of species i colliding with a target atom of species j. If the user has selected the LSS option for all the k-values for the bombarding beam, then the code supplies LSS k-values for the k_{ij} in Eq. (11); with the other possible settings for the input deck the code supplies LB values where they exist and LSS values where they do not ($Z_i < 6$, $Z_i > 92$, and $Z_j > 102$).

OTHER CHANGES

In its calculation of energy deposition, the original code used the approximation of Kulcinski, Laidler, and Doran [11] to estimate the energy distribution of the penetrating beam, as follows: A beam ion at depth x which is destined to stop at depth x' (and therefore has residual projected range $x' - x$) is considered to have energy E_1, where E_1 is defined by

$$R_p(E_1) = x' - x\,, \tag{12}$$

and R_p is the projected range of a different experiment in which a beam of energy E_1 is incident on the target. Matthews has discussed this approximation [12]; he points out that it gives an incorrect energy distribution at the target surface, and suggests that the approximation used by Marwick [13] and attributed to Johnston et al [14] be used. In that approximation, the energy E_1 is defined by

$$R_p(E_1) = \left(1 - \frac{x}{x'}\right) R_p(E_B)\,, \tag{13}$$

where E_B is the beam energy. This expression gives the correct result at $x = 0$ (where $E_1 = E_B$) and at $x = x'$ (where $E_1 = 0$). We have taken this opportunity to have the present version use the better expression, Eq. (13) rather than Eq. (12), even though the difference between the two is rarely significant [12].

The LSS stopping law of Eq. (8) is violated at high beam energies, and the user can have EDEP1 use any other stopping law by simply replacing the module ELCLAW in the code. However, at sufficiently high energies, a table elsewhere in the code runs out of room, requiring inconvenient additional coding by the user [15]. The present version eliminates this inconvenience by extending that table in REPLAC from its previous limit of $\epsilon = 640$ to $\epsilon = 100{,}000$ (REPLAC supplies the function $S_L(E)$ of Eq. (6) of Ref. 1).

To allow the user more convenient control over program flow when it is desired to do such things as graphics display, writing results in machine-readable form, or doing calculations that require access to the range tables or energy-deposition tables, we have added the three new modules START, RNGTBL, and DEPTBL. The program START calls EDEP1, which is now a subroutine rather than a program, and does nothing else. The dummy subroutines RNGTBL and DEPTBL do nothing; they are called, respectively, immediately after the calculation of range tables and immediately after the calculation of energy-deposition tables. All three modules are supplied with full sets of common statements, which allow user access to most of the important variables in the code.

When used with an optimizing compiler, it was possible for subroutine ERCINV to give incorrect results because the variable ZNO was being stored in a register rather than in memory, and so was lost to subsequent calls. This adaptation corrects that error. A correction by Spitznagel and Mueller [16] has been effected which eliminates one of the instabilities in JOG1BB. For conformity, the number of significant figures in some of the constants has been changed. Thus, for example, the constant 0.0793 in Eq. (10) of Ref. 1 and in subprogram ELSTOP has been replaced by 0.07952506. Several other minor corrections have been made, such as additional comment cards, and some constants made double precision.

At the time the original version was submitted, the computer for our group was a CDC-3800. We have since used a Texas Instruments Advanced Scientific computer, and then a Digital Equipment Corporation (DEC) VAX 11/780. Syntax changes were made throughout the code so that it now compiles on the latter two machines. The earlier version P2.07 and all prior versions were tested on a CDC-3800 using FORTRAN IV. Our aim has been to keep the present version consistent with FORTRAN IV and with the FORTRAN 66 used on the Texas Instruments Computer (a version of FORTRAN similar to that used on IBM 360-series machines). The present version has been tested with both DEC FORTRAN 66 and FORTRAN 77. Appendix A gives the listing of the present version.

CALCULATION OF DISPLACEMENTS PER ATOM

The following appends a remark to the discussion that led to Eq. (1b) of Ref. 1. That discussion shows that the displacements per atom at depth x is given by

$$dpa(x) = \frac{\tau}{N} \frac{\kappa}{2E_d} S_D(x) \tag{14}$$

where τ is the fluence of the irradiation, N is the density of target atoms, E_d is the target displacement energy, κ is a constant of order 0.8, and $S_D(x)$ is the energy deposition at depth x.

INPUT CARDS

This section, which describes the input variables and the format of input cards, replaces Section 7 of Ref. 1. The program flow is controlled by Card 1, Card 4, and Cards 6. The method used to calculate elastic stopping is controlled by Card 4, while the method used to calculate the inelastic stopping parameter k is controlled by Cards 6. The input parameters have been arranged so that a data deck for previous versions of EDEP1 will also work with the present version, but the default evaluations of elastic and inelastic stopping powers will be, respectively, those of WHB and LB.

Card 1 (Format 3I2)

The following three LIX parameters control the running of the code. For a normal run all three parameters are set to zero. In a normal run the energy deposition tables are printed, but the JOGIBB tables are not.

LIX(1) — The run immediately terminates on reading a "type 1" card with LIX(1) $\neq$ 0

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LIX(2) — For LIX(2) $\neq$ 0, only JOGIBB is run and the JOGIBB tables are printed. The energy deposition calculations are omitted.

LIX(3) — For LIX(3) $\neq$ 0, the JOGIBB tables are printed before printing the energy deposition tables. In other words, this option prints everything.

Card 2 (Format 72H)

Card 3 (Format 72H)

The messages on these cards are reprinted at the beginning of the output.

Card 4 (Format F5.1, F10.3)

EMAX — The maximum energy, in MeV, for which JOGIBB and REPLAC supply tables of values. It should be somewhat larger (approximately 100%) than the largest beam energy that will be used. If EMAX is positive, elastic collisions are calculated according to Wilson, Haggmark and Biersack (WHB) [6]. If EMAX is negative they are calculated according to Lindhard, Nielson and Scharff (LNS) [5].

CUTOFF — The energy (eV) cutoff T_1 appearing in Eq. (6) of Ref. 1. It is generally zero.

Card 5 (Format 2F10.3, I5)

ZONE — The atomic number of the beam ion.

AONE — The atomic weight of the beam ion.

NTWO — The number of atomic components in the target (maximum of six).

Card 6-1 (Format 2F10.3, E10.4, F10.3)

ZTWO(1) — The atomic number of the first target component.

ATWO(1) — The atomic weight of the first target component.

DENS(1) — The density (atoms/cc) of the first target component.

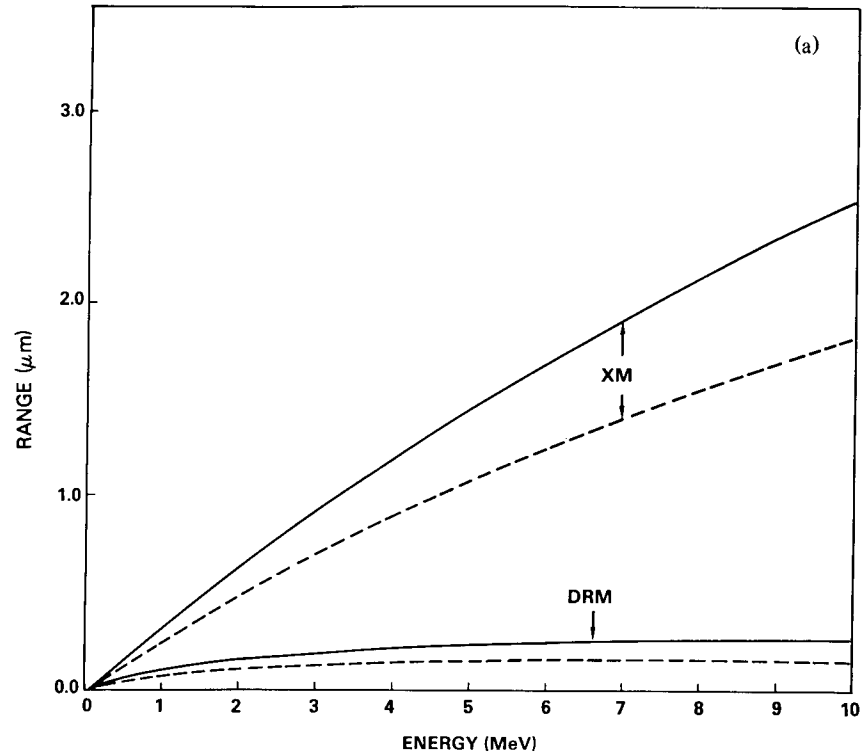
AKSTOP(1) — The electronic stopping parameter k for the ZONE-ZTWO(1) pair: (1) if AKSTOP(1) is 0 or blank, the program supplies the value according to tables given by Land and Brennan (LB) [9,10] (The LB value does not exist for ZONE less than 6 or greater than 92, or ZTWO(1) greater than 102. In these cases the code supplies the LSS [7] value). (2) if AKSTOP(1) is negative, the program computes the k-value according to the LSS expression, Eq. (9) above. (3) If AKSTOP(1) is supplied by the user, the program uses this value. If $k = 0$ is actually desired, a small value, say 1.E-20 may be read in.

Card 6-2

This is the same as Card 6-1, but is used for the second component of the target. There is a separate "type 6" card for each target component.

Card 7 (Format 2F10.3) (This card is not read if only JOGIBB is run.)

EB — The beam energy E_B in MeV. (E_B is called EZ in the code).



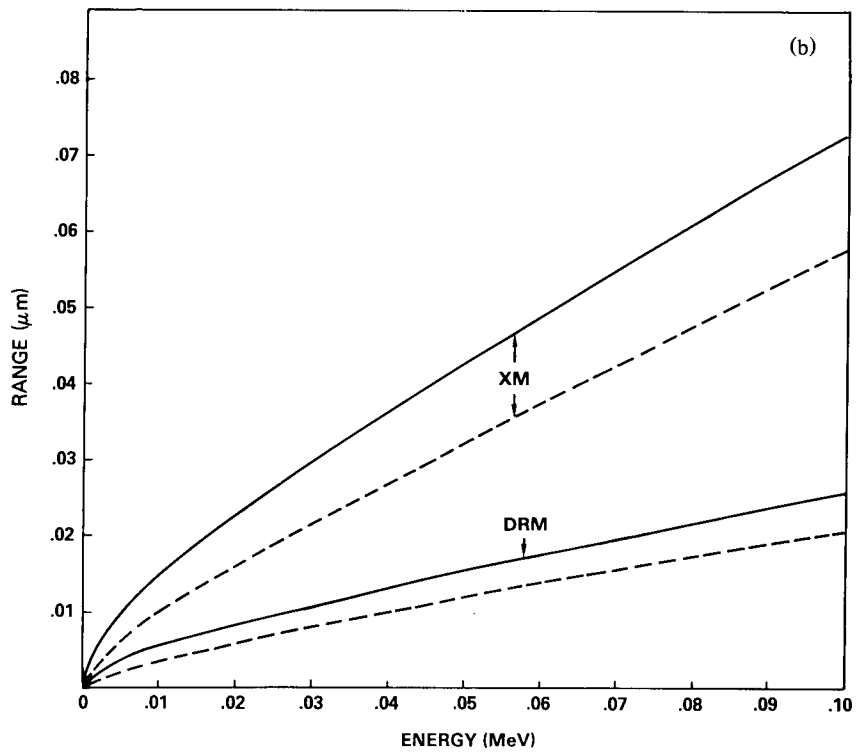


Fig. 1 — Comparison of average projection range (XM) and total range straggling (DRM). --- indicates the results given by the original version using LNS cross sections [5]; and ____ indicates the results given by the present version using WHB cross sections [6] and the tables of LB [9]. (a) Copper ions bombarding 316 stainless steel. (b) Arsenic ions bombarding silicon.

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DELTA — This is the spacing (μm) in the depth x for which the functions $S_D(X)$ and $S_B(X)$ are calculated. If DELTA is zero, the spacing is supplied by the program in such a way that these functions are evaluated for at least 100 values of x.

Cycling — After performing a complete calculation for one beam energy, the program reads a new "type 7" card and repeats the calculation and printout for this new E_B. However, if E_B is negative the program immediately returns and reads a new "type 1" card, and thus initiates a new calculation cycle for a new beam-target configuration. As previously described, the run is terminated by a "type 1" card.

SAMPLE RUN

The test-run output represents the case of copper ions incident on 316 stainless steel, and also the case of arsenic incident on silicon. For arsenic incident on silicon, only the range tables are produced, with EMAX = 0.100 MeV. For copper ions incident on 316 stainless steel, both the range table with EMAX = 10.0 and the energy deposition tables for the case of 5 MeV copper bombarding ions is produced. Appendix B gives the input data for the test run and Appendix C gives the printed output.

Figures 1 to 3 show a comparison of the calculations in the previous version, using LNS [5], and those with the present version using WHB [6] and LB [9].

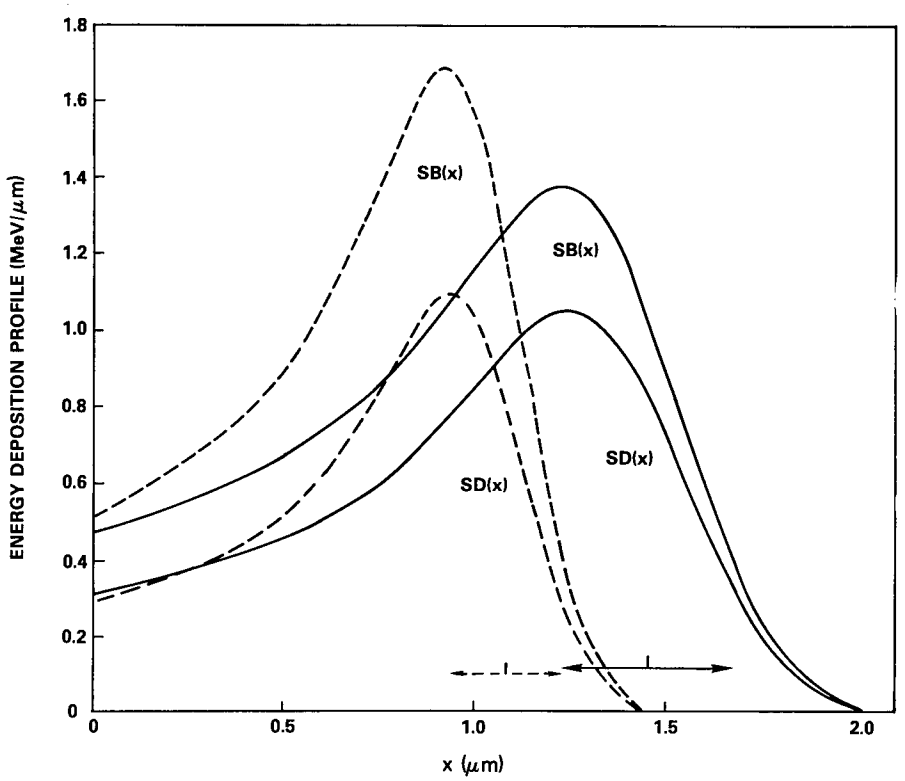

Fig. 2 — The effective rate of energy deposition as a function of the penetration depth x, for 5 MeV copper ions bombarding 316 stainless steel. SB(x) is calculated according to Eq. (4) of Ref. 1 and SD(x) according to Eq. (5) of Ref. 1 --- indicates the original version using LNS cross sections [5] and ____ indicates the present version using WHB cross sections [6] and the tables of LB [9]. The horizontal arrows and tic mark depict the mean range and range straggling for the two cases.

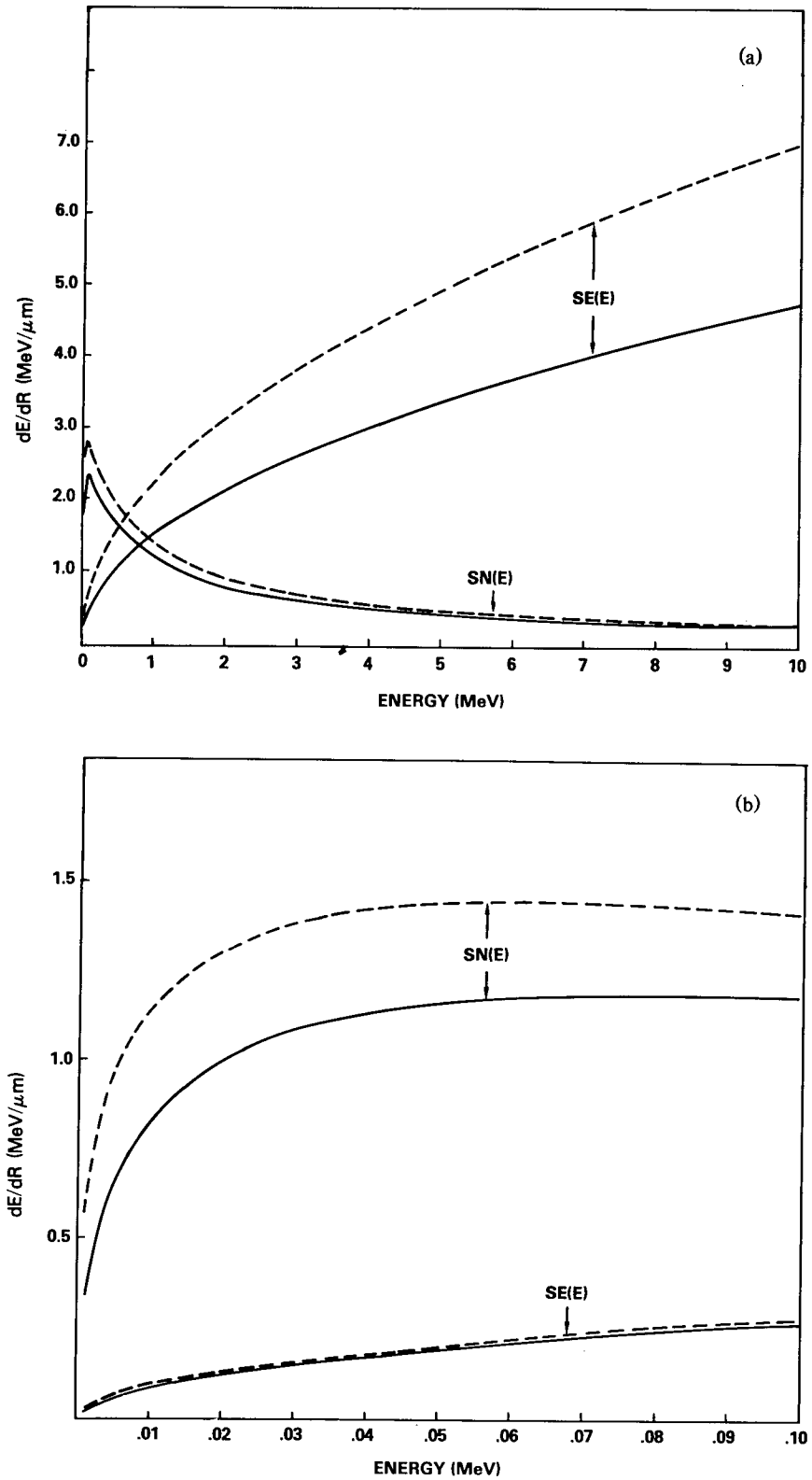

Fig. 3 — Energy loss to elastic collisions ($-dE/dR_{nuclear}$ = SN(E)), and energy loss to inelastic collisions ($-dE/dR_{electronic}$ = SE (E)). --- indicates the original version using LNS cross sections [5], and _____ indicates the present version using WHB cross sections [6] and the tables of LB [9]. (a) Copper ions bombarding 316 stainless steel, and (b) arsenic ions bombarding silicon.

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PROGRAMS ON TAPES AND DISCS

• NRL Users with Access to the CMRSD VAX 11/780

The pertinent program are on

CMRSD::SYS$USERDISKB:[B6670.EDEP1].

The filenames are EDEP1.COM, EDEP1.DAT, EDEP1.EXE, EDEP1.FOR, EDEP1.L1S, EDEP1.MAP, and EDEP1.OUT. EDEP1.OUT is the output for a typical run using the data on EDEP1.DAT. (EDEP1.DAT and EDEP1.OUT are printed in Appendix B and C respectively.) To test the program, the user should give the command,

$@[B6670.EDEP1]EDEP1

This will give a file TEST.OUT in the user's main directory which should be identical with Appendix C or the sample output in the file

[B6670.EDEP1]EDEP1.OUT.

To run EDEP1 with his or her own data, the user should give the commands,

$ASSIGN/USER_MODE name of data file in your directory SYS$INPUT

$ASSIGN/USER_MODE name of output file in your directory SYS$OUTPUT

$RUN [B6670.EDEP1]EDEP1

• NRL Users with Access to the Cray Front End VAX 11/785

The same files as are on the CMRSD directory [B6670.EDEP1] are on Tape #004788, stored at the Computer Control Center. They may be obtained by the following procedure.

$ SHOW DEVICES MT

or

$ SHOW DEVICES MU

(Choose any of the tape drives not allocated. <tape drive> indicates this name)

$ ALLOCATE <tape drive>

$ MOUNT/COMMENT="EDEP1 004788 NO WRITE RING" <tape drive> EDEP1

$ COPY <tape drive> *.* [directory] *.*

[or if want only the EDEP1.EXE file, use

$ COPY <tape drive> EDEP1.EXE [directory]*.*]

Note: To check that the files have been copied to your directory, do

$ DIR EDEP1

Then

$ DISMOUNT <tape drive>

$ DEALLOCATE <tape drive>

To test the program, the user should give the command:

$ @EDEP1

This will give a file TEST.OUT in the user's main directory which should be identical with Appendix C of this report.

To run EDEP1 with the user's own data, the user should give the commands

$ ASSIGN/USER_MODE name of data file in your directory SYS$INPUT

$ ASSIGN/USER_MODE name of output file in your directory SYS$OUTPUT

$ RUN EDEP1

- **Users Without Access to NRL Computers**

A tape has been sent to the Radiation Shielding and Information Center (RSIC), Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37830. This tape is labeled EDEP1 and has the following files: (1) EDEP1.FOR. This is the Fortran code with liberal comment statements describing input, output, references, and descriptions of subroutines. It is printed as Appendix A in this report. (2) EDEP1.DAT. This is the data for a sample run, which is printed as Appendix B of this report. (3) EDEP1.OUT. This is the output for the sample run of the data given in EDEP1.DAT. It is printed as Appendix C of this report. This tape can be obtained by writing to RSIC, c/o Nancy Hatmaker, and requesting a copy of the tape labeled EDEP1.

This new version of the Energy Deposition Code E-DEP-1 has been sent to Computer Physics Communication as an adaptation to the original code [1]. The program can be obtained from the CPC Program Library at Queen's University of Belfast, N. Ireland. Information concerning the new version of the Energy Deposition Code E-DEP-1 can be obtained by writing to

Miss C. Jackson

CPC Program Library

Department of Applied Mathematics

Queens University of Belfast

Belfast BT7 1NN

Northern Ireland

The catalogue number is ACIB0002, and the title is EDEP1.

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Appendix A

FORTRAN PROGRAM

```
      PROGRAM START                                                     809D
C                                                                       810D
C        THIS PROGRAM CALLS VERSION 5.00 OF EDEP1.                      811D
C                                                                       812D
C        EDEP1 VERSION P5.00 (10 OCTOBER 1985)                          813D
C        ADAPTATION BY C. M. DAVISSON AND I. MANNING, U. S. NAVAL       814D
C        RESEARCH LABORATORY, WASHINGTON, D.C. 20375, IN COMPUTER PHYS. 815D
C        COMMUN. (1986) AND NRL REPORT 8859 (1986) (ADAPTATION DECK D)  816D
C                                                                       817D
C        THIS IS A MODIFICATION OF E-DEP-1 VERSION P1.11 (5 MARCH 1976) 818D
C        DESCRIBED IN COMPUTER PHYS. COMMUN. 7,85 (1974) BY I.MANNING   819D
C        AND G.P.MUELLER, AND ITS CORRECTION DECKS A AND B (COMPUTER    820D
C        PHYS. COMMUN. 12,339 (1976) BY I. MANNING AND G.P. MUELLER),   821D
C        AND DECK C (COMPUTER PHYS. COMMUN. 12, 335 (1976) BY           822D
C        I. MANNING, M. ROSEN AND J.E. WESTMORELAND)                    823D
C                                                                       824D
C    ******************************************************************825D
C    **   PROGRAM START IS THE FIRST PROGRAM.  ITS ONLY FUNCTION IS TO 826D
C    **   CALL THE MAIN SUBROUTINE E-DEP-1.  IT HAS BEEN ADDED TO PROVIDE 827D
C    **   GREATER FLEXIBILITY FOR USERS WHO MAY WANT TO CALL THEIR OWN 828D
C    **   SUBROUTINES AT CERTAIN STAGES IN THE CALCULATION.            829D
C    ******************************************************************830D
C                                                                       831D
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX(3)                         832D
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAM,DNU,  833D
     1 RMS,RMSNU,SKEW,SKNU,CURT,CUNU,NDXA                               834D
      COMMON/C JOGIB/ ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),      835D
     1 EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),         836D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG          837D
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,  838D
     1 TALC,NTALC                                                       839D
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,            840D
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)                        841D
      COMMON/B52/ CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX                 842D
      COMMON/CM5/SNSN(4),SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2, 843D
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),             844D
     2 IDN1(4),IDN2(4)                                                  845D
      COMMON/CJEW/YPERP(400)                                            846D
      COMMON/C 63C/RB,C1,C2,X                                           847D
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)         848D
      CALL EDEP1                                                        849D
      END                                                               850D
      SUBROUTINE EDEP1                                                  959D
C        EDEP1 VERSION P5.00 (10 OCTOBER 1985)                          960D
C        ADAPTATION BY C. M. DAVISSON AND I. MANNING, U. S. NAVAL       961D
C        RESEARCH LABORATORY, WASHINGTON, D.C. 20375, IN COMPUTER PHYS. 962D
C        COMMUN. (1986), AND NRL REPORT 8859 (1986) (ADAPTATION DECK D) 963D
C                                                                       964D
C        THIS IS A MODIFICATION OF E-DEP-1 VERSION P1.11 (5 MARCH 1976) 965D
C        DESCRIBED IN COMPUTER PHYS. COMMUN. 7,85 (1974) BY I.MANNING   966D
C        AND G.P.MUELLER, AND ITS CORRECTION DECKS A AND B (COMPUTER    967D
C        PHYS. COMMUN. 12,339 (1976) BY I. MANNING AND G.P. MUELLER),   968D
C        AND DECK C (COMPUTER PHYS. COMMUN. 12, 335 (1976) BY           969D
C        I. MANNING, M. ROSEN AND J.E. WESTMORELAND)                    970D
C                                                                         10
C    ******************************************************************   11
C    **                          CARD NUMBERING                          12
C    **   FOLLOWING THE EDITORIAL POLICY OF COMPUTER PHYSICS              13
C    **   COMMUNICATIONS, THE CARDS IN THIS PROGRAM ARE NUMBERED          14
C    **   SEQUENTIALLY.                                                972D
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C     **                                                                973D
C     **              ORDER OF APPEARANCE OF SUBPROGRAMS                974D
C     **    1.  PROGRAM START WHICH CALLS E-DEP-1, AND HAS BEEN ADDED TO 975D
C     **        PROVIDE GREATER FLEXIBILITY FOR USERS WHO MAY WANT TO CALL 976D
C     **        THEIR OWN SUBROUTINES AT CERTAIN STAGES IN THE CALCULATION 977D
C     **    2.  THE MAIN SUBROUTINE E-DEP-1                               978D
C     **    3.  ALL MANNING AND MUELLER SUBPROGRAMS FOR E-DEP-1, ARRANGED 979D
C     **        IN ALPHABETICAL ORDER.  THESE INCLUDE DUMMY SUBROUTINES   980D
C     **        DEPTL AND RNGTBL FOR USERS WHO MAY WISH TO DO THEIR OWN   981D
C     **        CALCULATIONS USING THE ENERGY DEPOSITION AND RANGE TABLES 982D
C     **    4.  THE SUBROUTINE JOGIBB, OBTAINED FROM THE CODE OF JOHNSON  983D
C     **        AND GIBBONS (JG).                                         984D
C     **    5   THE SUBPROGRAMS FOR JOGIBB IN ALPHABETICAL ORDER          985D
C     **                                                                   28
C     **                              UNITS                                29
C     **    ALL ENERGY VARIABLES ARE IN MEV AND ALL SPATIAL VARIABLES      30
C     **    ARE IN MICRONS, UNLESS OTHERWISE NOTED.  IN JOGIBB (AND ITS    31
C     **    SUBPROGRAMS) THE ENERGIES ARE IN KEV.  THEY ARE CONVERTED      32
C     **    TO MEV AT THE END OF THE SUBROUTINE.                           33
C     ******************************************************************** 34
C                                                                          35
C     ******************************************************************** 36
C     **                            USER CHANGES                           37
C     **    THE VERSION P2.07 AND ALL PRIOR VERSIONS WERE WRITTEN AND     987D
C     **    TESTED ON A CDC 3800 UTILIZING FORTRAN IV.  THE PRESENT       988D
C     **    VERSION P5.00 WAS WRITTEN ON A DEC VAX 11/780. OUR AIM        989D
C     **    HAS BEEN TO KEEP THE CODE CONSISTENT WITH FORTRAN IV.         990D
C     **    IT HAS BEEN TESTED AND RUN ON BOTH DEC FORTRAN 77 AND         991D
C     **    DEC FORTRAN 66.                                               992D
C     ******************************************************************** 68
C                                                                          69
C     ******************************************************************** 70
C     **                            REFERENCES                             71
C     **    THE FOLLOWING SOURCES ARE SPECIFICALLY REFERED TO BY COMMENTS  72
C     **    CARDS IN THIS PROGRAM AND ITS SUBPROGRAMS.                     73
C     **    UNLESS OTHERWISE NOTED, EQUATION NUMBERS REFER                 74
C     **    TO THE LONG WRITE-UP.                                          75
C     **                                                                   76
C     **    AB    ABRAMOWITZ AND STEGUN, HANDBOOK OF MATHEMATICAL FUNCTIONS, 77
C     **          NBS APPLIED MATHEMATICS SERIES, NO. 55, U.S. GOVERNMENT 78
C     **          PRINTING OFFICE, WASHINGTON, D.C., 1964.                 79
C     **    JG     REF. 4 OF THE LONG WRITE-UP.                            80
C     **    LNS    REF. 7 OF THE LONG WRITE-UP.                            81
C     **    LNST   REF. 6 OF THE LONG WRITE-UP.                            82
C     **    LSS    REF. 2 OF THE LONG WRITE-UP.                            83
C     **    LW-U   LONG WRITE-UP IN COMPUTER PHYSICS COMMUNICATIONS.       84
C     **    ROB    REF. 8 OF THE LONG WRITE-UP.                            85
C     **    TEXT   SAME AS LONG WRITE-UP.                                  86
C     **    WHB    WILSON,HAGGMARK AND BIERSACK, PHYS. REV. B, VOL. 15     6D
C     **           P.2458 (1977).                                          7D
C     **    LB     LAND AND BRENNAN, ATOMIC DATA AND NUCLEAR TABLES       96D
C     **           VOL.22 PP.235-247 (1978).                             97D
C     ******************************************************************** 87
C                                                                          88
C     ******************************************************************** 89
C     **    THIS PROGRAM IS USED TO COORDINATE THE INPUT, OUTPUT AND       90
C     **    CALCULATING FUNCTIONS OF THE VARIOUS SUBPROGRAMS.              91
C     **    THE VARIABLES APPEARING IN THE COMMON STATEMENTS ARE DESCRIBED 92
C     **    IN SUBROUTINE PUTOUT, WITH THE EXCEPTION OF COMMON AREAS /CM5/ 93
C     **    AND /B52/, WHICH ARE DESCRIBED IN JOGIBB.                      94
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C     **   THE FIRST PORTION OF E DEP1 IS AN INPUT SECTION, WHICH IS
C     **   DESCRIBED IMMEDIATELY FOLLOWING THIS SET OF INTRODUCTORY
C     **   COMMENTS.  THE SECOND SECTION CALLS THE VARIOUS CALCULATIONAL
C     **   SUBROUTINES, AND THEN MAKES A SERIES OF CALLS TO THE OUTPUT
C     **   ROUTINE.  THIS PORTION IS DESCRIBED IN THE SECTION LABELED
C     **   CALCULATION AND OUTPUT.
C     ***********************************************************************
C
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX( 3)
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAM,DNU,
     1RMS,RMSNU,SKEW,SKNU,CURT,CUNU,NDXA
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
     1TALC,NTALC
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)
      DATA AK1/4HUSER/,AK2/4HLSS /,AK3/4HLB  /,AK4(1)/4HSUB(/,
     2 AK4(2)/4HLB) /,AK5(1)/4HSUB(/,AK5(2)/4HLSS)/
C
C     ......................................................................
C     ..   NOTE THAT THE FOLLOWING TWO CARDS, WHICH IDENTIFY THE INPUT
C     ..   AND OUTPUT UNITS, ARE SPECIFIC TO THE PARTICULAR COMPUTER BEING
C     ..   USED. THEY SHOULD BE CHECKED BY EACH USER.
      NIN=5
      NOUT=6
C     ......................................................................
C
C     ***********************************************************************
C     **
C     **                DESCRIPTION OF INPUT
C     **
C     **                INPUT CARDS
C     **   CARDS   VARIABLES                          FORMAT
C     **   1       LIX                                3I2
C     **   2       72H                                72H
C     **   3       72H                                72H
C     **   4       EMAX, CUTOFF                       F5.1,F10.5
C     **   5       ZONE, AONE, NTWO                   2F10.3, I5
C     **   6-1     Z2(1), A2(1), RHO(1), K(1)         2F10.3,E10.4,F10.3
C     **   6-2     Z2(2), A2(2), RHO(2), K(2)         2F10.3,E10.4,F10.3
C     **   6-
C     **   7       EZ, DELTA                          2F10.3
C     **
C     **                IDENTIFICATION OF INPUT VARIABLES
C     **   CARD
C     **   1       LIX IS AN ARRAY OF THREE PARAMETERS WHICH CONTROL THE
C     **           RUNNING OF THE PROGRAM.
C     **           THEIR USE IS DESCRIBED IN THE NEXT SECTION OF COMMENTS.
C     **   2       CARD 2 IS AN 72H MESSAGE THAT IS REPRINTED ON THE
C     **           OUTPUT.
C     **   3       SAME AS CARD 2.
C     **   4       EMAX(MEV) IS THE MAXIMUM VALUE OF THE ENERGY FOR WHICH
C     **           THE JOGIBB AND REPLAC ROUTINES ARE CALLED.  IF EMAX IS
C     **           POSITIVE ELASTIC COLLISIONS ARE CALCULATED ACCORDING TO
C     **           WHB, IF NEGATIVE ACCORDING TO LNS. SEE SUBROUTINE TFXS.
C     **           CUTOFF(EV) IS THE ENERGY CUTOFF T1 THAT APPEARS
C     **           IN EQ. (6).
C     **   5       ZONE AND AONE ARE THE CHARGE AND MASS(AMU) OF THE BEAM
C     **           IONS.  NTWO IS THE NUMBER OF COMPONENTS IN THE TARGET.
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C    **   6       EACH OF THE NTWO CARDS OF TYPE 6 CONTAINS THE CHARGE,
C    **           MASS(AMU), PARTIAL DENSITY(ATOMS/CM CUBED), AND
C    **           ELECTRONIC STOPPING PARAMETER FOR ONE OF THE TARGET
C    **           COMPONENTS. (SEE PRINT OUT FOR FURTHER DETAILS.)
C    **   7       EB(MEV) IS THE ENERGY OF THE BEAM ION.  AFTER A COMPLETE
C    **           RUN WITH A GIVEN EB, THE PROGRAM READS A NEW TYPE 7
C    **           CARD.  IF EB IS NEGATIVE, THE PROGRAM RETURNS TO
C    **           THE BEGINNING AND READS A NEW CARD OF TYPE 1.
C    **           DELTA(MICRONS) IS THE SPACING FOR WHICH THE FUNCTIONS
C    **           SB(X) AND SD(X) ARE CALCULATED.  IF DELTA IS ZERO ON
C    **           INPUT, IT IS SUPPLIED BY THE PROGRAM.
C    ***********************************************************************
C
  100 READ (NIN , 120)    LIX
  120 FORMAT (3I2)
C
      IF (LIX(1) .NE. 0)  GO TO 9000
      WRITE (NOUT,125)
  125 FORMAT(1H1,36HE-DEP-1 VERSION P5.00 (10 OCT. 1985), /, 67H INCORPO
     1RATES REVISION DECKS A AND B, AND ADAPTATION DECKS C AND D.,////)
      READ (NIN , 130)
  130 FORMAT (72H A MESSAGE A MESSAGE A MESSAGE A MESSAGE A MESSAGE A ME
     1SSAGE A MESSAGE A/72H A MESSAGE A MESSAGE A MESSAGE A MESSAGE A ME
     2SSAGE A MESSAGE A MESSAGE A)
C
      WRITE (NOUT, 135)
  135 FORMAT (49H THE FOLLOWING MESSAGE WAS READ IN WITH THE DATA.//)
C
      WRITE (NOUT, 130)
C
      READ (NIN, 140) EMAX, CUTOFF
  140 FORMAT (F5.1, F10.5)
      IF(EMAX)145,148,148
  145 IS=0
      EMAX=ABS(EMAX)
      GO TO 150
  148 IS=1
  150 CUTOFF=CUTOFF*1.E-6
C
      READ (NIN , 160) ZONE,AONE,NTWO
  160 FORMAT (2F10.3,I5)
C
      READ (NIN , 180) (ZTWO(I),ATWO(I),DENS(I),AKSTOP(I),I=1,NTWO)
  180 FORMAT(4F10.4)
C
      ITARG=0
      DO 240 I=1,NTWO
      IF (AKSTOP(I).LT.0.0) GO TO 200
      ITARG=1
      IF (AKSTOP(I).GT.0.0)GO TO 220
      Z22=ZTWO(I)
      A22=ATWO(I)
      IF (AKSTOP(I).EQ.0.0) CALL EKLAND(ZONE,AONE,Z22,A22,AKS,AKL)
      AKSTOP(I)=AKS
      AKLIST(I)=AKL
      GO TO 240
  200 AKLIST(I)=AK2
      AKSTOP(I)=ELSTOP(ZONE,AONE,ZTWO(I),ATWO(I))
      GO TO 240
  220 AKLIST(I)=AK1
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  240 CONTINUE
C
      QIX=0.42
      QAX=5.0
C
C    ***********************************************************************
C    **
C    **                CALCULATION AND OUTPUT SECTION
C    **    THIS SECTION FIRST CALLS JOGIBB AND REPLAC, WHICH CALCULATE AND
C    **    STORE THE FOLLOWING QUANTITIES, AS A FUNCTION OF ENERGY---
C    **    AVERAGE RANGE, RMS RANGE, AVERAGE PROJECTED RANGE,
C    **    RMS PROJECTED RANGE, SN(E1(XPRIME-X)), SL(E1(XPRIME-X)) AND
C    **    SE(E).  (SEE EQS. (4), (5), (6) AND (9).)
C    **
C    **    THE BEAM ENERGY AND PROJECTED RANGE INTERVAL ARE READ IN AND
C    **    SUBROUTINE STRAGL IS CALLED.  STRAGL RETURNS THE FOLLOWING
C    **    QUANTITIES---SB(X) AND SD(X), WHERE X IS THE DEPTH INTO THE
C    **    TARGET, AND VARIOUS MOMENTS OF THESE DISTRIBUTIONS.
C    **
C    **    THE CONTROL PARAMETERS, LIX(I), I=1,2,3, ARE USED AS FOLLOWS---
C    **    LIX( 1) .NE. 0,  RUN TERMINATES
C    **    LIX( 2) .NE. 0,  ONLY THE JOGIBB SECTION IS RUN AND PRINTED,
C    **                     AFTER WHICH A NEW TYPE 1 CARD IS READ
C    **    LIX( 3) .NE. 0,  OUTPUT OF JOGIBB IS PRINTED IN ADDITION TO
C    **                     THE REGULAR OUTPUT
C    **
C    **    THE USUAL VALUE FOR EACH LIX PARAMETER IS ZERO.
C    **    THE FIRST CARD IN A DATA SET CAN BE BLANK FOR A NORMAL RUN.
C    ***********************************************************************
C
  290 CALL JO GIBB
      CALL REPLAC
      CALL RNGTBL
      CALL PUTOUT(1)
C
      IF (LIX(2) .EQ. 0)  GO TO 300
      CALL PUTOUT(2)
      GO TO 100
  300 IF (LIX(3) .EQ. 0)  GO TO 400
      CALL PUTOUT(3)
C
  400 READ (NIN , 420) EZ,DELTA
  420 FORMAT(2F10.3)
      IF (EZ .LT. 0)  GO TO 100
C
  480 CALL STRAGL
      CALL DEPTBL
      IF (NERR .LT. 5)  GO TO 500
      CALL PUTOUT(4)
      GO TO 400
  500 CALL PUTOUT(6)
      GO TO 400
 9000 CONTINUE
      END
      SUBROUTINE DEPTBL
C
C    ***********************************************************************
C    **    SUBROUTINE DEPTBL IS A DUMMY ROUTINE PUT IN FOR THE CONVENIENCE
C    **    OF THE USER WHO WANTS TO DO HIS OWN CALCULATIONS USING THE
C    **    ENERGY DEPOSITION RESULTS.  IT IS CALLED BY E-DEP-1 AFTER THE
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C     **   CALL TO STRAGL. THE SUBROUTINE WHICH CALCULATES THE ENERGY
C     **   DEPOSITION FOR AN INPUT BEAM ENERGY.
C     ***********************************************************************
C
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX(3)
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAM,DNU,
     1 RMS,RMSNU,SKEW,SKNU,CURT,CUNU,NDXA
      COMMON/C JOGIB/ ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1 EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
     1 TALC,NTALC
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)
      COMMON/B52/ CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX
      COMMON/CM5/SNSN(4),SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),
     2 IDN1(4),IDN2(4)
      COMMON/CJEW/YPERP(400)
      COMMON/C 63C/RB,C1,C2,X
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)
      RETURN
      END
      SUBROUTINE EKLAND(Z11,A11,Z22,A22,AKS,AKL)
C
C     ***********************************************************************
C     **   EKLAND SUPPLIES THE ELECTRONIC STOPPING PARAMETER K,
C     **   USING TABLES FROM LAND AND BRENNAN (LB).
C     ***********************************************************************
C
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)
      COMMON/C JOGIB/ ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1 EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,JOGIB,NTWO,IS,ITARG
      DIMENSION KLB(102,87)
      DIMENSION KLB1(306),KLB2(306),KLB3(306),KLB4(306),KLB5(306),
     2 KLB6(306),KLB7(306),KLB8(306),KLB9(306),KLB10(306),KLB11(306),
     3 KLB12(306),KLB13(306),KLB14(306),KLB15(306),KLB16(306),KLB17(306)
     4,KLB18(306),KLB19(306),KLB20(306),KLB21(306),KLB22(306),KLB23(306)
     5,KLB24(306),KLB25(306),KLB26(306),KLB27(306),KLB28(306),KLB29(306)
      EQUIVALENCE(KLB1(1),KLB(1,1)),(KLB2(1),KLB(1,4)),(KLB3(1),KLB(1,7)
     2),(KLB4(1),KLB(1,10)),(KLB5(1),KLB(1,13)),(KLB6(1),KLB(1,16)),
     3 (KLB7(1),KLB(1,19)),(KLB8(1),KLB(1,22)),(KLB9(1),KLB(1,25)),
     4 (KLB10(1),KLB(1,28)),(KLB11(1),KLB(1,31)),(KLB12(1),KLB(1,34)),
     5 (KLB13(1),KLB(1,37)),(KLB14(1),KLB(1,40)),(KLB15(1),KLB(1,43)),
     6 (KLB16(1),KLB(1,46)),(KLB17(1),KLB(1,49)),(KLB18(1),KLB(1,52)),
     7 (KLB19(1),KLB(1,55)),(KLB20(1),KLB(1,58)),(KLB21(1),KLB(1,61)),
     8 (KLB22(1),KLB(1,64)),(KLB23(1),KLB(1,67)),(KLB24(1),KLB(1,70)),
     9 (KLB25(1),KLB(1,73)),(KLB26(1),KLB(1,76)),(KLB27(1),KLB(1,79)),
     1 (KLB28(1),KLB(1,82)),(KLB29(1),KLB(1,85))
C
C     ......................................................................
      DATA KLB1  /28,25,77,79,76,70,65,62,59,55,87,105,121,124,121,121,1
     C16,110,136,154,154,150,146,135,139,137,134,132,125,126,138,144,146
     C,149,149,147,175,198,201,200,187,183,189,178,174,163,165,170,182,1
     C89,194,200,204,204,233,257,264,260,248,244,241,237,234,238,227,224
     C,222,219,216,214,221,223,223,222,220,217,214,205,200,202,215,224,2
     C30,242,239,240,273,299,311,317,307,303,298,287,281,285,271,266,262
     C,257,253,249,26,23,75,78,75,69,64,61,57,53,86,104,122,124,121,121,
     C116,110,137,156,155,151,148,136,140,137,135,133,125,127,139,145,14
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C7,151,151,148,178,201,204,203,190,185,192,180,176,165,167,172,184,      151D
C192,197,204,207,207,237,262,269,265,253,249,246,242,238,243,232,22      152D
C9,226,223,221,218,226,228,227,226,224,221,217,208,204,205,218,228,      153D
C235,247,243,245,279,306,319,325,314,310,305,293,288,291,277,272,26      154D
C8,263,259,255,24,21,71,74,72,66,61,58,54,51,83,101,119,121,118,118      155D
C,113,107,134,153,152,149,145,133,137,135,132,130,122,124,136,142,1      156D
C44,148,148,145,175,199,202,201,188,183,190,178,173,162,164,170,182      157D
C,190,195,202,205,205,236,261,269,264,252,248,244,241,237,242,231,2      158D
C27,224,222,219,216,224,226,226,225,222,219,216,207,202,203,217,226      159D
C,234,246,242,243,279,306,319,326,314,310,305,293,287,291,277,272,2      160D
C67,262,258,254/                                                         161D
 DATA KLB2  /23,20,68,71,69,64,59,56,52,48,80,98,115,118,115,116,11      162D
C0,105,131,150,150,146,142,131,134,132,130,127,120,121,133,139,142,      163D
C145,145,143,173,197,200,199,185,181,187,175,171,160,162,167,179,18      164D
C7,192,199,203,203,234,259,267,263,250,246,242,239,235,240,228,225,      165D
C222,219,217,214,222,224,224,222,220,217,214,204,200,201,214,224,23      166D
C2,244,240,242,277,305,318,325,313,309,304,292,286,290,275,270,265,      167D
C261,256,252,21,18,65,68,66,61,56,53,49,46,77,94,111,114,111,112,10      168D
C6,101,127,146,145,142,138,126,130,128,125,123,115,117,129,135,137,      169D
C141,141,138,168,192,195,194,181,176,183,171,166,155,157,163,175,18      170D
C3,188,195,198,198,229,254,262,258,245,241,237,234,230,235,223,220,      171D
C217,215,212,209,217,219,219,218,215,212,209,200,195,196,210,219,22      172D
C7,239,236,237,272,300,313,320,308,304,299,287,281,285,270,265,260,      173D
C256,251,247,19,17,61,64,62,58,53,50,46,43,73,90,106,109,107,107,10      174D
C2,96,122,141,140,136,133,121,125,123,120,118,111,112,124,130,132,1      175D
C36,136,133,163,186,189,188,175,170,177,165,161,150,152,157,169,177      176D
C,182,188,192,192,223,248,255,251,238,235,231,227,223,228,217,214,2      177D
C11,208,205,203,210,212,212,211,209,206,203,193,189,190,203,213,220      178D
C,232,229,230,265,293,306,312,301,297,292,280,274,278,263,258,253,2      179D
C49,244,240/                                                             180D
 DATA KLB3  /33,31,81,86,86,82,77,74,70,66,97,116,134,139,138,140,1      181D
C35,130,157,176,175,172,167,155,159,156,153,150,142,144,156,163,167      182D
C,171,173,171,202,227,230,230,217,213,219,207,203,191,193,198,210,2      183D
C18,224,231,235,236,268,294,303,298,285,281,277,273,269,274,262,258      184D
C,255,252,249,246,254,256,257,256,254,251,248,239,234,236,249,259,2      185D
C67,280,277,279,315,344,358,365,354,349,345,332,326,330,314,309,304      186D
C,299,294,289,42,39,98,103,102,98,93,90,86,81,114,135,155,160,160,1      187D
C62,158,154,181,201,201,197,192,180,183,180,177,174,165,167,180,188      188D
C,191,197,199,198,230,257,261,261,248,243,250,238,233,221,223,228,2      189D
C40,249,254,262,267,269,302,329,338,334,320,315,311,307,303,308,295      190D
C,291,288,284,281,278,286,289,289,289,287,285,281,272,267,269,283,2      191D
C93,302,316,313,315,353,382,397,405,393,389,384,370,364,369,352,347      192D
C,341,336,330,326,49,46,113,119,117,113,108,104,100,94,131,153,175,      193D
C181,181,184,180,175,205,226,226,221,217,203,207,204,200,197,188,18      194D
C9,203,211,216,222,225,224,259,286,291,291,278,273,280,268,262,250,      195D
C252,257,270,279,285,293,299,301,336,365,374,370,355,350,346,341,33      196D
C7,343,328,324,321,317,313,310,319,322,322,322,320,318,315,305,300,      197D
C302,317,328,336,351,348,351,391,421,437,446,434,429,425,410,404,40      198D
C8,391,385,379,373,368,362/                                              199D
 DATA KLB4  /53,49,123,129,126,120,114,111,106,101,140,164,188,194,      200D
C193,196,191,186,217,240,239,235,230,216,220,217,213,210,200,202,21      201D
C7,225,230,236,239,238,274,303,308,308,294,289,297,284,278,265,267,      202D
C272,286,295,302,311,316,318,355,386,396,391,375,371,366,361,357,36      203D
C3,348,344,340,336,332,329,338,341,342,341,339,337,334,324,319,321,      204D
C336,347,356,372,369,372,413,445,462,471,458,453,448,434,427,431,41      205D
C4,408,401,395,389,384,53,49,127,134,130,123,117,113,108,102,144,17      206D
C0,195,201,199,201,196,190,223,247,247,242,237,222,226,223,220,216,      207D
C207,208,224,233,237,244,246,244,282,312,317,317,302,298,305,292,28      208D
C6,273,275,280,294,304,311,320,326,328,366,398,408,403,387,382,377,      209D
C373,368,374,359,355,351,347,343,340,349,352,353,352,350,347,344,33      210D
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C3,328,330,346,357,367,383,380,383,426,459.476,486,472,467,462,447,      211D
C440,445,426,420,414,408,402,396,53.49,129,136,132,125,118,114,109,      212D
C104,146,173,200,207,204.206,200,194,228,253,252,248,242,227,232,22     213D
C8,225,221,212,213,229,239,243,250,252,250,290,321,326,325,310.304,      214D
C312,298,292,279,281,286,301,311,318,328,334,336,376,409,419,414,39     215D
C8,393,388.383,378,384,369,365,361,357,353,349,359,362,362,361,359,      216D
C356,353,342,336,338,354,367,376,393,390,393,437,472,490,499,485,48     217D
C0,475,459,452,457.438,432,425,419,413.407/                              218D
 DATA KLB5  /51,47,127,135,132,124,117,113,108,102,146,173,201,208,      219D
C205,207,200,193,229,255,254,249,244,228,232,229,226,222,212,214,23     220D
C1,240,245,251,253,251,292,324,329,328,312,306,315,300,294,280,282,      221D
C288,303,314,321,331,337,339,380,414,425,419,403.397,392,387,382,38     222D
C9,373,369,365,361,357,353,363,366,366,365,363,360,356,345,339,341,      223D
C358,370,380,398,394,397,443,479,497,507,492,487,481,465,458,463,44     224D
C4,437,430,424,418,412,48,44,123,132,128,121,114,110,105,99,143,170      225D
C,198,205,203,204,197.190,226,253,252,246,241,226,230,227,224,220,2      226D
C10,211,228,238,243,249,251,249,290.322,328,327,310,304,313,298,292      227D
C,278,280,286,301,312,319,330,336,337,380,414,425,420,403,397,392,3      228D
C87,382,388,373,368,364,360,356,352,362,365,365,364,362,359,355,343      229D
C,337,339,356,369,379,397,393,396,443,480,499,508,494,488,482,466,4      230D
C58,463,444,437,430.424,417,412,61,58,139,149,148,142,135,132,126,1      231D
C20,164,192,222,230,229,232,227,220,257,284,283,278,273,257,261,257      232D
C,254,250,239,240.258.268,273,281,284,283,326,359,365,365,349,343,3      233D
C52,337,331,317,318,324,340,351,358,369,376,378,422,458,470,464,446     234D
C,441,435,430,425,431,415.410,406,401,397,393,403,406,407,406,404,4      235D
C01,398,386,380,382,400,413,424,443,439,442,491,529,549,559,544,539     236D
C,533,516,508,513,493,486,479,472,465,459/                               237D
 DATA KLB6  /58,55,136,146,144,138,131,128,122,116.160,188,217,226,      238D
C225,228,222,215,252,279,278,273,268,252,256,252,249,245,234,235,25     239D
C3,263,269,276,279,277,320,354,360,360,343,338,346,331,325,311,312,      240D
C318,334,345,353,364,370,373,417,453,465,459,441,436,430,425,419,42     241D
C6,409,405,400,396,392,388,398,401,402,401,399,396,392,380,374,376,      242D
C394,407,418,437,433,436,486,524,544,554,539,534,527,510,503,508,48     243D
C7,480,473,466,460,454,59,57,137,147,147,141,134,131,126,119,163,19      244D
C1,220,229,229,232,226,220,257,284,284,278,273,257,261,257,254,249,      245D
C239,240,257,268,273,281,284,283,326,361,367,367,350,345,353,338,33      246D
C2,318,319,325,341,352,360,371,378,380,424,461,473,467,449,444,438,      247D
C433,427,434,417,412,408,403,399,395,405,408,409,409,407,404,400,38     248D
C8,382,384,402,416,426,446,441,445,495,533,553,565,549,544,537,520,      249D
C512,518,497,490,483,476,469,463,51,48,124,135,134,128,121,118,113,      250D
C107,150,177,205,214,213,216,210,203,240,267,266,261,255,240,244,24     251D
C0,237,233,222,223,240,251,256,264,266,265,308,341,347,347,330,325,      252D
C333,318,312,298,299,305,321,332,340,351,357,359,403,440,452,446,42     253D
C8,422,417,411,406,413,396,391,387,383,378,374,385,388,388,388,385,      254D
C382,378,367,361,363,381,394,405,424,419,423,472,511,531,541,526,52     255D
C0,514,497,489,494,474,467,460,453,446,440/                              256D
 DATA KLB7  /49,46,120,130,130,125,118,114,109,103,146,173,200,209,      257D
C208,211,205,199,235,262,261,256,250,235,239,235,232,228,217,218,23     258D
C5,245,251,258,261,260,302,335,341,341,324,319,328,313,307,292,294,      259D
C300,316,327,334,345,351,354,397,433,445,439,421.416,411,405,400,40     260D
C7,390,385,381,377,372,368,379,382,383,382,380,376,373,361,355,357,      261D
C375,388,399,417,413,417,466,504,524,535,519,514,508,491,483,488,46     262D
C8,461,454,447,440,434,54,51,127,137,137,132,125,122,117,111,153,18      263D
C0,208,216,216,220,214,208,245,271,270,265,260,244,248,244,241,237,      264D
C226,227,244,254,260,268,270,270,312,346,352,352,335,330,339,324,31     265D
C8,303,305,311,326,337,345,356,363,365,409,445,457,451,433,427,422,      266D
C417,411,418,401,397,392,388,383,379,389.393,394,393,391,388,384,37     267D
C3,367,369,387,400,410,429,425,429,478,517,536,547,532,527,521,503,      268D
C496,501,480,473,466,459,452,446,53,50,124,134,135,130,123,120,115,      269D
C109,151,177,205,213,213,217,211,205,242,268,267,262,256,241,245,24     270D
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UNCLASSIFIED

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C301,305,299,292,338,371,370,364,357,338,342,338,334,329,316,316,33      391D
C8,350,358,369,373,373,426,468,476,477,457,451,462,444,437,420,422,      392D
C429,447,460,470,483,492,496,550,595,611,604,582,575,568,562,555,56      393D
C3,543,537,532,526,521,516,528,532,533,532,530,527,523,510,503,506,      394D
C527,543,556,580,575,580,640,687,712,726,708,701,694,674,664,670,64      395D
C6,637,629,620,612,604,71,68,167,183,182,175,167,163,157,149,202,23      396D
C6,273,285,285,290,283,276,322,354,353,347,340,322,326,322,317,313,      397D
C300,301,322,334,342,352,357,356,409,450,458,458,439,433,443,426,41      398D
C8,402,403,410,429,442,451,465,473,477,531,576,592,585,562,556,549,      399D
C543,536,544,524,518,513,507,502,497,509,513,514,513,511,508,504,49      400D
C0,483,486,507,523,536,560,555,560,620,667,692,706,687,681,674,653,      401D
C644,650,626,617,608,600,592,584,68,65,162,177,177,170,162,158,152,      402D
C145,196,230,266,279,279,284,277,270,315,347,347,340,334,315,319,31      403D
C5,311,306,293,294,315,327,335,345,350,349,402,442,451,451,431,425,      404D
C435,418,411,394,396,403,421,434,443,457,466,469,523,568,583,577,55      405D
C4,548,541,535,528,536,516,510,505,499,494,489,501,505,506,505,503,      406D
C500,496,482,475,478,499,515,528,552,547,552,612,659,683,697,679,67      407D
C2,665,645,635,641,617,609,600,592,583,576/                              408D
 DATA KLB15 /72,70,167,182,182,176,168,164,158,151,202,236,272,285,      409D
C285,290,284,277,322,354,354,347,341,322,326,322,318,313,300,301,32      410D
C2,334,342,352,357,356,409,450,458,459,439,433,444,426,419,403,404,      411D
C411,429,442,451,465,474,477,531,576,592,585,563,556,549,543,537,54      412D
C5,524,518,513,507,502,497,509,513,514,514,512,508,504,491,484,487,      413D
C508,524,537,561,556,561,621,668,692,707,688,682,675,654,645,651,62      414D
C7,618,609,601,593,585,77,74,173,188,188,182,174,171,165,157,209,24      415D
C3,279,292,293,298,292,285,330,363,362,356,349,330,335,330,326,321,      416D
C308,309,330,342,350,361,365,365,418,459,467,468,449,443,453,436,42      417D
C9,412,414,420,439,452,461,475,484,487,541,586,602,595,573,566,559,      418D
C553,547,555,534,528,523,517,512,507,519,523,524,524,522,519,515,50      419D
C1,495,497,518,534,548,572,567,572,631,678,703,718,699,693,686,665,      420D
C656,662,638,629,620,612,604,596,85,82,183,199,200,193,186,183,176,      421D
C169,221,255,292,305,306,312,306,300,345,378,377,371,364,346,350,34      422D
C6,341,336,323,324,344,357,365,376,381,381,434,476,485,485,466,461,      423D
C471,454,447,431,432,439,457,470,479,493,502,506,560,605,621,614,59      424D
C2,585,578,572,565,574,553,547,541,536,530,525,537,541,543,542,541,      425D
C538,534,521,514,517,538,554,567,592,587,592,652,699,724,739,720,71      426D
C4,707,687,677,683,659,650,641,633,624,617/                              427D
 DATA KLB16 /91,88,192,209,209,203,195,192,185,178,230,265,302,316,      428D
C317,323,318,311,358,391,390,384,377,358,362,358,353,348,335,336,35      429D
C6,369,377,389,394,394,448,490,499,500,481,475,486,469,462,445,447,      430D
C453,472,485,494,508,517,521,575,621,637,630,607,601,594,587,581,58      431D
C9,568,562,556,551,545,540,552,556,558,558,556,553,550,537,530,533,      432D
C554,570,583,608,603,608,668,716,741,756,737,731,724,704,695,701,67      433D
C6,667,658,650,641,634,95,92,200,217,216,209,202,198,192,184,238,27      434D
C3,311,324,326,332,327,320,367,401,400,394,387,368,372,368,363,358,      435D
C344,345,366,379,387,399,404,404,459,501,510,511,493,487,498,481,47      436D
C4,457,458,465,483,497,506,520,529,533,588,633,650,643,620,613,607,      437D
C600,593,602,581,575,569,563,558,552,564,569,570,570,569,566,562,54      438D
C9,542,546,567,583,596,621,616,622,682,730,755,770,752,746,739,718,      439D
C709,715,690,681,672,664,655,647,100,96,209,225,224,217,209,206,199      440D
C,191,246,282,321,335,336,342,337,331,378,412,411,405,398,379,383,3      441D
C78,374,368,355,355,377,390,398,410,415,416,471,514,523,524,506,500      442D
C,511,494,487,470,472,478,497,510,519,533,543,547,602,648,665,658,6      443D
C35,628,621,614,608,616,595,589,583,577,572,566,579,583,585,585,583      444D
C,580,577,564,557,560,581,598,611,637,631,637,698,746,771,787,768,7      445D
C62,755,734,725,731,706,697,688,680,671,663/                             446D
 DATA KLB17 /103,98,216,233,231,222,214,210,204,196,252,289,329,343      447D
C,344,350,344,338,386,421,420,414,407,387,391,387,382,376,363,363,3      448D
C85,399,407,419,424,425,481,524,534,535,516,510,521,504,497,480,481      449D
C,488,507,520,530,544,553,557,613,660,677,670,646,640,633,626,619,6      450D
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C28,606,600,594,588,583,577,590,594,596,596,594,591,588,575,568,571      451D
C,593,609,623.648.643.649,710,759.785.800,781,775,768,747,738,744,7      452D
C19,710,701,692,683,675,99,94,212,230,227,219,210,207,200,192,248,2      453D
C85,326,340,341,347,341,334,383,417,417,410,403,384,388,383,379,373      454D
C,360,360,382,395,404.416,421,422,478,521,530,532,513,507,518,501,4      455D
C94,477,478,485,504,517,527,541,550,554,610,657,674,667.643,637,630      456D
C,623,616,625,603,597,591,585,580.574,587,591,593,593,591,589,585,5      457D
C72,565,568,590,606,620,645,640,646,707,756,781,797,778,772,765,744      458D
C,735,741,716,707,698,689,680,672,116,113,236,256,255,248,240,237,2      459D
C30,222,280,318,360,375,378,385,381,375,425,461,461,454,447,427,431      460D
C,426,421,415,401,401,423,437,446,459,466.467,525,570,581,583,564,5      461D
C59,571,553,546,529,531,537,556,570,579,594,604,609,666,713,731,724      462D
C,700,693,686,679,672,681,659,653,646,640,634,629,641,646,648,648,6      463D
C47,645,641,629,622,626,648,665,679,705,700,706,768,818,845,861,842      464D
C.836,829,808,799,805,780,770,761,752,743,734/                           465D
 DATA KLB18 /114,109,236,256,254,245,236,233,226,217.277,316,359,37      466D
C4,376,383,377,371,422,458,457,451,444,423,427,423,417,412,398,398,      467D
C420,435,444.456,463,464,523,568,578,580.561,555,567,549,542,525,52      468D
C6,533,552,566,576,591,601,605,663,712,729,722,698,691,684,677,670,      469D
C679,657,650,644,638,632,626,639,644,646,646,644,642,638,625,618,62      470D
C2,644,661,676,702,697,703,766,816,843,859,840,834,827,806,796,803,      471D
C777,768,758,749,740,732,112,109,230,250,249,242,234,231,224,216,27      472D
C4,312,353,369,371,378,373,367,417,453,453,446,439,419,423,418,413,      473D
C407,394,394,416,430,439,452,458,459,517,562,572,574,555,550,562,54      474D
C4,537,520,522,528,547,561,570,585,595,600,657,705,722,715,691,684,      475D
C677,670,663,672,650,644,637,631,626,620,632,637,639,639,638,636,63      476D
C2,619,613,616,638,655,669,696,690,696,759,809,835,851,832,826,820,      477D
C798,789,795,770,761,751,742,733,725,126,123,248,270,271,265,258,25      478D
C5,248,240,298,337,380,397,400,409,404,399,451,487,487,481,473,453,      479D
C457,452,446,440,426,426,448,463,472,486,493,495,554,600,612,614,59      480D
C6,591,603,586,578,561,563,569,588,602,612,627,637,642,700,749,768,      481D
C761,736,729,722,715,708,717,694,687,681,675,668,663,675,680,683,68      482D
C3,682,680,677.664,657,661,684,701,715,743,737,744,807,858,885,902,      483D
C883,877,870,849,839,846,820,810,801,792,782,773/                        484D
 DATA KLB19 /107,104,223,242,242,235,228,224,217,209,266,304,345,36      485D
C0,363,370,365,359,408,444,443,437,430,410,414,409,404,398,384,385,      486D
C407,421,430,442,448,449,507,551,562,563,545,539,551,533,526,509,51      487D
C1,517,536,550,559,574,584,588,645,693,710,703,679,673,666,659,652,      488D
C661,639,632,626,620,614,609,621,626,628,628,627,624,621,608,601,60      489D
C4,626,643,657,684,678,684,747,796.823,838,820,814,807,786,776,783,      490D
C757,748,739,730,720,712,120,118,240,262,263,257,250,247,240,232,28      491D
C9,328,370,387,390,398,394,388,439,476,476,469,462,442,446,441,435,      492D
C429,415,415,437,452,461,474,481,483,542,587,599,601,582,577,589,57      493D
C2,565,548,549,556,575,588,598,613,623,628,686,735,753,746,721,714,      494D
C707,700,693,702,679,673,666,660,654,648,661,666,668,669,668,665,66      495D
C2,649,643,646,669,686,700,727,722,728,792,842,869,885,867,861,854,      496D
C832,823,830,804,794,785,775,766,758,103,100,215,235,235,228,221,21      497D
C7,211,202,259,296,337,352,354,361,356,349,399,434,433,427,420,400,      498D
C404,399,394,389,375,375,397,411,420,432,438,439,496,540,551,552,53      499D
C3,528,539,522,515,498,499,506,525,538,548,562,572,577,633,680,698,      500D
C691,667,660,653,646,639,648,626,620,614,608,602,597,609,614,616,61      501D
C6,614,612,608,595,589,592,614,631,645,671,665,671,733,782,809,824,      502D
C806,800,793,772,762,769,743,734,725,716,707,699/                        503D
 DATA KLB20 /126,124,248,270,272,266,259,256,249,241,299,338,381,39      504D
C8,401,410,406,401,452,489,489,483,475,455,459,454,448,442,428,428,      505D
C450,465,474,488,495,497,557,603,614,617,598,593,606,588,581,564,56      506D
C5,572,591,605,615,630,640,645,703,753,771,764,739,732,725,718,711,      507D
C720,697,690,684,678,672,666,679,683,686,686,685,683,680,667,661,66      508D
C4,687,704,719,746,741,747,811,862,889,906,887,881,874,853,843,850,      509D
C824,814,805,795,786,777,104,102,218,238,238,231,224,220,214,205,26      510D
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C1,238,234,223,224,241,251,257,264,267,266,308,342,348,348,332,327,     271D
C335,320,314,300,302,307,323,334,341,352,359,361,404,440,452,447,42     272D
C9,423,418,412,407,414,397,393,388,384,379,375,385,389,390,389,387,     273D
C384,380,369,363,365,383,396,406,425,421,425,474,512,532,543,527,52     274D
C2,516,499,491,496,476,469,462,455,448,442/                             275D
 DATA KLB8  /46,44,113,124,124,120,114,111,105,100,140,166,193,201,     276D
C201,204,199,193,229,254,254,249,243,228,232,228,225,221,210,212,22     277D
C8,238,243,251,254,253,294,327,333,333,317,312,320,306,300,286,287,     278D
C293,308,319,326,337,344,346,389,424,436,430,412,407,402,396,391,39     279D
C8,381,377,372,368,364,360,370,373,374,373,371,368,365,353,347,350,     280D
C367,380,390,409,405,409,457,495,514,525,510,504,498,482,474,479,45     281D
C9,452,445,438,431,425,45,43,111,121,122,118,112,108,103,98,138,163     282D
C,189,197,197,201,196,191,225,251,250,245,240,225,228,225,221,217,2     283D
C07,208,225,234,240,247,250,249,290,323,329,329,313,308,316,302,296     284D
C,282,283,289,304,315,322,333,339,341,384,419,431,425,407,402,397,3     285D
C91,386,393,377,372,367,363,359,355,365,368,369,368,367,364,360,349     286D
C,343,345,362,375,386,404,400,404,452,489,508,519,504,499,493,476,4     287D
C69,474,454,447,440,433,426,420,43,41,107,118,119,115,109,106,101,9     288D
C5,134,159,185,193,193,197,192,187,221,246,245,240,235,220,224,220,     289D
C217,213,203,204,220,229,235,242,245,244,285,317,323,323,307,302,31     290D
C1,296,290,277,278,284,299,309,317,327,333,336,377,412,424,418,401,     291D
C396,390,385,380,386,370,366,361,357,353,349,359,362,363,362,360,35     292D
C8,354,343,337,339,356,369,379,398,394,397,445,482,501,512,497,492,     293D
C486,469,461,466,447,440,433,426,419,414/                               294D
 DATA KLB9  /47,45,113,122,123,119,113,110,105,99,138,163,189,197,1     295D
C97,201,196,191,225,250,249,244,239,224,228,225,221,217,207,208,224     296D
C,234,239,246,249,248,289,321,327,327,311,306,315,300,294,280,282,2     297D
C88,303,313,320,331,337,339,381,416,427,422,404,399,394,389,384,390     298D
C,374,369,365,361,356,352,362,366,367,366,364,361,358,347,341,343,3     299D
C60,373,383,401,397,401,448,485,504,515,500,495,489,472,465,470,450     300D
C,443,436,430,423,417,51,49,121,130,130,126,120,116,111,105,146,171     301D
C,198,206,206,210,205,199,234,259,259,254,248,233,237,233,230,226,2     302D
C15,217,233,243,248,256,259,258,299,331,337,337,322,317,325,311,305     303D
C,291,292,298,313,324,331,341,348,350,392,427,438,433,415,410,405,3     304D
C99,394,401,385,380,375,371,367,363,373,376,377,377,375,372,369,358     305D
C,352,354,371,384,394,412,409,412,459,496,516,526,512,506,501,484,4     306D
C76,481,462,455,448,441,434,428,59,56,133,143,143,138,132,129,123,1     307D
C17,159,185,213,221,222,226,221,216,251,277,276,271,266,250,254,251     308D
C,247,243,232,233,250,260,265,274,277,276,318,351,357,358,342,337,3     309D
C46,331,325,311,313,318,334,344,351,362,369,371,414,449,461,456,438     310D
C,432,427,422,416,423,406,402,397,393,388,384,394,398,399,398,397,3     311D
C94,391,380,374,376,393,406,417,436,432,435,483,521,540,551,536,531     312D
C,525,509,501,506,486,479,472,465,458,452/                              313D
 DATA KLB10 /64,61,143,153,152,147,140,137,131,125,168,196,225,233,     314D
C234,238,233,228,264,290,290,285,279,263,267,263,260,255,244,245,26     315D
C3,273,279,287,290,290,333,366,373,373,358,353,361,347,341,326,328,     316D
C334,349,360,367,378,385,388,431,467,479,474,455,450,444,439,434,44     317D
C1,424,419,414,410,405,401,411,415,416,416,414,411,408,397,391,393,     318D
C411,424,434,454,450,454,502,540,560,571,556,551,545,528,521,526,50     319D
C5,498,491,484,477,471,67,63,150,160,158,152,146,142,137,130,175,20     320D
C4,234,243,242,246,241,236,273,300,300,294,289,273,276,273,269,265,     321D
C253,254,272,283,289,297,300,300,344,378,385,385,369,364,373,358,35     322D
C2,337,339,345,360,371,379,390,397,400,444,481,493,488,469,464,458,     323D
C453,447,454,437,432,427,423,418,414,424,428,429,429,427,424,421,40     324D
C9,403,406,424,437,448,467,463,467,517,555,576,587,572,567,561,543,     325D
C536,541,520,513,506,498,491,485,69,65,157,168,165,158,151,147,142,     326D
C135,182,212,243,252,252,255,250,244,283,311,310,304,299,282,286,28     327D
C2,278,274,263,264,282,293,299,308,311,310,355,391,397,398,381,376,     328D
C385,370,364,349,351,356,372,384,392,403,410,413,458,496,509,503,48     329D
C4,478,473,467,462,469,451,446,441,437,432,428,438,442,443,443,441,     330D
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C438,434,423,417,419,438,451,462,482,478,482,533,572,593,604,589,58
C4,577,560,552,557,536,529,522,514,507,501/
 DATA KLB11 /70,66,161,172,169,161,154,150,144,137,186,217,249,258,
C258,261,255,248,289,317,317,311,305,288,292,289,285,280,269,270,28
C8,299,306,315,318,317,363,399,406,406,389,384,393,378,371,356,358,
C364,380,392,400,412,419,422,468,507,520,514,495,489,483,477,472,47
C9,461,456,451,446,442,437,448,452,453,452,450,448,444,432,426,428,
C447,461,472,493,488,493,544,584,606,617,602,596,590,572,564,569,54
C8,540,533,525,518,512,70,65,162,174,170,162,154,150,144,137,187,21
C9,252,262,261,264,257,250,291,321,320,314,308,291,295,292,288,283,
C272,273,292,303,309,319,322,320,368,405,412,411,394,388,398,382,37
C5,360,361,368,384,396,404,416,424,427,475,514,527,521,501,496,490,
C484,478,485,467,462,457,452,448,443,454,458,459,458,456,453,449,43
C7,431,433,452,466,478,499,495,499,552,593,614,626,610,604,598,580,
C571,577,555,548,540,532,525,518,84,81,181,196,194,187,180,176,170,
C163,213,246,281,293,293,298,292,286,329,359,359,353,346,329,333,32
C9,324,320,307,308,328,340,347,357,361,361,410,449,457,457,440,435,
C444,428,422,406,408,414,431,443,451,464,472,476,525,566,580,574,55
C3,547,541,535,529,537,518,512,507,502,497,492,503,507,509,508,507,
C504,500,488,482,485,504,519,531,553,548,553,608,651,673,686,669,66
C4,657,639,630,636,613,605,597,589,582,574/
 DATA KLB12 /94,92,195,212,212,206,199,196,189,182,233,267,303,316,
C317,323,318,313,357,389,388,382,376,357,361,357,352,347,334,335,35
C5,368,375,386,391,392,443,483,491,493,475,470,480,464,457,441,443,
C449,466,479,487,500,509,513,564,606,621,615,594,587,581,575,569,57
C7,557,551,545,540,535,530,541,546,547,547,546,543,540,527,521,524,
C544,559,572,595,590,595,651,695,719,733,716,710,704,684,676,682,65
C8,650,642,634,625,618,88,85,190,205,204,197,189,185,179,172,224,25
C8,295,308,308,313,307,300,345,377,377,370,364,345,350,345,341,336,
C323,324,344,357,364,375,379,379,431,471,479,480,462,456,466,450,44
C3,427,428,435,452,465,474,487,496,499,551,594,609,602,581,575,568,
C562,556,564,544,538,533,527,522,517,529,533,534,534,532,529,526,51
C3,506,509,530,545,558,581,576,581,638,683,706,720,702,696,690,670,
C661,667,644,636,627,619,611,604,81,77,182,198,195,186,178,174,168,
C160,214,248,286,298,297,301,294,287,332,364,363,357,350,332,336,33
C2,328,323,311,311,332,345,352,362,366,365,418,458,466,466,447,441,
C451,434,427,410,412,418,437,449,458,472,480,484,536,580,595,588,56
C7,560,554,547,541,549,529,524,518,513,508,503,515,518,520,519,517,
C514,509,496,490,492,513,528,541,564,559,564,622,668,691,705,687,68
C1,674,654,645,651,627,619,611,602,594,587/
 DATA KLB13 /79,75,179,194,192,184,176,172,165,158,211,246,283,295,
C295,300,292,285,330,363,362,356,349,330,335,331,326,322,309,310,33
C1,343,351,361,365,364,417,457,466,466,446,440,450,433,426,410,411,
C418,436,449,458,472,480,484,537,581,596,589,567,561,554,548,542,55
C0,530,524,519,513,508,503,515,519,520,519,517,514,510,497,490,493,
C513,529,542,565,560,565,624,670,694,707,689,683,676,656,647,653,62
C9,621,612,604,596,588,84,81,185,202,200,193,184,181,174,167,220,25
C5,293,306,306,311,304,297,343,376,375,369,362,343,348,343,339,334,
C321,322,343,356,363,374,378,378,431,472,481,481,462,456,467,449,44
C2,426,427,434,452,465,474,488,497,501,554,599,615,608,585,579,572,
C566,559,567,547,541,536,530,525,520,532,536,537,537,535,532,528,51
C4,508,511,531,547,560,584,579,584,643,690,714,729,710,704,697,677,
C668,674,650,641,632,624,616,608,76,73,175,191,189,182,173,169,163,
C156,209,243,281,293,294,298,291,284,330,362,362,355,348,330,334,33
C0,325,321,308,309,330,342,350,360,365,364,417,458,467,467,447,441,
C451,434,427,410,412,418,437,450,459,473,482,485,539,584,599,592,57
C0,564,557,551,544,552,532,526,521,515,510,505,517,521,522,521,519,
C516,512,499,492,494,515,531,544,568,563,568,628,674,699,713,694,68
C8,681,661,651,657,633,625,616,608,599,592/
 DATA KLB14 /80,77,179,196,195,188,180,176,169,162,215,250,287,300,
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C2,299,341,356,358,365,360.354,403,439.438,432,425,405,409,404,399,      511D
C393,380,380,402,416,425,437,443,444,502,546,556,558.539,534,545,52      512D
C8,521,504,505,512,531,544,554,568,578,583,640,687,705,698,674,667,      513D
C660,653,646,655,633,627,621,615,609,603,616,620,622,622,621,618,61      514D
C5,602,595,598,620,637,651,678.672,678,741,790,817,833,814,808,801,      515D
C780,770,777,751,742,733,723,714,706,111,110,225,246,248.242,235,23      516D
C2,226,217,273,311,352,367,371.379,374,369,418,454,454,447,440,420,      517D
C424,419,414,408,394,394,416,430,439,452,459,460,518,562,573,575,55      518D
C7,552,564,546,539,522,524,530,549.562,572,587,597,601,658,706,724,      519D
C717.693,686,679,672,665,674,652,645.639,633,627,621,634,639,641,64      520D
C1,640,638,634,621,615,618,640,657,671,698,692,699,761,811,837,853,      521D
C835,829,822,801,791,798,772,763,754,745,735,727/                        522D
 DATA KLB21 /100,98,211,230,231,225,217,214,207,199,255,292,332,347      523D
C.349,356,351,345,394,429,429,422,415,395,399,395,390,384,370,371,3      524D
C92,406,415,427,433,434,491,535,545,547,528,523,534,516,509,492,494      525D
C,500,519,533,542,557,566,571,627,674,692.685,661,654,647,640,634,6      526D
C42,621.614,608,602,597,591,603,608,610,610,609,606,602,589,583,586      527D
C,608,625,639,664,659,665,727,776,802,818,799,793,786,765,756,762,7      528D
C37,728,719,710,701,693.107,106,219,239,241,236,229,226,219,211,266      529D
C,303,343,358,362,369,365,360,409,444,444,437,430,410,414,409,404,3      530D
C98,385,385,406,420,429,442,448,450,507,551,561,564,545,540,552,534      531D
C,527,511,512,518,537,551,560,574,584,589,645,693,710,703,679,673,6      532D
C66,659,652,661,639,632,626,620,614,609,621,626,628,628,627,625,621      533D
C,608,602,605,627,644,658,684,679,685,747,796,822,838,820,814,807,7      534D
C86,776,783,757,748,739,730,721,713.105,104,215,235,237,232,226,223      535D
C,216,208,263,299,339,354,357,365,361,355,404,439,439,432,425,406,4      536D
C10,405,400,394,380,380,402,415,424,437,443,445,501,545,556,558,540      537D
C,535,546,529,522,505,506,513,532,545,554,569,578,583,639,686,703,6      538D
C97,673,666,659,652,645,654,632,626,620,614,608,602,615,620,622,622      539D
C,621,618,615,602,596,599,621,638,651,677,672,678,740,789,815,831,8      540D
C12.806,800,779,769,776,750,741,732,723,714,706/                         541D
 DATA KLB22 /104.103,212,232,234,229,223,220,213,205,259,295,335,35      542D
C0,353,361,357,351,400,434,434,428,421,401,405,400,395,389,376,376,      543D
C397,411,420,432.438,440,496,540,550,552,534,529,540,523,516,500,50      544D
C1,507,526.539,549,563.572,577.633,680.697.690,666,660,653,646,639,      545D
C648,626,620,614,608,602,596,609,613,615,616,615,612,609,596,590,59      546D
C3.615.631,645,671,666,672,733,782,808,823,805,799,792,771,762,769,      547D
C743,734,725,716,707.699.102,101,209,229,231,226.220,217,210,202,25      548D
C6,292,331,346,349,357,352,347,395,430,429,423,416,397,401,396,391,      549D
C385,371,372,393,406,415,427,434.435,491,534,545,547,529,524,535,51      550D
C8,511,494,496,502,521,534,543.557,567,571,627,673.691,684,660,654,      551D
C647,640,633,642,620,614,608,602,596,590,603,607,610,610,609,606,60      552D
C3,590,584,587,609,625,639,665,659,665,726,775,801,816,798,792,785,      553D
C765,755,762,737,727,718,709,701,692,100,99,206,225,228,224,217,214      554D
C,208,199,253,288,327,342,345,353,349,343,391,425,425,419,412,392,3      555D
C96,391,386,381,367,367,388,402,411,423,429,430,486,529,539,541,523      556D
C,518,530,513,506,489,490,497,515,528,538,552,561,566,621,667,684,6      557D
C78,654,648,641,634,627,636,614,608,602,596,590,585,597,602,604,604      558D
C,603,601,597,584,578,581,603,619.633,658,653,659,720,768,794,809,7      559D
C91,785,779,758,749,755,730,721,712,703,694.686/                         560D
 DATA KLB23 /102,101,210,230,232,227,220,217,211,202,257,292,332,34      561D
C7,350,358,353,348,396,430,430,424,417,397,401,397,391,386,372,372,      562D
C394,407,416,428,435,436,492,536,546,548,530,525,536,519,512,495,49      563D
C6,503,521,535,544,558,568,572,628,675,692,685,662,655,648,641,634,      564D
C643,621,615,609,603,597,592,604,609,611,611,610,607,604,591,585,58      565D
C8,610,626,640,666,661,667,728,776,802,818,800,794,787,766,757,763,      566D
C738,729,720,711,702,694,103,102,213,232,234,229,222,219,212,204,25      567D
C9.295,335,350,353,361,356,350,399,434,434,427,420,400,405,400,395,      568D
C389,375,375,397,411,420,432,438,439,496,540,550,552,534,529,540,52      569D
C3,516,499,500,507,525,539,548,563,572,577,633,680,698,691,667,660,      570D
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C653,646,640,648,626,620,614,608,602,597,609,614,616,616,615,612,60      571D
C9,596,589,593,614,631,645,671,666,672,734,783,809,825,806,800,793,      572D
C772,763,769,744,735,726,716,707,699,103,101,214,234,235,229,222,21     573D
C9,212,204,260,296,337,352,355,362,357,351,401,436,435,429,422,402,      574D
C406,401,396,391,377,377,399,413,422,434,440,441,499,543,553,555,53     575D
C6,531,542,525,518,501,502,509,528,541,551,565,575,580,636,684,701,      576D
C695,671,664,657,650,643,652,630,623,617,611,605,600,612,617,619,61     577D
C9,618,615,612,599,592,595,617,634,648,674,669,675,737,787,814,829,      578D
C810,805,798,776,767,773,748,739,729,720,711,703/                        579D
 DATA KLB24 /103,101,214,234,235,229,222,218,212,204,260,297,338,35      580D
C3,355,363,357,351,401,437,436,430,422,402,407,402,397,391,377,377,      581D
C399,413,422,435,441,442,500,544,555,556,537,532,543,526,518,501,50     582D
C3,509,529,542,552,566,576,581,638,686,704,697,673,666,659,652,645,      583D
C654,632,625,619,613,607,602,614,619,621,621,619,617,613,600,593,59     584D
C6,619,636,650,676,671,677,740,790,817,832,813,807,800,779,769,776,      585D
C750,741,732,722,713,705,102,99,214,233,234,228,220,217,210,202,259     586D
C,296,337,352,355,362,357,350,400,436,436,429,422,402,406,401,396,3      587D
C90,376,377,399,413,422,434,440,441,500,544,555,556,537,531,543,525     588D
C,518,501,502,509,528,542,552,566,576,581,639,687,705,698,673,666,6     589D
C59,652,645,654,632,626,619,613,608,602,615,619,621,621,620,617,613     590D
C,600,593,596,619,636,650,677,671,677,741,791,818,834,815,809,801,7      591D
C80,770,777,751,742,732,723,714,706,93,90,202,221,222,215,207,203,1     592D
C97,188,245,282,323,338,340,346,340,333,383,419,418,412,404,384,389      593D
C,384,379,374,360,360,382,396,405,417,423,423,482,526,536,537,517,5     594D
C12,523,505,498,480,482,489,508,522,532,547,556,561,619,667,685,678      595D
C,653,647,640,633,626,634,612,606,600,594,588,583,595,600,601,601,5     596D
C99,596,592,579,572,575,597,615,629,655,650,656,720,770,797,813,793      597D
C,787,780,758,748,755,729,720,710,701,692,684/                           598D
 DATA KLB25 /84,81,191,210,210,203,195,191,184,176,232,269,310,325,      599D
C326,332,326,319,368,404,403,396,389,369,373,369,364,359,345,345,36     600D
C8,382,390,402,408,408,466,510,520,521,501,495,506,488,480,463,464,      601D
C471,491,505,514,529,539,543,602,650,668,660,636,629,622,615,608,61     602D
C7,595,589,583,577,571,566,578,582,584,584,582,579,574,561,553,557,      603D
C579,596,610,637,631,637,701,752,779,795,775,769,761,740,730,736,71     604D
C0,701,692,683,673,665,82,79,188,207,207,200,192,188,181,173,229,26      605D
C6,307,321,323,329,323,315,365,401,400,393,386,366,370,365,361,355,      606D
C342,342,364,378,387,399,404,404,463,507,517,518,497,491,502,484,47     607D
C7,459,461,468,487,501,511,526,536,540,599,648,665,658,633,626,619,      608D
C612,605,614,592,586,580,574,568,562,575,579,581,581,579,576,571,55     609D
C7,550,553,576,593,607,634,628,634,699,750,777,793,773,766,759,737,      610D
C727,734,707,698,689,680,671,662,87,84,194,213,214,207,199,195,188,      611D
C180,237,274,315,329,331,338,331,324,374,410,409,403,395,375,379,37     612D
C5,370,364,351,351,373,387,396,409,414,414,473,518,528,529,508,502,      613D
C514,495,488,470,472,479,499,513,522,537,547,552,611,660,678,670,64     614D
C6,639,632,625,618,626,604,598,592,586,580,574,587,591,593,593,591,      615D
C588,584,570,562,566,588,606,620,647,641,647,712,763,791,807,787,78     616D
C0,773,751,741,748,721,712,702,693,684,676/                              617D
 DATA KLB26 /92,89,201,221,221,215,207,203,196,188,245,282,324,339,      618D
C341,348,341,334,385,421,420,414,406,386,390,386,381,375,361,362,38     619D
C4,398,407,420,425,426,485,530,541,542,521,515,527,509,501,484,485,      620D
C492,512,526,536,551,561,565,625,674,692,685,660,653,646,639,632,64     621D
C1,618,612,606,599,594,588,601,605,607,607,605,602,598,584,577,580,      622D
C603,620,635,662,656,662,728,779,807,823,803,797,789,767,757,764,73     623D
C7,728,718,709,700,691,101,98,213,233,235,228,221,217,210,202,259,2     624D
C97,339,355,358,365,359,353,404,440,440,433,426,405,410,405,400,394      625D
C,380,380,403,417,426,439,445,446,506,552,562,564,544,538,550,532,5     626D
C24,507,508,515,535,549,559,574,584,589,649,699,717,710,685,678,670      627D
C,663,656,665,642,636,629,623,617,611,624,629,631,631,629,626,622,6     628D
C09,602,605,628,646,660,688,682,688,754,806,834,851,831,824,817,795      629D
C,785,791,765,755,746,736,727,718,108,105,223,244,246,239,232,228,2     630D
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C22,213,271,310,352,368,371,379,374,367,419,456,456,449,442,421,425      631D
C,420,415,409,395,395,418,432,442,455,461,462,523,569,581,582,562,5      632D
C57,569,550,543,525,527,533,554,568,578,593,604,608,669,719,738,730      633D
C,705,698,691,683,676,685,662,656,649,643,637,631,644,649,651,651,6      634D
C49,647,643,629,622,626,649,666,681,709,703,710,776,828,857,873,853      635D
C,847,840,817,807,814,787,778,768,758,749,740/                           636D
 DATA KLB27 /113,111,233,253,255,248,241,237,231,222,281,320,363,38      637D
C0,383,391,386,379,432,470,469,462,455,434,438,433,428,422,408,408,      638D
C430,445,455,468,475,476,537,584,596,597,577,572,584,566,558,541,54      639D
C2,549,569,583,594,609,620,625,685,736,755,748,722,715,708,700,693,      640D
C702,679,672,666,659,653,647,660,665,667,665,666,664,660,646,639,64      641D
C3,666,684,699,727,721,727,794,847,876,893,873,866,859,837,826,833,      642D
C806,797,787,777,768,759,118,115,241,262,262,256,248,244,238,229,28      643D
C9,328,372,389,393,401,395,389,443,481,480,473,466,445,449,444,439,      644D
C433,418,418,441,456,466,479,486,487,549,597,609,611,591,585,597,57      645D
C9,572,554,555,562,582,597,607,623,633,638,700,751,770,762,737,729,      646D
C722,715,707,717,693,687,680,673,667,661,674,679,682,682,680,678,67      647D
C4,660,653,657,681,699,714,742,736,743,810,863,892,909,889,883,876,      648D
C853,843,850,823,813,803,793,784,775,121,117,248,269,269,262,253,25      649D
C0,243,234,295,336,380,398,401,409,404,397,451,490,490,483,475,454,      650D
C458,453,448,441,427,427,450,465,475,489,496,497,560,608,620,622,60      651D
C1,596,608,590,583,565,566,573,593,608,618,634,645,650,712,764,783,      652D
C775,749,742,735,727,720,729,706,699,692,686,679,673,687,691,694,69      653D
C4,693,690,686,673,666,669,693,711,726,755,749,756,824,877,906,924,      654D
C904,897,890,867,857,864,837,827,817,807,797,788/                        655D
 DATA KLB28 /124,119,254,276,275,266,258,254,247,238,300,342,387,40      656D
C5,408,416,410,404,459,498,497,490,483,461,465,460,455,449,434,434,      657D
C457,472,482,497,504,505,568,617,629,631,611,605,618,599,592,574,57      658D
C5,582,603,617,628,644,654,660,722,775,794,786,760,753,745,738,730,      659D
C740,716,709,702,696,690,683,697,702,704,704,703,701,697,683,676,68      660D
C0,704,722,737,766,760,767,835,889,919,936,916,910,902,879,869,876,      661D
C849,839,829,819,809,800,143,140,280,305,305,298,290,287,280,271,33      662D
C5,377,424,443,447,457,453,447,504,544,544,537,529,508,512,506,501,      663D
C494,478,478,502,517,528,543,551,553,619,669,682,685,665,660,673,65      664D
C5,648,630,631,638,659,673,684,700,711,717,781,834,854,847,820,813,      665D
C805,797,790,800,775,768,761,754,747,741,755,760,762,763,762,760,75      666D
C7,743,736,741,765,784,799,829,823,830,900,955,985,1003,983,977,970      667D
C,946,936,944,915,905,895,885,875,865,160,158,304,330,332,326,319,3      668D
C17,310,301,365,409,458,478,483,494,490,486,544,586,586,579,571,549      669D
C,553,548,541,534,518,518,542,558,569,585,594,597,664,716,730,733,7      670D
C14,710,723,705,698,680,681,688,709,724,735,751,763,769,833,888,909      671D
C,902,874,867,859,851,843,854,828,820,813,806,799,793,807,812,815,8      672D
C16,816,814,811,798,791,795,820,839,855,886,880,888,958,1014,1045,1      673D
C064,1044,1038,1030,1007,997,1004,976,965,955,945,934,924/               674D
 DATA KLB29 /165,162,312,339,341,334,326,324,317,307,373,418,468,48      675D
C8,494,505,501,496,555,598,598,591,583,561,565,559,553,546,530,529,      676D
C554,570,581,597,606,609,677,730,744,748,728,724,738,719,712,694,69      677D
C5,702,723,738,749,766,778,784,849,905,926,919,891,883,875,867,859,      678D
C870,844,836,829,822,815,808,823,828,831,832,832,830,827,814,807,81      679D
C1,837,856,872,903,897,905,976,1033,1064,1083,1063,1057,1049,1026,1      680D
C015,1023,994,984,973,963,952,943,167,164,318,346,347,339,331,328,3      681D
C21,311,379,424,475,496,501,512,508,503,563,606,607,600,591,569,573      682D
C,567,561,554,538,537,562,578,590,606,615,618,687,740,755,758,738,7      683D
C34,748,729,722,704,705,712,734,749,760,777,789,795,861,918,939,931      684D
C,903,895,887,879,872,882,856,848,841,834,827,820,834,840,843,844,8      685D
C44,842,839,825,818,823,848,868,885,916,910,918,990,1047,1079,1098,      686D
C1077,1071,1064,1040,1030,1037,1008,998,987,977,966,956,153,150,295      687D
C,321,323,316,308,306,299,289,354,398,447,467,472,483,478,473,531,5      688D
C73,573,566,558,536,540,535,529,522,506,505,530,546,557,573,581,584      689D
C,651,703,717,720,700,695,709,690,683,664,666,673,694,709,720,736,7      690D
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      C48,754,819,874,896,888,860,852,845,837,829,839,814,806,799,792,785     691D
      C,779,793,798,801,802,801,799,796,782,775,780,805,824,840,871,865,8     692D
      C72,943,1000,1031,1050,1029,1023,1016,992,981,989,960,950,939,929,9     693D
      C19,909/                                                                694D
C     ..............................................................          695D
C                                                                             696D
      IF(Z11.LT.6.0.OR.Z11.GT.92.0.OR.Z22.GT.102.0)GO TO 90                   697D
      JZ=Z22                                                                  698D
      IZ=Z11-5.0                                                              699D
      EK100 = KLB(JZ,IZ)                                                      700D
      EKTABL=EK100/100.                                                       701D
      C1=12.088927                                                            702D
      C2=3.0735774E-2                                                         703D
      C3=6.0202359E-3                                                         704D
      EX=2.0/3.0                                                              705D
      ZZ2=Z11**EX+Z22**EX                                                     706D
      ZZ1=SQRT(ZZ2)                                                           707D
      RHOXL=C3*ZZ2*(A11+A22)**2/A11                                           708D
      ELIND=C2*Z11*Z22*ZZ1*(A11+A22)/A22                                      709D
      DIV=SQRT(ELIND)*A22*SQRT(A11)                                           710D
      AKS=C1*EKTABL*RHOXL/DIV                                                 711D
      AKL=AK3                                                                 712D
      GO TO 100                                                               713D
   90 AKL=AK2                                                                 714D
      AKS=ELSTOP(Z11,A11,Z22,A22)                                             715D
  100 RETURN                                                                  716D
      END                                                                     717D
      SUBROUTINE EKTARG                                                        244
C     SUB 318   P1.06        EKTARG                                             7B
C                                                                              246
C    ****************************************************************         247
C    **   EKTARG SUPPLIES THE ELECTRONIC STOPPING PARAMETER KS FOR EQ(7)     1345D
C    **   OF THE LONG WRITE-UP, AND IS OBTAINED AS DISCUSSED IN SEC. 3,      1346D
C    **   EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986)     1347D
C    **   AND NRL REPORT 8859 (1986). THE LINDHARD UNITS OF LENGTH AND       1348D
C    **   ENERGY FOR THE AVERAGE SUBSTRATE ARE ALSO CALCULATED.              1349D
C    ****************************************************************         253
C                                                                              254
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),           1031D
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),               1032D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG               1033D
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,       1034D
     1TALC,NTALC                                                             1035D
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,                   260
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)                             1351D
C                                                                              262
      IF (NTWO .GT. 1)  GO TO 100                                              263
      AAVE=ATWO(1)                                                             264
      ZAVE=ZTWO(1)                                                             265
      RHO=DENS(1)                                                              266
      GO TO 200                                                                267
C                                                                              268
  100 AAVE=0                                                                   269
      RHO=0                                                                    270
      ZAVE=0                                                                   271
      DO 120 I=1,NTWO                                                          272
      AAVE=AAVE+ATWO(I)*DENS(I)                                                273
      ZAVE=ZAVE+ZTWO(I)*DENS(I)                                                274
  120 RHO=RHO+DENS(I)                                                          275
      AAVE=AAVE/RHO                                                            276
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      ZAVE=ZAVE/RHO
C
  200 A=.88534138*5.2917706E-9/(SQRT(2.)*(ZAVE**(1./3.)))
      BETA=A/2./(ZAVE*ZAVE*1.4399757E-13)
      GLIND=1.
      FACTOR=A*A*RHO*GLIND*1.E-4*3.1415927
      ELIND=1./BETA
      XLIND=1./FACTOR
      IF (NTWO .GT. 1)  GO TO 500
      IF (ZONE .NE. ZTWO(1))  GO TO 500
      IF (AONE .NE. ATWO(1)) GO TO 500
      AK=AKSTOP(1)
      RETURN
  500 SUM1=0
      SUM2=0
      DO 600 I=1,NTWO
      Z1=ZTWO(I)
      A1=ATWO(I)
      DN1=DENS(I)/1.0E22
      DO 600 J=1,NTWO
      Z2=ZTWO(J)
      A2=ATWO(J)
      DN2=DENS(J)/1.0E22
      IF(ITARG.EQ.1)GO TO 550
      AKS=ELSTOP(Z1,A1,Z2,A2)
      GO TO 560
  550 CALL EKLAND(Z1,A1,Z2,A2,AKS,AKL)
  560 TERM1=AKS*DN1*DN2
      TERM2=DN1*DN2
      SUM1=SUM1+TERM1
      SUM2=SUM2+TERM2
  600 CONTINUE
      AK=SUM1/SUM2
      RETURN
      END
      FUNCTION ELCLAW(E)
C     FCN 311   P1.03          ELCLAW
C
C   ******************************************************************
C   **   THIS ROUTINE RETURNS THE ELECTRONIC STOPPING CROSS SECTION,
C   **   SE(E), IN REDUCED VARIABLES, AS A FUNCTION OF THE ION ENERGY E.
C   **   SPECIFICALLY, SE(E)=K*SQRT(EPSILON).
C   **   THIS FUNCTION SERVES ONLY THE JOGIBB SECTION OF THE CODE--
C   **   SPECIFICALLY, SEE SUBROUTINE TFXS.
C   ******************************************************************
C
      COMMON/B52/  CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX
C
      ELCLAW=CNSE*SQRT(E)
      RETURN
      END
      FUNCTION   ELSTOP(Z,A,ZZ,AA)
C     FCN 306   P1.02          ELSTOP
C
C   ******************************************************************
C   **   THIS FUNCTION RETURNS THE LSS ELECTRONIC STOPPING PARAMETER K.
C   **   IT IS A FUNCTION OF (ZONE,AONE,ZTWO,ATWO).
C   **   IF THE TARGET MATERIAL IS NOT A PURE SUBSTANCE, THEN AVERAGE
C   **   VALUES OF ZTWO AND ATWO ARE SUPPLIED BY THE ROUTINE EKTARG.
C   **   THE EXPRESSION FOR K IS OBTAINED FROM EQ. (10) OF THE LONG
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C     **   WRITE-UP.                                                      318
C     ***********************************************************************  319
C                                                                          320
      TT=2./3.                                                             321
      ADD=A+AA                                                             322
      AC=ADD*ADD*ADD                                                       323
      ZADD=Z**TT+ZZ**TT                                                    324
        ELSTOP=0.07952506*SQRT(Z*ZZ*AC/(AA*A*A*A))*                       951D
     1(Z**(1./6.))/(ZADD**0.75)                                            326
      END                                                                  327
      SUBROUTINE ERCINV  (Y,Z,NUM)                                         328
C     SUB 303   P1.02          ERCINV                                      329
C                                                                          330
C     ***********************************************************************  331
C     **   GIVEN Y, THIS ROUTINE RETURNS THE INVERSE OF THE COMPLEMENTARY  332
C     **   ERROR FUNCTION.                                                 333
C     **   IF Y .EQ. ERFC(Z), THEN ERCINV RETURNS Z FOR ANY Y SUCH THAT    334
C     **   THE RESULTING Z IS BETWEEN 0 AND 10, THAT IS, FOR ANY Y         335
C     **   BETWEEN 1.E-44 AND 1.00.                                        336
C     **                                                                   337
C     **   THE METHOD IS TO EXPAND IN A TAYLOR SERIES AROUND A VALUE OF Y, 338
C     **   CALLED YZERO, FOR WHICH THE VALUE OF Z IS KNOWN.  THE ARRAY YNO 339
C     **   CONTAINS THE NEGATIVES OF THE NATURAL LOGS OF THE VALUES OF Y   340
C     **   FOR Z .EQ. 0.02, 0.1(0.1)10.0.                                  341
C     **                                                                   342
C     **   NUM IS AN ERROR AND WARNING CODE.  PROGRAM STRAGL, WHICH        343
C     **   CALLS ERCINV, WILL NOT GENERATE ANY VALUE OF Y WHICH WILL CAUSE 344
C     **   AN ERROR OR WARNING.                                            345
C     **   THE VALUES RETURNED ARE ACCURATE TO BETTER THAN ONE PART        346
C     **   IN 5.0E+6.                                                     924D
C     ***********************************************************************  348
C                                                                          349
      DIMENSION YNO(101),ZNO(101),A(50)                                    350
      DIMENSION YNOA(77),YNOB(24)                                         926D
      EQUIVALENCE(YNOA,YNO(1))                                            927D
      EQUIVALENCE(YNOB,YNO(78))                                           928D
      COMMON/C ERCIN/ZNO,YNO                                              929D
C                                                                          351
C     ......................................................................  352
      DATA M/0/                                                           931D
      DATA  PISQT/1.772453850905516/                                     1174D
      DATA  YNOA/0.0228230503,                                           1175D
     1   0.1193049737,   0.2519322338,   0.3984300514,   0.5593024584,     357
     1   0.7350111298,   0.9259777268,   1.1325865135,   1.3551871067,     358
     1   1.5940972466,   1.8496055100,   2.1219739112,   2.4114403552,     359
     1   2.7182209221,   3.0425119751,   3.3844920896,   3.7443238088,     360
     1   4.1221552342,   4.5181214595,   4.9323458627,   5.3649412646,     361
     1   5.8160109689,   6.2856496932,   6.7739444028,   7.2809750560,     362
     1   7.8068152728,   8.3515329310,   8.9151907018,   9.4978465310,     363
     1  10.0995540654,  10.7203630419,  11.3603196321,  12.0194667543,     364
     1  12.6978443549,  13.3954896594,  14.1124374028,  14.8487200313,     365
     1  15.6043678946,  16.3794094166,  17.1738712052,  17.9877783055,     366
     1  18.8211541758,  19.6740209088,  20.5463992981,  21.4383089328,     367
     1  22.3497683243,  23.2807948454,  24.2314050505,  25.2016144912,     368
     1  26.1914380342,  27.2008895422,  28.2299823482,  29.2787290215,     369
     1  30.3471415238,  31.4352312004,  32.5430089096,  33.6704848940,     370
     1  34.8176689949,  35.9845705153,  37.1711984146,  38.3775611594,     371
     1  39.6036669286,  40.8495234363,  42.1151381163,  43.4005181389,     372
     1  44.7056701966,  46.0306008598,  47.3753164513,  48.7398228832,     373
     1  50.1241259221,  51.5282310955,  52.9521436486,  54.3958688127,     374
```

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     1  55.8594113784,  57.3427761281,  58.8459674688,  60.3689898998/      933D
      DATA YNOB/                                                            934D
     1  61.9118475905,  63.4745445857,  65.0570847727,  66.6594719868,       376
     1  68.2817097716,  69.9238017350,  71.5857512020,  73.2675614301,       377
     1  74.9692356773,  76.6907769293,  78.4321881589,  80.1934722234,       378
     1  81.9746319074,  83.7756698895,  85.5965887401,  87.4373909589,       379
     1  89.2980790865,  91.1786554139,  93.0791221876,  94.9994816985,       380
     1  96.9397360701,  98.8998874277, 100.8799377512, 102.8798890170/     1177D
C    ..................................................................      383
C                                                                            384
      IF (M .EQ. 101)  GO TO 60                                              385
      ZNO(1)=0.02                                                            386
      YNO(1)=EXP(-YNO(1))                                                    387
      X=0.1                                                                  388
      DO 40 I=2,101                                                          389
      ZNO(I)=X                                                               390
      YNO(I)=EXP(-YNO(I))                                                    391
   40 X=X+0.1                                                                392
      M=101                                                                  393
C                                                                            394
   60 IF (Y .LT. YNO(M))  GO TO 600                                          395
      IF (Y .EQ. 1.)  GO TO 700                                              396
      IF (Y .LT. YNO(2)) GO TO 80                                            397
      I=2                                                                    398
      BR=0.45                                                                399
      CUT=1.E-10                                                             400
      GO TO 130                                                              401
C                                                                            402
   80 DO 100 I=1,M                                                           403
      IF (Y .GT. YNO(I))  GO TO 110                                          404
  100 CONTINUE                                                               405
  110 CUT=1.E-8                                                              406
      IF (I .LT. 11)  GO TO 120                                              407
      CUT=1.E-7                                                              408
      IF (I .LT. 41)  GO TO 120                                              409
      CUT=1.E-6                                                              410
  120 Q=ALOG(-ALOG(Y))                                                       411
      BR=0.46-Q*(0.0261+0.0113*Q)                                            412
  130 IF (((Y-YNO(I))/(YNO(I-1)-YNO(I))) .LT.  BR )  GO TO 140               413
      I=I-1                                                                  414
  140 YZERO=YNO(I)                                                           415
C                                                                            416
      PZERO=EXP(-ZNO(I)*ZNO(I))                                              417
      A(1)=ZNO(I)                                                            418
      A(2)=0.25                                                              419
      DEL=PISQT*(YZERO-Y)/PZERO                                              420
      POWER=DEL*DEL*DEL                                                      421
      P=-1.0+DEL*(A(1)+DEL*A(2))                                             422
C                                                                            423
      DO 300 N=3,50                                                          424
      I=N-2                                                                  425
      COE=0.0                                                                426
      DO 200 J=1,I                                                           427
  200 COE=COE+J*(J+1)*A(J+1)*A(N-1-J)                                        428
      COE=COE/(N*(N-1))                                                      429
      A(N)=COE                                                               430
      X=POWER*COE                                                            431
      P=P+X                                                                  432
      IF (ABS(X/P) .LT.  CUT )  GO TO 400                                    433
  300 POWER=POWER*DEL                                                        434
```

```
C
  400 NUM=N
      P=-PZERO*P
      IF (P .LE. 0)  GO TO 500
      P=-ALOG(P)
      IF (P .LT. 0)  GO TO 480
      Z=SQRT(P)
      RETURN
C
  480 NUM=NUM+100
  500 Z=P
      NUM=-NUM
      RETURN
C
  600 Z=10.0
      NUM=-100
      RETURN
C
  700 Z=0.0
      NUM=0
      RETURN
      END
      FUNCTION ERRORC(X)
C     FCN 302   P1.01          ERRORC
C
C   ***********************************************************************
C   **   THIS FUNCTION RETURNS THE COMPLIMENTARY ERROR FUNCTION, WHICH
C   **   IS DISCUSSED IN CHAPTER 7 OF AB.  IT IS EVALUATED USING
C   **   THE RATIONAL APPROXIMATION OF AB(7.1.26).
C   ***********************************************************************
C
      DIMENSION A(5)
C
C   .......................................................................
      DATA A/.254829592,-.284496736,1.421413741,-1.453152027,
     11.061405429/
C   .......................................................................
C
      IF (X .NE. 0)  GO TO 50
      ERRORC=1.
      RETURN
C
   50 T=1./(1.+0.3275911*X)
      Y=A(5)
      DO 100 I=1,4
  100 Y=Y*T+A(5-I)
      ERRORC=T*Y*EXP(-X*X)
      RETURN
      END
      FUNCTION F(R)
C     FCN 305   P2.02          F(R)
C
C   ***********************************************************************
C   **   THIS ROUTINE SUPPLIES THE INTEGRAND OF EQ. (4) OF THE LONG
C   **   WRITE-UP.  THE GAUSSIAN F(XPRIME) IS CALCULATED WITHIN THE
C   **   ROUTINE AND SN(E1(XPRIME-X)) TIMES DR/DXPRIME IS INTERPOLATED
C   **   FROM THE ANSX TABLE SUPPLIED BY SUBROUTINE REPLAC.
C   ***********************************************************************
C
      COMMON /C 63C/ RB,C1,C2,X
```

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```
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
     1TALC,NTALC
C
      M=NJOGIB
      MMO=M-1
      R2=((R-X)/R)*RB
      IF (R2 .GE. 0)  GO TO 100
   40 F=0
      RETURN
C
  100 Y=R-RB
      Y=Y*Y/C2
      IF (Y .GT. 12.5)  GO TO 40
      F1=C1*EXP(-Y)
      IF (R2 .GE. RNP(1))  GO TO 200
      S2=ANSX(1)*(R2-RNP(2))/(RNP(1)-RNP(2))+
     1   ANSX(2)*(R2-RNP(1)) /(RNP(2)-RNP(1))
      GO TO 400
  200 IF (R2 .LE. RNP( M )) GO TO 300
      S2=ANSX(MMO)*(R2-RNP( M ))/(RNP(MMO)-RNP( M ))
     1  ANSX( M )*(R2-RNP(MMO))/(RNP( M )-RNP(MMO))
      GO TO 400
  300 CALL   TERP4A(R2,S2,RNP,ANSX, M ,NNNNNN)
  400 F=F1*S2
      RETURN
      END
      FUNCTION FIVDIV(X,Y,N)
C     FCN 315   P1.03          FIVDIV
C
C   ******************************************************************
C   **   THIS FUNCTION PROVIDES THE DERIVATIVE OF A TABULAR FUNCTION.
C   **   FIVE ORDINATES (X(N-2),...,X(N+2)) AND THE CORRESPONDING FIVE
C   **   ABSCISSAS (Y(N-2),...,Y(N+2)) ARE USED IN A DIFFERENTIATED
C   **   FIVE-POINT LAGRANGIAN INTERPOLATION FORMULA TO PROVIDE THE
C   **   DERIVATIVE OF THE Y FUNCTION AT X(N).  THE INPUT ARRAYS X AND Y
C   **   MAY BE DIMENSIONED UP TO 300.  THE RESTRICTIONS ON N
C   **   ARE (N .GE. 3) AND (N .LE.((DIMENSION OF ARRAY)-2)).
C   ******************************************************************
C
      DIMENSION X(300),Y(300),Q(5)
C
      DO 100 L=1,5
      NL=N+L-3
      Q(L)=1
      DO 100 K=1,5
      NK=N+K-3
      IF (K .EQ. L)  GO TO 100
      Q(L)=Q(L)*(X(NL)-X(NK))
  100 CONTINUE
      Z=0
      DO 200 L=1,5
      IF (L .EQ. 3)  GO TO 200
      NL=N+L-3
      Z=Z+(Y(N)+Q(3)*Y(NL)/Q(L))/(X(N)-X(NL))
  200 CONTINUE
      FIVDIV=Z
      RETURN
```

```
      END                                                                557
      FUNCTION FTOH(Z)                                                   558
C     FCN 310   P1.01          FTOH                                      559
C                                                                        560
C   ******************************************************************   561
C   **   THIS ROUTINE RETURNS F(SQRT(T)). IF LSS IS CHOSEN IT IS GIVEN  1382D
C   **   BY LNS, TABLE 2A, WHICH HAS A DISCUSSION OF THE FUNCTIONS      1383D
C   **   ASYMPTOTIC VALUES APPEARING IMMEDIATELY BELOW THE TABLE. FOR   1384D
C   **   LSS F(SQRT(T))IS STORED AS A FUNCTION OF LOG10(SQRT(T)).       1385D
C   **   IF WHB IS CHOSEN EQ.(18) OF WHB IS USED TO CALCULATE F(SQRT(T))1386D
C   **   AFTER CHANGING SQRT(T) TO THE FIRSOV VALUE                     1387D
C   ******************************************************************   567
C                                                                        568
      DIMENSION FA(15),ZLA(15)                                           569
C                                                                        570
      COMMON/C JOGIB/ ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),       1389D
     1 EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),          1390D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG           1391D
C   ..................................................................   571
      DATA ZLA/ -2.69897,-2.39794,-2.   ,-1.69897,-1.39794,-1.,-.823909, 1182D
     1  -.69897,-.39794,0.,.30103,.60206,1.,1.30103,1.60206/             1183D
C                                                                        1184D
      DATA  FA/   .162,.209,.280,.334,.383,.431,.435,.428,.385,.275,     1185D
     1   .184,.107,.050,.025,.0125/                                      1186D
C   ..................................................................   581
C                                                                        582
      DATA A/.56258/,B/1.1776/,C/.62680/                                 1393D
      DATA EX1/1.62680/,EX2/2.62680/                                     1394D
C                                                                        1395D
      IF(IS.EQ.1)GO TO 5                                                 1396D
C                                                                        1397D
      IF(Z .LT. .002) GOTO 1                                             583
      IF (Z .GT. 40.) GOTO2                                              584
      ZL=ALOG10(Z)                                                       585
      CALL   TERP 4A(ZL,FTOH,ZLA,FA,15,LOOK)                             586
      RETURN                                                             587
 1    FTOH=1.43 * Z** .35                                                588
      RETURN                                                             589
 2    FTOH= .5 / Z                                                       590
      RETURN                                                             591
C                                                                        1399D
    5 ZFIRS=Z/CWHBN                                                      1400D
      X=B*ZFIRS                                                          1401D
      IF(ZFIRS.LT.0.83.OR.ZFIRS.GT.0.87)GO TO 10                         1402D
      Y=X-1                                                              1403D
      FTOH=A*(0.5+(C-2)*Y/6)                                             1404D
      RETURN                                                             1405D
   10 ENUM=X**EX1-1-EX1*ALOG(X)                                          1406D
      DENOM=X**EX2-2*X+X**(-C)                                           1407D
      FTOH=A*ENUM/DENOM                                                  1408D
      RETURN                                                             1409D
      END                                                                592
      FUNCTION G(R)                                                      593
C     FCN 307   P2.02          G(R)                                      594
C                                                                        595
C   ******************************************************************   596
C   **   THIS ROUTINE SUPPLIES THE INTEGRAND OF EQ. (5) OF THE LONG     597
C   **   WRITE-UP.  THE GAUSSIAN F(XPRIME) OF EQ. (3) IS CALCULATED     598
C   **   WITHIN THE ROUTINE AND SL(E1(XPRIME-X)) TIMES DR/DXPRIME       599
C   **   IS INTERPOLATED FROM THE SCOX TABLE SUPPLIED BY THE REPLAC     600
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C    **   SUBROUTINE.
C    ***************************************************************
C
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON /C 63C/ RB,C1,C2,X
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
     1TALC,NTALC
C
      M=NJOGIB
      MMO=M-1
      R2=((R-X)/R)*RB
      IF (R2 .GE. 0)  GO TO 100
   40 G=0
      RETURN
C
  100 Y=R-RB
      Y=Y*Y/C2
      IF (Y .GT. 12.5)  GO TO 40
      F1=C1*EXP(-Y)
      IF (R2 .GE. RNP(1))  GO TO 200
      S2=SCOX(1)*(R2-RNP(2))/(RNP(1)-RNP(2))+
     1   SCOX(2)*(R2-RNP(1)) /(RNP(2)-RNP(1))
      GO TO 400
  200 IF (R2 .LE. RNP( M )) GO TO 300
      S2=SCOX(MMO)*(R2-RNP( M ))/(RNP(MMO)-RNP( M ))
     1  SCOX( M )*(R2-RNP(MMO))/(RNP( M )-RNP(MMO))
      GO TO 400
  300 CALL   TERP4A(R2,S2,RNP,SCOX, M ,NNNNNN)
  400 G=F1*S2
      RETURN
      END
      FUNCTION GAUS 16 (A,B,FUNC)
C     FCN 312   P1.02          GAUS 16
C
C    ***************************************************************
C    **   GAUS 16 RETURNS THE INTEGRAL(A,B).
C    **   THE ARRAYS X AND W ARE THE ABSCISSAS AND WEIGHT FACTORS FOR
C    **   16 POINT GAUSSIAN QUADRATURE.  SEE AB(25.4.30) AND
C    **   AB(TABLE 25.4).
C    ***************************************************************
C
C
      DIMENSION  X(8),W(8)
C
C    ...............................................................
      DATA X/9.501250984E-2,.2816035508,.45801677777,.6178762444,
     1 .7554044084,.8656312024,.9445750231,.9894009350/
C
      DATA  W/
     1      .1894506105,.1826034150,.1691565194,.1495959888,.1246289713,
     2 9.515851168E-2,6.225352394E-2,2.715245941E-2/
C    ...............................................................
C
      C=(B-A)/2.
      D=(B+A)/2.
      SUM=0
      DO 1 I=1,8
      Y=C*X(I)
```

```
      Y1=Y+D
      Y2=-Y+D
    1 SUM= SUM + W(I)* ( FUNC(Y1) + FUNC(Y2) )
      GAUS 16= C* SUM
      END
      FUNCTION GRAN(Q)
C     FCN 309   P1.03          GRAN
C
C    ******************************************************************
C    **   THIS FUNCTION SUPPLIES THE INTEGRAND OF EQ.( 6).  THE ODD
C    **   COMBINATION OF VARIABLES APPEARING HERE IS DUE TO A CHANGE OF
C    **   VARIABLES USED IN EQ.( 6) TO IMPROVE THE ACCURACY OF THE
C    **   NUMERICAL INTEGRATION.
C    **   ETA(Z) IS AN ARITHMETIC STATEMENT FUNCTION THAT SUPPLIES THE
C    **   THE FUNCTION ETA(Z) OF EQ. (7),  IT IS TAKEN FROM
C    **   EQS. (4.5)-(4.9) OF ROBINSON(ROB).
C    ******************************************************************
C
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)
C
      ETA(Z)= 1./(1.  +AK*(Z+3.4008*(Z**(1./6.))+.40244*(Z**0.75)))
C
      EX=EXP(Q)
      T=EX-1.
      Z=ARG*T*T
      GRAN=EX*FTOH(T)*ETA(Z)
      END
      FUNCTION LAGR15  (GAMMA,B,FUNC)
C     FCN 301   P1.02          LAGR15
C
C    ******************************************************************
C    **   THIS FUNCTION RETURNS THE FOLLOWING---
C    **   LAGR15 .EQ. THE INTEGRAL(0,INFINITY) OF FUNC( (X/GAMMA)+B)
C    **   DIVIDED BY GAMMA.
C    **   THE PROCEDURE IS A 15 POINT LAGUERRE-GAUSS QUADRATURE, WHICH
C    **   IS DESCRIBED, FOR INSTANCE, IN AB(25.4.45).
C    **   THOUGH GAMMA WOULD BE AN ARBITRARY PARAMETER IF THE INTEGRATION
C    **   WERE PERFORMED EXACTLY, IT IS SET SO AS TO IMPROVE THE
C    **   ACCURACY OF THE NUMERICAL EVALUATION.  THE ARRAYS X AND WE ARE
C    **   THE ABSCISSAS AND WEIGHT FACTORS FOR THE LAGUERRE INTEGRATION,
C    **   TAKEN FROM AB(TABLE 25.9).
C    ******************************************************************
C
         REAL LAGR15
C
      DIMENSION X(15),WE(15)
C
C    ..................................................................
      DATA       X   /    0.093307812017,0.492691740302,1.215595412071,
     1 2.269949526204,3.667622721751,5.425336627414,7.565916226613,
     2 10.120228568019,13.130282482176,16.654407708330,20.776478899449,
     3 25.623894226729,31.407519169754,38.530683306486,48.026085572686/
C
      DATA          WE  /    0.239578170311, 0.560100842793,
     1 0.887008262919, 1.22366440215, 1.57444872163, 1.94475197653,
     2 2.34150205664, 2.77404192683, 3.25564334640, 3.80631171423,
     3 4.45847775384, 5.27001778443, 6.35956346973, 8.03178763212,
     4 11.5277721009/
C    ..................................................................
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C                                                                       729
C                                                                       731
      SUM=0                                                             732
      DO 100 I=1,15                                                     733
  100 SUM=SUM+WE(I)*FUNC(X(I)/GAMMA+B)                                  734
      LAGR  15=SUM/GAMMA                                                735
      RETURN                                                            736
      END                                                               737
      SUBROUTINE PUTOUT(MODE)                                           738
C     SUB 307   P1.10          PUTOUT                                   12C
C                                                                       740
C   ******************************************************************  741
C   **   ALL OF THE OUTPUT FOR THE E DEP1 SYSTEM IS HANDLED BY THIS     742
C   **   SUBROUTINE.  THE VARIOUS CALLS OF THIS ROUTINE, DEPENDING ON   743
C   **   THE VARIABLE MODE, ARE DESCRIBED BELOW---                      744
C   **   MODE .EQ. 1, INITIAL OUPUT, PARAMETERS, ETC.                   745
C   **   MODE .EQ. 2, A HEADER SAYING THAT ONLY JOGIBB WILL BE PRINTED. 746
C   **   MODE .EQ. 3, JOGIBB AND REPLAC OUTPUT.                         747
C   **   MODE .EQ. 4, ERROR SIGNAL FROM THE INTERPOLATION ROUTINE.      748
C   **   MODE .EQ. 5, DUMMY MODE, USED AT NRL FOR PLOT CALLS.           749
C   **   MODE .EQ. 6, OUTPUT OF STRAGL.                                 750
C   **                                                                  751
C   **   ALL OF THE COMMON FIELDS IN THE SYSTEM, EXCEPT CM5 AND B52,    752
C   **   ARE DESCRIBED BELOW.  THE OTHER TWO ARE DESCRIBED IN JOGIBB.   753
C   ******************************************************************  754
C                                                                       755
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX( 3)                        756
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAM,DNU,  1050D
     1RMS,RMSNU,SKEW,SKNU,CURT,CUNU,NDXA                                1051D
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),      1052D
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),          1053D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG          1054D
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,  1055D
     1TALC,NTALC                                                        1056D
      COMMON /C 63C/ RB,C1,C2,X                                          764
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,             765
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)                        1429D
      COMMON/CJEW/YPERP(400)                                            1058D
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)          719D
C                                                                       767
C   ******************************************************************  768
C   **                DESCRIPTION OF THE COMMON VARIABLES               769
C   **   DELTA IS THE SPACING OF THE STORED VALUES OF THE DEPTH         770
C   **   VARIABLE X.                                                    771
C   **   NERR IS AN ERROR CODE FOR TERP4A.  LIX IS DESCRIBED IN THE     772
C   **   INPUT SECTION OF E DEP1.                                       773
C   **                                                                  774
C   **   EZ IS THE BEAM ION ENERGY.  NDXA IS THE NUMBER OF POINTS (IN X) 775
C   **   FOR WHICH SB(X) AND SD(X) ARE EVALUATED--THESE POINTS ARE      776
C   **   STORED IN XVAR.  SBB AND SBNU ARE SB (EQ.(4)) AND              777
C   **   SD (EQ.(5)), RESPECTIVELY.                                     1243D
C   **   EBARE, DAMDAM, RMS, SKEW AND CURT ARE THE TOTAL ENERGY         779
C   **   DEPOSITED, AVERAGE DEPTH OF DEPOSITED ENERGY, SPREAD, SKEWNESS 780
C   **   AND KURTOSIS FOR THE SB(X) DISTRIBUTION, RESPECTIVELY.         781
C   **   ENU, DNUDNU, RMSNU, SKEWNU AND CURTNU ARE THE EQUIVALENT       782
C   **   QUANTITIES FOR THE SD(X) DISTRIBUTION.                         783
C   **                                                                  784
C   **   ZONE AND AONE ARE THE CHARGE AND MASS(AMU) OF THE BEAM ION.    785
C   **   ZTWO(I) AND ATWO(I), I .EQ. 1,...,NTWO, ARE THE CHARGE AND MASS 786
C   **   OF EACH OF THE NTWO COMPONENTS OF THE TARGET MATERIAL.  THE    787
```

```
C     **    DENSITY(ATOMS/CC) FOR THE I TH COMPONENT IS DENS(I).  THE
C     **    ELECTRONIC STOPPING PARAMETER FOR THE BEAM ION-I TH TARGET
C     **    COMPONENT PAIR IS AKSTOP(I).
C     **
C     **    FOR EACH ELEMENT EMEV(I) OF THE ARRAY EMEV, I .EQ. 1,...,
C     **    NJOGIB, THERE CORRESPONDS AN ELEMENT OF EACH OF THE SIX
C     **    FOLLOWING ARRAYS.  THESE CORRESPONDING ELEMENTS ARE,
C     **    RESPECTIVELY, THE AVERAGE PROJECTED RANGE, THE RMS PROJECTED
C     **    RANGE, THE AVERAGE TOTAL RANGE, THE RMS TOTAL RANGE, SN AND
C     **    SE.  NOTE THAT HERE SN AND SE ARE CONSIDERED AS FUNCTIONS OF
C     **    THE ION ENERGY, RATHER THAN OF THE RESIDUAL RANGE.
C     **    SEE THE DISCUSSION FOLLOWING EQ.(4) OF THE LONG WRITE-UP.
C     **    E ERR IS A JOHNSON-GIBBONS PARAMENTER WHOSE USE IS DESCRIBED
C     **    IN THE LW-U.  EMAX IS AN INPUT PARAMETER.  THE JOGIBB
C     **    TABLES ARE FILLED UP TO AN ENERGY, AND CORRESPONDING NJOGIB,
C     **    SUCH THAT EMEV(NJOGIB) .GE. EMAX.
C     **
C     **    ANSCOR IS THE FUNCTION SL OF EQ.(6), AGAIN EXPRESSED AS A
C     **    FUCNTION OF THE ENERGY INSTEAD OF THE RANGE.
C     **    DERV IS DR/DX, THAT IS, THE DERIVATIVE OF THE TOTAL RANGE WITH
C     **    RESPECT TO THE PROJECTED RANGE.  ANSX IS ANSN TIMES DERV AND
C     **    SCOX IS DERV TIMES ANSCOR.
C     **    CUTOFF IS THE ENERGY CUTOFF, T1, USED IN THE EVALUATION OF
C     **    EQ.(6).  WE USUALLY TAKE CUTOFF=0.
C     **    FOR A GIVEN BEAM ION ENERGY, INTERPOLATIONS ARE MADE IN THE
C     **    JOHNSON-GIBBONS TABLES TO OBTAIN THE RMS SPREAD IN THE
C     **    PROJECTED RANGE(ALPHA) AND THE RMS SPREAD IN THE TOTAL
C     **    RANGE(TALC).  NTALC IS SET TO 1.  IF TALC IS GREATER THAN
C     **    ALPHA, THE TWO ARE INTERCHANGED AND NTALC IS SET TO 2.
C     **    THE REASON FOR THIS CHANGE IS GIVEN IN THE LONG WRITE-UP.
C     **
C     **    RB, C1 AND C2 ARE RELATED TO THE PARAMETERS APPEARING
C     **    IS EQUATION (2) OF THE LONG WRITE-UP--
C     **    C1=1/(ALPHA*SQRT(2*PI)),
C     **    C2=2*ALPHA**2.
C     **
C     **    ARG IS THE ARGUEMENT THAT REPLAC USES WHEN IT CALLS THE
C     **    FUNCTION GRAN (THIS CALL IS IMPLICIT IN THE CALL TO GAUS16).
C     **    ZAVE AND AAVE ARE THE DENSITY WEIGHTED CHARGE AND MASS FOR THE
C     **    TARGET MATERIAL.  AK IS THE ELECTRONIC STOPPING PARAMETER,
C     **    GIVEN BY EKTARG. RHO IS THE OVERALL DENSITY
C     **    OF THE TARGET.  XLIND, ELIND AND GLIND ARE THE LINDHARD UNITS
C     **    OF LENGTH AND ENERGY AND THE KINEMATICAL FACTOR GIVING THE
C     **    MAXIMUM ENERGY TRANSFER IN A BEAM ION-PKA COLLISION.  THE
C     **    EQUIVALENT  QUANTITIES FOR EACH TARGET COMPONENT ARE LOCATED
C     **    IN THE THREE ARRAYS THAT FOLLOW GLIND.
C     ***********************************************************************
C
C     .......................................................................
C     ..    NOTE THAT THE FOLLOWING FORTRAN STATEMENT, WHICH DEFINES THE
C     ..    OUTPUT UNIT, IS SPECIFIC TO THE PARTICULAR COMPUTER BEING USED.
C     ..    IT SHOULD BE CHECKED BY EACH USER.
      NOUT=6
C     .......................................................................
C
      GO TO (1000,1500,1700,2810,2900,3000),MODE
C
 1000 WRITE (NOUT,1140) LIX
 1140 FORMAT(//67H THE PARAMETER SET THAT CONTROLS THE RUNNING OF THE CO
     1DE IS LIX(3)=,3I4///)
```

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C                                                                       848
      WRITE (NOUT, 1160)  ZONE,AONE                                     849
 1160 FORMAT (35H BEAM AND TARGET CHARACTERISTICS---/                   850
     1 25X,6HCHARGE,6X,4HMASS,7X,7HDENSITY,8X,1HK,6X,7HK VALUE,5X,     1436D
     2 6HX LIND,6X,6HE LIND,6X,6HX FIRS,6X,6HE FIRS,/                  1437D
     3 36X,5H(AMU),4X,10H(ATOMS/CC),15X,8HGIVEN BY,3X,9H(MICRONS),     1438D
     4 5X,5H(KEV),5X,9H(MICRONS),5X,5H(KEV),/                          1439D
     5 18H INCOMING BEAM ION,5X,F4.0,7X,F7.3)                          1440D
C                                                                       1441D
      WRITE (NOUT,1180) (I,ZTWO(I),ATWO(I),DENS(I),AKSTOP(I),AKLIST(I), 1442D
     1         XLIN(I),ELIN(I),XFIRS(I),EFIRS(I),I=1,NTWO)             1443D
 1180 FORMAT(17H TARGET COMPONENT,I2,4X,0PF4.0,7X,F7.3,3X,1PE11.4,     1444D
     1 3X,E11.4,3X,A4,5X,0PF9.6,3X,3PF9.3,3X,0PF9.6,3X,3PF9.3)          1445D
C                                                                       1446D
      IF(ITARG.EQ.0)GO TO 1182                                          1447D
      AKSUB(1)=AK4(1)                                                   1448D
      AKSUB(2)=AK4(2)                                                   1449D
      GO TO 1185                                                        1450D
 1182 AKSUB(1)=AK5(1)                                                   1451D
      AKSUB(2)=AK5(2)                                                   1452D
C                                                                       1453D
 1185 WRITE (NOUT,1190) ZAVE,AAVE,RHO,AK,AKSUB,XLIND,ELIND              1454D
 1190 FORMAT(18H SUBSTRATE AVERAGE,5X,F8.3,3X,F7.3,3X,1PE11.4,3X,       1455D
     1 E11.4,3X,2A4,1X,0PF9.6,3X,3PF9.3,/,                             1456D
     2 4X,11HFOR EQ.(7),///)                                           1457D
      X=0.024801*AONE*(ZONE**(4./3.))                                   864
      WRITE (NOUT,1200) X                                               865
 1200 FORMAT ( 51H K IS THE ELECTRONIC STOPPING PARAMETER OF EQ.(14)./  866
     1100H THIS ELECTRONIC STOPPING LAW REQUIRES THAT THE BEAM ION ENERG 867
     2Y BE LESS THAN ELIM, GIVEN BY EQ.(15)./                           868
     3 46H FOR THE BEAM AND TARGET JUST DESCRIBED, ELIM=,               869
     4F9.3,5H MEV.///)                                                  870
      WRITE(NOUT,1220)                                                  733D
 1220 FORMAT(27H NOTATION IN COLUMN 6 ABOVE,//,5X,81HUSER - POSITIVE K V 734D
     2ALUE HAS BEEN INPUT ON DATA CARD. PROGRAM HAS USED THIS VALUE.,//, 735D
     3 6X,75HLSS - PROGRAM HAS COMPUTED K VALUE ACCORDING TO THE LSS EXP 736D
     4RESSION EQ.(10).,/,14X,107HEITHER NEGATIVE K VALUE HAS BEEN INPUT 737D
     5ON DATA CARD OR Z VALUES ARE NOT COVERED BY LAND AND BRENNAN TABLE 738D
     6S.,/)                                                             739D
      WRITE(NOUT,1240)                                                  740D
 1240 FORMAT(7X,104HLB - ZERO K VALUE HAS BEEN INPUT ON DATA CARD. PROGR 741D
     2AM HAS SUPPLIED K VALUE ACCORDING TO TABLES GIVEN BY,/,14X,114HD. 742D
     3LAND AND J. BRENNAN, ATOMIC DATA AND NUCLEAR TABLES VOL. 22, (1978 743D
     4), PP. 235 - 247, AND SUBSEQUENT NSWC REPORT.,/)                 1460D
      WRITE(NOUT,1260)                                                  1461D
 1260 FORMAT(2X,116HSUB(LB) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO 1462D
     1 EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).,/ 1463D
     3 14X,112HLAND-BRENNAN VALUES ARE USED WHENEVER POSSIBLE. IF THE PA 1464D
     4RTICULAR COMBINATION IS NOT IN THE LAND-BRENNAN TABLES,/,         1465D
     5 14X,25HTHEN LSS VALUES ARE USED.,/)                              1466D
      WRITE(NOUT,1280)                                                  1467D
 1280 FORMAT(1X,116HSUB(LSS) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO 1468D
     1 EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).,/ 1469D
     314X,102HTHE USER HAS SELECTED THE LSS OPTION FOR ALL BEAM-TARGET C 1470D
     4OMBINATIONS, AND LSS VALUES ARE USED IN THIS,/,                   1471D
     514X,26HSUBSTRATE AVERAGE AS WELL.,///)                            1472D
      WRITE(NOUT,1285)                                                  1473D
 1285 FORMAT(95H X LIND IS THE LINDHARD DISTANCE UNIT USED BY LSS (DANSK 1474D
     2E VIDENSKAB. SELSKAB 33, NO.14 (1963)).,//,                       1475D
     3 48H E LIND IS THE LINDHARD ENERGY UNIT USED BY LSS.,//,          1476D
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     4 85H X FIRS IS THE FIRSOV DISTANCE UNIT USED BY WHB (PHYS. REV. B,   1477D
     5 VOL.15 P.2458 (1977)).,//,                                          1478D
     6 46H E FIRS IS THE FIRSOV ENERGY UNIT USED BY WHB.,///)              1479D
      WRITE (NOUT,1300) CUTOFF                                               871
 1300 FORMAT ( 46H THE ENERGY CUTOFF APPEARING IN EQ.(10) IS T1=,            872
     16PF8.0,4H EV.)                                                         873
      IF(IS.EQ.1)GO TO 1400                                                  25D
      WRITE(NOUT,1350)                                                       26D
 1350 FORMAT(///,77H ELASTIC COLLISIONS ARE CALCULATED ACCORDING TO LIND     27D
     2HARD,NIELSEN,AND SCHARFF,,/,50H MATT.-FYS. MEDD. VOL.36, NO.10, (1     28D
     3968), TABLE 2B.)                                                       29D
      GO TO 1450                                                             30D
 1400 WRITE(NOUT,1425)                                                       31D
 1425 FORMAT(///,77H ELASTIC COLLISIONS ARE CALCULATED ACCORDING TO WILS     32D
     2ON,HAGGMARK,AND BIERSACK,,/,75H PHYS. REV. B, VOL 15, P.2458 (1977     33D
     3), USING EQUATIONS (14) AND (16) AND THE,/,58H AVERAGE FITTED CONS     34D
     4TANTS GIVEN IN TABLE II OF THAT PAPER.)                                35D
C                                                                            874
C                                                                            875
C                                                                            876
 1450 RETURN                                                                 37D
C                                                                            878
C                                                                            879
 1500 WRITE (NOUT, 1600)                                                     880
 1600 FORMAT(///, 38H THIS RUN GENERATES RANGE TABLES ONLY./ 37H ENERGY      18B
     1DEPOSITION IS NOT CALCULATED.)                                         19B
C                                                                            883
C                                                                            884
 1700 WRITE (NOUT, 1900)                                                     885
 1900 FORMAT (91H1THERE FOLLOWS THE OUTPUT OF THE JOHNSON-GIBBONS SUBROU     886
     1TINE FOR THE PARAMETERS GIVEN ABOVE./                                  887
     261H UNITS OF RANGE AND ENERGY ARE MICRONS AND MEV, RESPECTIVELY. /     888
     3/21H       E = ION ENERGY./                                            889
     434H      XM = AVERAGE PROJECTED RANGE./                                390
     530H     DXM = RMS PROJECTED RANGE./                                    891
     1 24H    YPERP= LATERAL RANGE.   /                                      16C
     630H      RM = AVERAGE TOTAL RANGE./                                    892
     726H     DRM = RMS TOTAL RANGE./                                        893
     842H  SN(E) = (DE/DR)NUCLEAR, AS GIVEN BY LSS.)                         894
      WRITE (NOUT,1920)                                                      895
 1920 FORMAT (43H  SL(E) = (DE/DR)NUCLEAR, AS GIVEN BY LNST./                896
     1102H            THIS TERM IS SUPPLIED BY MANNING AND MUELLER, RATHER   897
     2 THAN BY THE JOHNSON-GIBBONS SUBROUTINE./                              898
     3106H  SE(E) = (DE/DR)ELECTRONIC.  (DE/DR)ELECTRONIC = K*SQRT(EPSIL     899
     4ON, WHERE EPSILON IS THE LSS REDUCED ENERGY./                          900
     578H            THE ELECTRONIC STOPPING PARAMETER, K, IS GIVEN ON THE   901
     6 PREVIOUS PAGE./                                                       902
     768H  DR/DX = DERIVATIVE OF TOTAL RANGE WITH RESPECT TO PROJECTED R     903
     8ANGE.//)                                                               904
 2000 WRITE (NOUT,2020) E ERR                                                905
 2020 FORMAT (                                                               906
     1120H  E ERR = A JOHNSON-GIBBONS PARAMETER.  THE TABULAR JOHNSON-GI     907
     2BBONS ENTRIES ARE UNRELIABLE FOR ENERGIES LESS THAN E ERR./            908
     322H            FOR THIS RUN/                                           909
     49H  E ERR =,F7.3,5H MEV.////)                                          910
      WRITE (NOUT,2025)                                                      911
 2025 FORMAT ( 77H NOTE--AS DESCRIBED IN THE LONG WRITE-UP, ONE SHOULD T     912
     1AKE DXM = MAX(DXM,DRM).////)                                           913
C                                                                            914
      WRITE (NOUT,2035)                                                      915
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 2035 FORMAT (7X,1HE,11X,2HXM ,10X,3HDXM , 8X,5HYPERP,                  18C
     2  11X,2HRM,10X,3HDRM,                                             19C
     310X,5HSN(E),10X,5HSL(E),10X,5HSE(E),10X,5HDR/DX)                  20C
      DO 2200 I=1,NJOGIB                                               21C
      WRITE (NOUT, 2040) EMEV(I),RNP(I),DRNP(I),YPERP(I),              22C
     2                                        RN(I),DRN(I),ANSN(I),    23C
     3ANSCOR(I),ANSE(I),DERV(I)                                        24C
 2040 FORMAT(F8.3, 5(1X,F12.7), 4(4X,E11.5) )                         767D
 2200 CONTINUE                                                         922
C                                                                      923
      WRITE (NOUT, 2320)                                               924
 2320 FORMAT (//)                                                      925
C                                                                      926
      RETURN                                                           927
C                                                                      928
C                                                                      929
 2810 WRITE (NOUT, 2820) NERR                                          930
 2820 FORMAT(18H THERE IS A NERR =,I2,64H ERROR INDICATED IN SUBROUTINE 1245D
     1IN TERP 4A, CALLED FROM STRAGGLE.)                              1246D
C                                                                     1247D
 2840 WRITE (NOUT, 2850) EZ                                           1248D
 2850 FORMAT(31H THE OFFENDING VARIABLE IS E  =,E15.7,1H.)            1249D
C                                                                      936
      RETURN                                                           937
C                                                                      938
C                                                                      939
 2900 CONTINUE                                                         940
      RETURN                                                           941
C                                                                      942
C                                                                      943
 3000 WRITE (NOUT,3020) EZ,EZ,EZ                                       944
 3020 FORMAT (1H1,3(9X,13HBEAM ENERGY =,F7.3,4H MEV)/                  945
     1/54H THE BEAM ION AND TARGET MATERIAL ARE DESCRIBED ABOVE./      946
     258H X REPRESENTS THE DEPTH(MICRONS) INTO THE TARGET MATERIAL./   947
     3106H SB(X) IS THE EFFECTIVE RATE OF ENERGY DEPOSITION AT THE DEPTH 948
     4 X ACCORDING TO EQ.(4) OF THE LONG WRITE-UP./                    949
     6 86H SD(X) IS THE EFFECTIVE RATE OF ENERGY DEPOSITION AT THE DEPTH 950
     7 X ACCORDING TO EQ. (5)./                                        951
     850H BOTH SB(X) AND SD(X) ARE IN UNITS OF MEV/MICRON. //)         952
C                                                                      953
      WRITE (NOUT,3025)                                                954
 3025 FORMAT (3(10X,1HX,6X,5HSD(X),9X,5HSB(X),7X))                    1251D
C                                                                      956
      N=NDXA/3                                                         957
      IF (3*N .EQ. NDXA)  GO TO 3030                                   958
      N=N+1                                                            959
 3030 N2=N+N                                                           960
C                                                                      961
      DO 3040 I=1,N                                                    962
      I2=I+N                                                           963
      I3=I+N2                                                          964
 3040 WRITE (NOUT,3050) XVAR(I),SBNU(I),SBB(I),XVAR(I2),SBNU(I2),SBB(I2) 965
     1,XVAR(I3),SBNU(I3),SBB(I3)                                       966
 3050 FORMAT (3(F11.4,2E13.4,7X))                                     1253D
C                                                                      968
      ALPHA=SQRT(C2/2)                                                 969
      WRITE (NOUT,3060) EZ,RB,ALPHA                                    970
 3060 FORMAT (1H0,18X,42HRANGE AND DEPOSITED ENERGY CHARACTERISTICS/  1255D
     128X,13HBEAM ENERGY =,F7.3,4H MEV////20X,                         972
     220H RANGE (STOPPED ION)/                                         973
```

```
     327X,2HXM            ,15X,F8.4,8H MICRONS/                                 974
     426X,3HDXM           ,15X,F8.4,8H MICRONS///)                              975
C                                                                               976
      WRITE (NOUT,3080) ENU,EBARE,DNU,DAM,RMSNU,RMS,SKNU,SKEW,CUNU,CURT         977
 3080 FORMAT (17H DEPOSITED ENERGY, 5X,                                         978
     1    18HSD(X) DISTRIBUTION, 5X,18HSB(X) DISTRIBUTION,                      979
     25X,12HSEE EQUATION//                                                      980
     34X,5HTOTAL,15X,F8.5,4H MEV,11X,F8.5,4H MEV,14X,4H(19)/                    21B
     44X,10HMEAN DEPTH,8X,2(F10.5,8H MICRONS,5X),9H     (20)/                  769D
     54X,13HRMS STD. DEV.,5X,2(F10.5,8H MICRONS,5X),9H     (21)/               770D
     64X,8HSKEWNESS,12X,2(F8.5,15X),7H   (22)/                                  24B
     74X,8HKURTOSIS,12X,2(F8.5,15X),7H   (23))                                  25B
C                                                                               986
 3500 RETURN                                                                    987
      END                                                                       988
      SUBROUTINE RBYRP                                                          989
C     SUB 323   P1.02          RBYRP                                            990
C                                                                               991
C    ******************************************************************         992
C    **   THIS ROUTINE PROVIDES THE DERIVATIVE OF THE TOTAL RANGE WITH          993
C    **   RESPECT TO THE PROJECTED RANGE.  TABLES OF THESE TWO RANGES ARE       994
C    **    FORMED BY THE JOGIBB SUBROUTINE.  THE DERIVATIVES ARE OBTAINED       995
C    **   BY USING THE FUNCTION FIVDIV.  DERV(1) IS A SPECIAL CASE.             996
C    **   IT IS OBTAINED BY USING A 3-POINT LAGRANGIAN FORMULA AND              997
C    **   NOTING THAT BOTH RANGES ARE ZERO FOR ZERO ENERGY.                     998
C    ******************************************************************         999
C                                                                              1000
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),            1060D
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),                1061D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG                1062D
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,        1063D
     1TALC,NTALC                                                              1064D
C                                                                               1006
      DIMENSION XAP(5),YAP(5)                                                   1007
C                                                                               1008
      XAP(1)=0                                                                  1009
      YAP(1)=0                                                                  1010
      DO 100 L=1,4                                                              1011
      XAP(L+1)=RNP(L)                                                           1012
  100 YAP(L+1)=RN(L)                                                            1013
      DERV(2)=FIVDIV(XAP,YAP,3)                                                 1014
      N=NJOGIB-2                                                                1015
      DO 200 I=3,N                                                              1016
      J=I                                                                       1017
  200 DERV(I)=FIVDIV(RNP,RN,J)                                                  1018
      Z=RNP(2)-RNP(1)                                                           1019
      DERV(1)=RN(1)*(1./RNP(1)-1./Z)+RN(2)*RNP(1)/(Z*RNP(2))                    1020
      DERV(N+1)=0.0                                                             942D
      DERV(N+2)=0.0                                                             943D
      RETURN                                                                    1021
      END                                                                       1022
      SUBROUTINE REPLAC                                                         1023
C     SUB 311   P2.04          REPLAC                                            27B
C                                                                              1025
C    ******************************************************************        1026
C    **   REPLAC SUPPLIES THE FUNCTION SL(E1) OF EQ.(6).  GIVEN THE BEAM       1027
C    **   AND TARGET CHARACTERISTICS, IT EVALUATES THE INTEGRAL                 1028
C    **   IN EQ.( 6) FOR UP TO 49 VALUES OF THE ION KINETIC ENERGY.  A          1029
C    **   TABLE OF THESE VALUES IS STORED IN THE ARRAY RESULT.  THEN, FOR       1030
C    **   EACH ELEMENT  OF THE EMEV ARRAY GENERATED BY JOGIBB, THE              1031
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C     **   CPRRESPONDING VALUE OF SL(E1) IS FOUND FROM RESULT BY
C     **   INTERPOLATION.
C     **   THESE VALUES ARE STORED IN THE ARRAY ANSCOR, WHICH PARALLELS
C     **   THE OUTPUT OF JOGIBB FOR SN(E1).
C     **   NEW ARRAYS (ANSX AND SCOX) ARE FORMED FROM ANSN AND ANSCOR BY
C     **   MULTIPLYING EACH ELEMENT OF THE OLD ARRAYS BY THE APPROPIATE
C     **   VALUE OF DR/DX.  THE VALUES OF DR/DX ARE STORED IN THE
C     **   ARRAY DERV.
C     ***********************************************************************
C
      DIMENSION EPSIL(84),RESULT(84),EPOG(84)
C
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
     1TALC,NTALC
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)
C
C     ......................................................................
      DATA EPSIL/   0.00,  0.01,  0.02,  0.05,  0.10,  0.20,  0.35,
     1              0.5,   0.7,   1.0,   2.0,   4.0,   6.5,   9.0,
     2             12.5,  16.0,  19.5,  23.0,  26.5,  30.0,  35.0,
     3             40.0,  45.0,  50.0,  60.0,  70.0,  80.0,  90.0,
     4            100.0, 120.0, 140.0, 160.0, 180.0, 200.0, 220.0,
     5            240.0, 260.0, 280.0, 300.0, 320.0, 340.0, 360.0,
     6            400.0, 440.0, 480.0, 520.0, 560.0, 600.0, 640.0,
     7      700.,    800.,    900.,   1000.,   1200.,   1400.,   1650.,
     8     1900.,   2250.,   2600.,   3000.,   3500.,   4100.,   4800.,
     9     5600.,   6400.,   7400.,   8600.,  10000.,  11500.,  13500.,
     1    15500.,  18000.,  21000.,  25000.,  29000.,  34000.,  40000.,
     2    46000.,  53000.,  60000.,  70000.,  80000.,  90000., 100000./
C     ......................................................................
C
      EXTERNAL GRAN
C
      CALL EKTARG
      DO 100 I=1,400
  100 ANSCOR(I)=0.0
      DO 120 I=1,84
  120 EPOG(I)=ALOG(1.+EPSIL(I))
C
      DO 600 N=1,NTWO
      ZIVE=ZTWO(N)
      AIVE=ATWO(N)
      RHU=DENS(N)
      CWHBN=CWHB(N)
      A=.88534138*5.2917706E-9/SQRT((ZONE**(2./3.))+(ZIVE**(2./3.)))
      BETA=A*(AIVE/(AIVE+AONE))/(ZONE*ZIVE*1.4399757E-13)
      GAMMA=4*AIVE*AONE/((AONE+AIVE)**2)
      FACTOR=A*A*RHU*GAMMA*1.E-4*3.1415927
      XLIN(N)=1./FACTOR
      ELIN(N)=1./BETA
      GLIN(N)=GAMMA
      XFIRS(N)=XLIN(N)*(CWHB(N))**2
      EFIRS(N)=ELIN(N)*CWHB(N)
      NO=84
      DEL=0.5
      RESULT(1)=0
```

```
      NIP=1
      E=0
      DO 400 I=2,84
      IF (E .LE. EMAX)  GO TO 220
      GO TO (210,420), NIP
  210 NIP=2
  220 EP=EPSIL(I)
      E=EP/BETA
      TONE=ALOG(1.+EP*SQRT(CUTOFF/(E*GAMMA)))
      ARG=GAMMA/(EP*ELIND*BETA)
      UP=EPOG(I)
C
      SUM=0
      BOT=TONE
      TOP=DEL
  300 IF (BOT .LE. TOP)  GO TO 340
      TOP=TOP+DEL
      GO TO 300
  340 SUM=SUM+GAUS 16(BOT,TOP,GRAN)
C
      DO 360 IN=1,50
      BOT=TOP
      TOP=TOP+DEL
      IF (UP .LE. TOP)  GO TO 380
  360 SUM=SUM+GAUS 16(BOT,TOP,GRAN)
      GO TO 400
  380 SUM=SUM+GAUS 16(BOT,UP,GRAN)
  400 RESULT(I)=SUM*FACTOR*E/(EP*EP)
      GO TO 440
  420 NO=I
  440 DO 500 I=1,NJOGIB
      EP=BETA*EMEV(I)
      AP=ALOG(1+EP)
      CALL   TERP 4A(AP,RESIN,EPOG ,RESULT,NO,NRESIN)
  500 ANSCOR(I)=RESIN+ANSCOR(I)
  600 CONTINUE
      CALL RBYRP
      DO 700 L=1,NJOGIB
      ANSX(L)=ANSN(L)*DERV(L)
  700 SCOX(L)=ANSCOR(L)*DERV(L)
      RETURN
      END
      SUBROUTINE RNGTBL
C
C   ******************************************************************
C   **   SUBROUTINE RNGTBL IS A DUMMY ROUTINE PUT IN FOR THE CONVENIENCE
C   **   OF THE USER WHO WANTS TO DO HIS OWN CALCULATIONS USING THE
C   **   RANGE TABLES.  IT IS CALLED BY E-DEP-1 AFTER THE CALLS TO
C   **   JOGIBB AND REPLAC, SUBROUTINES WHICH CALCULATE VARIOUS
C   **   FUNCTIONS OF THE RANGE AS A FUNCTION OF ENERGY, UP TO A
C   **   MAXIMUM ENERGY, EMAX, WHICH IS AN INPUT VALUE.
C   ******************************************************************
C
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX(3)
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAM,DNU,
     1 RMS,RMSNU,SKEW,SKNU,CURT,CUNU,NDXA
      COMMON/C JOGIB/ ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),
     1 EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF,
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     1 TALC,NTALC                                                       904D
      COMMON/C REPLA/ARG,AK,AAVE,ZAVE,RHO,XLIND,ELIND,GLIND,            905D
     1 XLIN(6),ELIN(6),GLIN(6),XFIRS(6),EFIRS(6)                        906D
      COMMON/B52/ CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX                 907D
      COMMON/CM5/SNSN(4),SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2, 908D
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),             909D
     2 IDN1(4),IDN2(4)                                                  910D
      COMMON/CJEW/YPERP(400)                                            911D
      COMMON/C 63C/RB,C1,C2,X                                           912D
      COMMON/C AK/ AKLIST(6),AK1,AK2,AK3,AK4(2),AK5(2),AKSUB(2)         913D
      RETURN                                                            914D
      END                                                               915D
      SUBROUTINE STRAGL                                                 1128
C     SUB 302   P2.04          STRAGL                                    32B
C                                                                       1130
C    ******************************************************************1131
C    **   STRAGL SUPPLIES THE FUNCTIONS SB(X) AND SD(X) BY EVALUATING  1132
C    **   THE INTEGRALS IN EQS. (4) AND (5) OF THE TEXT.   THE NUMERICAL 1133
C    **   METHODS USED ARE DESCRIBED IN THE TEXT.                      1134
C    **                                                                1135
C    **   THE SECOND SECTION OF STRAGL THEN USES THESE FUNCTIONS TO    1136
C    **   CALCULATE THE ENERGY DEPOSITED INTO NUCLEAR MOTION AND       1137
C    **   THE AVERAGE AND RMS DEPTHS OF BOTH THE DAMAGE AND THE FINAL  1138
C    **   POSITION OF THE STOPPED IONS.  THESE QUANTITIES ARE EVALUATED 1139
C    **   USING SIMPSONS RULE WITH APPROXIMATELY 100 POINTS.  IT IS    1140
C    **   CONVENIENT TO USE SIMPSONS RULE IN THIS CASE BECAUSE THE     1141
C    **   FUNCTIONS SD(X) AND SB(X) ARE AVAILABLE FOR EQUIDISTANT VALUES 1142
C    **   OF THE INDEPENDENT VARIABLE X.  ALSO, BOTH FUNCTIONS ARE SMOOTH 1143
C    **   ENOUGH THAT SIMPSONS RULE SHOULD BE ADEQUATE.                1144
C    ******************************************************************1145
C                                                                       1146
            REAL LAGR15                                                 1147
C                                                                       1148
      DIMENSION DAM(4),DNU(4)                                           1150
C                                                                       1151
      COMMON/C STRAG/ DELTA,QIX,QAX,NERR,LIX( 3)                        1152
      COMMON/C 63C/RB,C1,C2,X                                           1153
      COMMON/C DISP/EZ,XVAR(300),SBB(300),SBNU(300),EBARE,ENU,DAMDAM,  1072D
     1DNUDNU,RMS,RMSNU,SKEW,SKEWNU,CURT,CURTNU,NDXA                    1073D
      COMMON/C JOGIB /ZONE,AONE,ZTWO(6),ATWO(6),DENS(6),AKSTOP(6),     1074D
     1EMEV(400),RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),         1075D
     2 ANSE(400),E ERR,EMAX,CWHB(6),CWHBN,NJOGIB,NTWO,IS,ITARG         1076D
      COMMON/C NSCOR/ANSCOR(400),DERV(400),ANSX(400),SCOX(400),CUTOFF, 1077D
     1TALC,NTALC                                                       1078D
C                                                                       1162
      EXTERNAL  F                                                       1163
      EXTERNAL G                                                        1164
C                                                                       1165
      PI=3.141592653589793                                              1166
      TPISQ=SQRT(2.*PI)                                                 1167
      TWSQ=SQRT(2.)                                                     1168
      CALL   TERP 4A(EZ,RB,EMEV,RNP, NJOGIB,NERR)                       1169
      CALL   TERP 4B(EZ,ALPHA,EMEV,DRNP,NJOGIB,NERR)                    1170
      CALL   TERP 4B(EZ,TALC ,EMEV,DRN ,NJOGIB,NERR)                    1171
      NTALC=1                                                           1172
      IF (TALC .LT. ALPHA)  GO TO 200                                   1173
      NTALC=2                                                           1174
      X=ALPHA                                                           1175
      ALPHA=TALC                                                        1176
      TALC=X                                                            1177
```

```
  200 CONTINUE
      IF (NERR .LE. 5)  GO TO 220
      RETURN
C
  220 X=QIX*ALPHA
      RL=RB-X
      RU=RB+X
      C1=1./(TPISQ*ALPHA)
      C2=2.*ALPHA*ALPHA
      XX=X/(TWSQ*ALPHA)
      XX=0.5*ERRORC(XX)
      CALL ERCINV  (XX,YY,NUMERI )
      GAMMA=YY*TWSQ/ALPHA
      L=0
C
      XM=RB+QAX*ALPHA
      IF (DELTA .NE. 0.0) GO TO 235
      Y=XM/100.
      DO 230 I=1,4
      YY=Y*(10.**I)
      IF (YY .LT. 1.0)  GO TO 230
      NAY=YY
      YY=NAY
      DELTA=YY/(10.**I)
      GO TO 235
  230 CONTINUE
C
  235 X=0
      DX=DELTA
      K=XM/DX
      NDXA=K+1
  236 N3=NDXA/3
      IF (3*N3 .EQ. NDXA)  GO TO 238
      NDXA=NDXA+1
      GO TO 236
  238 CONTINUE
      IF (NDXA .LE. 300)  GO TO 240
      NDXA=300
  240 L=L+1
C
  360 GA =0.0
      GB  =0.0
      GC  =0.0
      GD  =0.0
      GE  =0.0
      GH  =0.0
      IF (X .GE. RU)  GO TO 400
      IF (X .GE. RL)  GO TO 380
  370 GA=GAUS16(X,RL,F)
      GB=GAUS16(RL,RU,F)
      GC=LAGR15(GAMMA,RU,F)
      GD=GAUS 16(X,RL,G)
      GE=GAUS 16(RL,RU,G)
      GH=LAG  R15(GAMMA,RU,G)
      GO TO 420
  380 GB=GAUS16(X,RU,F)
      GC=LAGR15(GAMMA,RU,F)
      GE=GAUS16(X,RU,G)
      GH=LAGR15(GAMMA,RU,G)
      GO TO 420
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  400 XX=(X-RB)/(TWSQ*ALPHA)
      XX=0.5*ERRORC(XX)
      CALL ERCINV  (XX,YY,NUMERI )
      TAMMA=YY*TWSQ/ALPHA
      GC=LAGR15(TAMMA,X,F)
      GH=LAGR15(TAMMA,X,G)
C
  420 SBB(L)=GA+GB+GC
      SBNU(L)=GD+GE+GH
      XVAR(L)=X
      X=X+DX
      IF (L .LT. NDXA)  GO TO 240
  500 CONTINUE
C
      EBARE=0.5*SBB(1)
      ENU=SBNU(1)*0.5
      DO 520 I=1,4
      DAM(I)=0
  520 DNU(I)=0
      SBB(NDXA)=0.5*SBB(NDXA)
      SBNU(NDXA)=0.5*SBNU(NDXA)
C
      DO 600 L=2,NDXA
      X=SBB(L)
      EBARE=EBARE+X
      Y=SBNU(L)
      ENU=ENU+Y
C
      DO 600 I=1,4
      Z=XVAR(L)**I
      DAM(I)=DAM(I)+X*Z
  600 DNU(I)=DNU(I)+Y*Z
C
      EBARE=EBARE*DELTA
      ENU=ENU*DELTA
      X=DELTA/EBARE
      Y=DELTA/ENU
      DO 620 I=1,4
      DAM(I)=DAM(I)*X
  620 DNU(I)=DNU(I)*Y
      SBB(NDXA)=2.0*SBB(NDXA)
      SBNU(NDXA)=2.0*SBNU(NDXA)
C
      RMS  =SQRT(DAM(2)-DAM(1)*DAM(1))
      RMSNU=SQRT(DNU(2)-DNU(1)*DNU(1))
      SKEW =(DAM(3)-3.*DAM(2)*DAM(1)+2.*(DAM(1)**3.))/(RMS**3.)
      SKEWNU=(DNU(3)-3.*DNU(2)*DNU(1)+2.*(DNU(1)**3.))/(RMSNU**3.)
      CURT  =(DAM(4)-4.*DAM(3)*DAM(1)+6.*DAM(2)*DAM(1)*DAM(1)
     1-3.*(DAM(1)**4.))/(RMS  **4.)
      CURTNU=(DNU(4)-4.*DNU(3)*DNU(1)+6.*DNU(2)*DNU(1)*DNU(1)
     1-3.*(DNU(1)**4.))/(RMSNU**4.)
      DAMDAM=DAM(1)
      DNUDNU=DNU(1)
      RETURN
      END
      SUBROUTINE   TERP 4A(X,Y,XX,YY,NU,NSET)
C     SUB 301   P1.02          TERP 4A
C
C   ****************************************************************
C   **   THIS IS A FOUR POINT LAGRANGIAN INTERPOLATION ROUTINE.
```

```
C     **    FOR EACH ELEMENT OF THE ARRAY XX THERE IS A CORRESPONDING
C     **    ELEMENT IN THE ARRAY YY, THAT IS, YY(I) .EQ. FUNCTION(XX(I)).
C     **    THIS ROUTINE RETURNS Y .EQ. FUNCTION(X).
C     **
C     **    THE NU ELEMENTS OF ARRAY XX ARE PRESUMED TO BE IN MONOTONICALLY
C     **    NON-DECREASING ORDER.  THE XX ARRAY IS SEARCHED TO FIND THE
C     **    PAIR OF ELEMENTS, XX(I) AND XX(I+1), BETWEEN WHICH THE VARIABLE
C     **    X LIES.  THESE TWO ELEMENTS, ALONG WITH XX(I-1) AND XX(I+2),
C     **    ARE USED IN THE INTERPOLATION PROCEDURE, ALONG WITH THE
C     **    CORRESPONDING ELEMENTS OF THE YY ARRAY.  SEE AB(25.2.1).
C     **
C     **    NSET SERVES AS AN ERROR AND WARNING CODE---
C     **    NSET .EQ. 1, X IDENTICALLY EQUAL TO XX(I), SOME I
C     **    NSET .EQ. 2, NORMAL RETURN
C     **    NSET .EQ. 3, XX(1) .LT. X .LT. XX(2)
C     **    NSET .EQ. 4, XX(NU-1) .LT. X .LT. XX(NU)
C     **    NSET .EQ. 5, X .LT. XX(1), Y SET TO ZERO
C     **    NSET .EQ. 6, XX(NU) .LT. X, Y SET TO ZERO
C     **    NSET .EQ. 7, INTERNAL ERROR
C     **    NSET .EQ. 8, INTERNAL ERROR
C     **
C     **    THIS ROUTINE CAN BE REENTERED AT THE ENTRY POINT LABELED
C     **    TERP 4B.  THE SAME VALUE OF X AND THE SAME XX ARRAY ARE
C     **    PRESUMED, BUT A NEW YY ARRAY (THAT IS, A NEW FUNCTION OF X)
C     **    CAN BE USED, SO THAT Y .EQ. NEW FUNCTION(X) IS RETURNED.
C     ***********************************************************************
C
      DIMENSION XX(NU),YY(NU),C(4)
      COMMON /C TERP4/ D(4),N
C
      NSET=2
      IF (X-XX(2)) 120,100,200
  100 N=2
      GO TO 500
  120 IF (X-XX(1)) 160,140,180
  140 N=1
      GO TO 500
  160 NSET=5
      Y=0
      RETURN
  180 N=2
      NSET=3
      GO TO 600
C
  200 IF (X-XX(NU-1)) 400,220,240
  220 N=NU-1
      GO TO 500
  240 IF (X-XX(NU)) 300,260,280
  260 N=NU
      GO TO 500
  280 NSET=6
      Y=0
      RETURN
  300 N=NU-2
      NSET=4
      GO TO 600
C
  400 M=NU
      MS=2
      Q=NU/5.
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C
      DIMENSION RP(150),RC(150),RR(150),RM(150),RD(150),ARHO(6),
     1AEPS(6),ANSE(6),AGAM(6),AMU(6),SNEL(150),SEEL(150),Z(6)
C
      COMMON/C JOGIB  /Z1,A1X,Z2(6),A2X(6),AN2(6),AK(6),EMEV(400),
     1  RNP(400),DRNP(400),RN(400),DRN(400),ANSN(400),AANSE(400),EERR,
     2  EMAX,CWHB(6),CWHBN,NJOGIB,N2,IS,ITARG
      COMMON/B52/  CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),
     2 IDN1(4),IDN2(4)
      COMMON/CJEW/YPERP(400)
      COMMON/C TFXS/CEPSF,CRHOF,AEPSF(6),ARHOF(6)
C
C     ******************************************************************
C     **                          COMMON
C     **   COMMON/C JOGIB/ IS DISCUSSED IN PUTOUT.
C     **   COMMON/C B52/ IS USED TO COMMUNICATE WITH TFXS.  IT IS TAKEN
C     **   DIRECTLY FROM AN UNLABELED COMMON STATEMENT IN THE JG PROGRAM,
C     **   EXCEPT THAT THE LAST VARIABLE IN THEIR COMMON IS UNUSED
C     **   IN OURS.
C     **   COMMON/CM5/ IS USED TO COMMUNICATE WITH THE JG FUNCTIONS DRPDE,
C     **   DRRDE, DRCDE, DRMDE, AND DRDDE.  THE LAST SIX VARIABLES(ARRAYS)
C     **   WERE ADDED TO FORM A LINK WITH THE FUNCTIONS DX1DE AND DX2DE,
C     **   WHICH WE FORMED OUT OF PARTS OF THE DRPDE AND DRRDE FUNCTIONS
C     **   OF JOHNSON AND GIBBONS.  SEE THE DISCUSSION IN
C     **   SUBROUTINE KUTTA.
C     ******************************************************************
C
      EXTERNAL DRPDE,DRCDE,DRRDE,DRMDE,DRDDE,DX1DE,DX2DE
C
      E=8.8541878E-12
      PI=3.1415926536
      A0=0.52917706
      Q=1.6021892E-19
C
      NO=N2
      I1=0
      DO 2 I=1,N2
      Z(I)=Z2(I)
      M(I)=A2X(I)
    2 N(I)=AN2(I)
      ZI=Z1
      MI=A1X
      DO 200 I=1,NO
      AMU(I)=M(I)/MI
      TX=ZI**(2.0/3.0)+Z(I)**(2.0/3.0)
      RTTX=SQRT(TX)
      A=A0*0.88534138*1.0E-04/RTTX
      AEPS(I)=A*M(I)*4.*PI*E*1.0E-03/(ZI*Z(I)*Q*(MI+M(I)))
      AGAM(I)=4.*MI*M(I)/(MI+M(I))**2
      ARHO(I)=N(I)*PI*A**2*AGAM(I)*1.0E-12
      ANSE(I)= AK(I)* ARHO(I) / SQRT( AEPS(I) )
      ZI1=ZI
      ZI2=Z(I)
      RTTXF=(SQRT(ZI1)+SQRT(ZI2))**(2.0/3.0)
      CWHB(I)=RTTXF/RTTX
      AF=A0*0.88534138*1.0E-04/RTTXF
      AEPSF(I)=AF*M(I)*4.*PI*E*1.0E-03/(Z(I)*ZI*Q*(MI+M(I)))
      ARHOF(I)=N(I)*PI*AF**2*AGAM(I)*1.0E-12
```

```
  200 CONTINUE                                                          1553
      EP2=0.0                                                           1554
      IX=2                                                              1555
      SNSN(4)=0.0                                                       1556
      SNSE(4)=0.0                                                       1557
      SNOM(4)=0.0                                                       1558
      SMNS(4)=0.0                                                       1559
      SOMG(4)=0.0                                                       1560
      EN=0.01                                                           1561
      DO 320 MM=1,NO                                                    1562
      CRHO=ARHO(MM)                                                     1563
      CEPS=AEPS(MM)                                                     1564
      CNSE=ANSE(MM)                                                     1565
      GAMA=AGAM(MM)                                                     1566
      MU=AMU(MM)                                                        1567
      CRHOF=ARHOF(MM)                                                  1302D
      CEPSF=AEPSF(MM)                                                  1303D
      CALL TFXS(EN,IS)                                                   39D
      SNSN(4)=SNSN(4)+NSN                                               1569
      SNSE(4)=SNSE(4)+NSE                                               1570
      SNOM(4)=SNOM(4)+MU*NOM/EN                                         1571
      SMNS(4)=SMNS(4)+MU*NSN/EN                                         1572
  320 SOMG(4)=SOMG(4)+NOM                                               1573
      IND=1                                                             1574
      RPN=0.0                                                           1575
      RCN=0.0                                                           1576
      RRN=0.0                                                           1577
      RMN=0.0                                                           1578
      RDN=0.0                                                           1579
      X1N=0.0                                                           1580
      X2N=0.0                                                           1581
      EXP1(4)=1.0                                                       1582
      EXP2(4)=1.0                                                       1583
      FRP(4)=0.0                                                        1584
      EMAX1=EMAX-1.0E-6                                                1153D
      EE=.1                                                              33C
      XN=0.0                                                            1586
      IJ=1                                                              1587
      II=1                                                              1588
      IK=1                                                              1589
      IL=10                                                             1590
      GO TO 810                                                         1591
  801 IND=10                                                             35C
      EE=1.                                                              36C
      XN=.1                                                              37C
      IJ=1                                                              1595
      II=20                                                             1596
      IK=2                                                              1597
      IL=10                                                             1598
      GO TO 810                                                         1599
 5802 IND=2                                                              39C
      EE=10.                                                             40C
      XN=20.                                                             41C
      IJ=3                                                               42C
      II=20                                                              43C
      IK=1                                                               44C
      IL=10                                                              45C
      GOTO 810                                                           46C
  802 EE=20.0                                                           1600
      IND=3                                                             1601
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      MAX=ALOG(Q)/ALOG(2.)
      IF (MAX .GE.  1)  GO TO 410
      N=0
      GO TO 450
  410 DO 440 I=1,MAX
      M=M/2
      N=M+MS
      IF (X-XX(N)) 440,500,420
  420 MS=N
  440 CONTINUE
      N=MS
  450 DO 460 I=1,20
      N=N+1
      IF (X-XX(N)) 580,500,460
  460 CONTINUE
  480 NSET=7
      RETURN
C
      ENTRY   TERP 4B (X,Y,XX,YY,NU,NSET)
      GO TO (500,700,700,700,700,280,480,480),NSET
C
  500 NSET=1
      Y=YY(N)
      RETURN
C
  580 N=N-1
  600 DO 620 I=1,4
      C(I)=XX(N+I-2)
  620 D(I)=1
      DO 640 I=1,4
      DO 640 J=1,4
      IF (I .EQ. J)  GO TO 640
      D(I)=D(I)*(X-C(J))/(C(I)-C(J))
  640 CONTINUE
C
  700 Y=0
      DO 720 I=1,4
  720 Y=Y+D(I)*YY(N+I-2)
      RETURN
      END
      SUBROUTINE JOGIBB
C     SUB 313   P1.06          JOGIBB
C
C   ******************************************************************
C   **    SUBROUTINE JOGIBB IS THE CORE OF THE JOHNSON-GIBBONS(JG)
C   **    PROGRAM FOR CALCULATING THE RANGE AND STRAGGLING OF AN ION BEAM
C   **    IN AN AMORPHOUS TARGET.  WE HAVE MADE TWO MAJOR CHANGES IN
C   **    THEIR PROGRAM---THEIRS WAS SELF-CONTAINED, WITH ITS OWN INPUT
C   **    AND OUTPUT, WHEREAS OUR VERSION IS A SUBROUTINE WITH WHICH WE
C   **    COMMUNICATE VIA COMMON STATEMENTS, AND WE HAVE EXTENDED THE
C   **    ENERGY RANGE.  IN ADDITION, WE IMPROVED THE TFXS SUBROUTINE, AS
C   **    IS NOTED IN ITS COMMENTS CARDS, AND MADE A NUMBER OF MINOR
C   **    MODIFICATIONS WHICH ARE INDICATED BELOW.
C   **
C   **    IN THE FOLLOWING DISCUSSION THE STATEMENT NUMBERS FOR BOTH THE
C   **    JG PROGRAM AND THE E-DEP-1 PROGRAM APPLY TO THE FIRST VERSION
C   **    OF E-DEP-1 (P2.00).  THEY APPLY ONLY GENERALLY TO THE PRESENT
C   **    VERSION (P5.00), SINCE SOME STATEMENTS FOR VARIABLES NOT USED
C   **    HAVE BEEN REMOVED, AND SOME FOR EXTENDING THE ENERGY UP TO
C   **    125 MEV HAVE BEEN ADDED.
```

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C     **                                                                1012D
C     **   THE LISTING PROVIDED BY JOHNSON-GIBBONS IN THEIR BOOK INDICATES   1441
C     **   A MAIN PROGRAM WITH 330 STATEMENTS, NUMBERED 2 TO 331.           1442
C     **   OF THESE WE RETAIN NUMBERS 5, 7, 10-14, 17-19, 24-32, 51,        1443
C     **   57-157, AND 177-215.  ALMOST ALL OF THOSE PAST NUMBER 215 ARE    1444
C     **   OUTPUT AND FORMAT STATEMENTS.  HEREAFTER, THE NUMBERS IN         1445
C     **   PARENTHESES ARE JG STATEMENT NUMBERS.  STATEMENTS IN OUR         1446
C     **   VERSION ARE LABELED STN-M, WHERE M IS THE NUMBER OF STATEMENTS   1447
C     **   BY WHICH THE LABELED STATEMENT PRECEEDS OR FOLLOWS FORTRAN       1448
C     **   STATEMENT NUMBER N.                                              1449
C     **   THE DATA STATEMENT (9) IS CHANGED AS DESCRIBED IN E DEP1.        1450
C     **   THE COMMON STATEMENTS ARE DISCUSSED IN PUTOUT AND BELOW.         1451
C     **   ST200-1 REPLACES (33- 50).  IT SUPPLIES THE ELECTRONIC STOPPING  1452
C     **   PARAMETER K IN THE SAME MANNER THAT FUNCTION ELSTOP DOES AND     1453
C     **   THE SAME WAY THAT JG GENERALLY DO, EXCEPT THAT THEY HAD          1454
C     **   SPECIAL PROVISIONS FOR SOME PARTICLULAR CASES.                   1455
C     **   IN OUR VERSION K IS SUPPLIED AS JUST MENTIONED, CAN BE READ IN   1456
C     **   AS AN INPUT PARAMENTER, OR CAN BE REPLACED BY AN ENTIRELY        1457
C     **   DIFFERENT ELECTRONIC STOPPING LAW BY SUBSTITUTING DIFFERENT      1458
C     **   ELSTOP, EKTARG AND ELCLAW FUNCTIONS.                             1459
C     **   MOST OF THE JG STATEMENTS DISCARDED FROM THE EARLY PART OF THE   1460
C     **   THEIR PROGRAM WERE INPUT-OUTPUT STATEMENTS.                      1461
C     **                                                                    1462
C     **   WE WILL NOW RUN THROUGH THE STATEMENTS IN OUR VERSION OF THE     1463
C     **   JOHNSON-GIBBONS PROGRAM---                                       1464
C     **   THE REAL... AND INTEGER... STATEMENTS ARE FROM JG EXCEPT THAT    1465
C     **   WE INCREASE THE NUMBER OF ALLOWED TARGET COMPONENTS FROM FOUR    1466
C     **   TO SIX.  THE DIMENSION RP... STATEMENT IS SUBSTANTIALLY THE      1467
C     **   SAME, EXCEPT FOR MINOR CHANGES IN DIMENSIONS AND IN THE NAMES    1468
C     **   OF SEVERAL VARIABLES.  THE COMMON STATEMENTS ARE DISCUSSED       1469
C     **   BELOW AND THE DATA STATEMENTS ARE DISCUSSED IN E DEP1.           1470
C     **   ST2-7 THROUGH ST2+2 ESSENTIALLY TAKE OUR VARIABLES FROM          1471
C     **   THE COMMON STATEMENTS AND TRANSFER THE VALUES TO THE JG          1472
C     **   VARIABLES.                                                       1473
C     **   ST2+3 THROUGH ST200-2 ARE FROM JG.  ST200-1 IS DISCUSSED ABOVE.  1474
C     **   ST200 THROUGH ST804-2 ARE FROM JG.                               1475
C     **   ST804-1 THROUGH ST810-1 EXTEND THE ENERGY RANGE.  THEY ARE       1476
C     **   PATTERNED AFTER JG.                                              1477
C     **   ST810 THROUGH ST605 ARE FROM JG.  NOTE THAT ST629 HAS BEEN       1478
C     **   SLIGHTLY MODIFIED, BUT PERFORMS THE SAME FUNCTION AS THE         1479
C     **   JG STATEMENT.                                                    1480
C     **   ST606 THROUGH ST637-1 PLACE OUR RESULTS INTO COMMON.  IN THE     1481
C     **   PROCESS THE ENERGY VARIABLES ARE CONVERTED FROM KEV TO MEV.      1482
C     **   ST637 TESTS A JG ERROR PARAMETER, WHICH IS PLACED IN COMMON      1483
C     **   BY ST651.  ST650+1 RETURNS IN ORDER TO CALCULATE THE RANGE AND   1484
C     **   STRAGGLING FOR THE NEXT ENERGY VALUE, UNLESS THE TEST IN         1485
C     **   ST640 HAS BEEN SATISFIED.                                        1486
C     **   ST651+1 PLACES THE NUMBER OF ENERGY VALUES IN THE JG ARRAY       1487
C     **   INTO COMMON.                                                     1488
C     ***********************************************************************1489
C                                                                           1490
      REAL NSN,NSE,NOM,MU,N(6),M(6),MI                                     1224D
      REAL IE                                                                29C
      INTEGER Z,ZI                                                         1226D
C                                                                             39B
C     ...................................................................     40B
      REAL*8 RPN,RPN1,RCN,RCN1,RRN,RRN1,RMN,RMN1,RDN,RDN1,X1N,X1N1,        1127D
     1X2N,X2N1,EXP1,EXP2,FRP,DEXP                                          1128D
C     ...................................................................     43B
C                                                                             44B
```

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```
      XN=200.0                                                          1602
      IJ=11                                                             1603
      II=25                                                             1604
      IK=1                                                              1605
      IL=10                                                             1606
      GO TO 810                                                         1607
  803 EE=50.0                                                           1608
      IND=4                                                             1609
      XN=500.0                                                          1610
      IJ=11                                                             1611
      II=20                                                             1612
      IK=1                                                              1613
      IL=10                                                             1614
      GO TO 810                                                         1615
  804 EE=50.0                                                           1616
      IND=5                                                             1617
      XN=1000.0                                                         1618
      IJ=21                                                             1619
      II=60                                                             1620
      IK=1                                                              1621
      IL=10                                                             1622
      GO TO 810                                                         1623
  806 EE=50.0                                                           1624
      IND=6                                                             1625
      XN=3000.0                                                         1626
      IJ=61                                                             1627
      II=100                                                            1628
      IK=1                                                              1629
      IL=10                                                             1630
      GOTO 810                                                          1631
 5806 EE=100.                                                           1632
      IND=7                                                             1633
      XN=5000.                                                          1634
      IJ=51                                                             1635
      II=100                                                            1636
      IK=1                                                              1637
      IL=10                                                             1638
      GO TO 810                                                         1639
 5807 IND=8                                                             1640
      EE=200.                                                           1641
      XN=10000.                                                         1642
      IJ=51                                                             1643
      II=100                                                            1644
      IK=1                                                              1645
      IL=10                                                             1646
      GO TO 810                                                         1647
 5808 IND=11                                                            791D
      EE=400.                                                           1649
      XN=20000.                                                         1650
      IJ=51                                                             1651
      II=125                                                            1652
      IK=1                                                              1653
      IL=10                                                             1654
      GO TO 810                                                         793D
 5809 IND=9                                                             794D
      EE=1000                                                           795D
      XN=50000                                                          796D
      IJ=51                                                             797D
      II=125                                                            798D
      IK=1                                                              799D
```

```
      IL=10                                                             800D
  810 H=EE/10.0                                                         1655
      DO 825 I=IJ,II                                                    1656
      DO 824 J=IK,IL                                                    1657
      SNSN(1)=SNSN(4)                                                   1658
      SNSE(1)=SNSE(4)                                                   1659
      SNOM(1)=SNOM(4)                                                   1660
      SMNS(1)=SMNS(4)                                                   1661
      SOMG(1)=SOMG(4)                                                   1662
      DO 818 K=2,4                                                      1663
      SNSN(K)=0.0                                                       1664
      SNSE(K)=0.0                                                       1665
      SNOM(K)=0.0                                                       1666
      SMNS(K)=0.0                                                       1667
  818 SOMG(K)=0.0                                                       1668
      EN=XN+0.4*H                                                       1669
      L=2                                                               1670
      GO TO 819                                                         1671
  821 EN=XN+0.4557373*H                                                 1672
      L=3                                                               1673
      GO TO 819                                                         1674
  822 EN=XN+H                                                           1675
      L=4                                                               1676
  819 DO 820 MM=1,NO                                                    1677
      CRHO=ARHO(MM)                                                     1678
      CEPS=AEPS(MM)                                                     1679
      CNSE=ANSE(MM)                                                     1680
      GAMA=AGAM(MM)                                                     1681
      MU=AMU(MM)                                                        1682
      CRHOF=ARHOF(MM)                                                  1305D
      CEPSF=AEPSF(MM)                                                  1306D
      CALL TFXS(EN,IS)                                                   41D
      SNSN(L)=SNSN(L)+NSN                                               1684
      SNSE(L)=SNSE(L)+NSE                                               1685
      SNOM(L)=SNOM(L)+MU*NOM/EN                                         1686
      SMNS(L)=SMNS(L)+MU*NSN/EN                                         1687
  820 SOMG(L)=SOMG(L)+NOM                                               1688
      LL=L-1                                                            1689
      GO TO (821,822,823),LL                                            1690
  823 CALL KUTTA(RMN1,RMN,XN,DRMDE,H)                                   1691
      CALL KUTTA(RDN1,RDN,XN,DRDDE,H)                                   1692
      CALL KUTTA(X1N1,X1N,XN,DX1DE,H)                                   1693
      EXP1(1)=DEXP(X1N-X1N1)                                            1694
      EXP1(2)=EXP1(1)*0.6+0.4                                           1695
      EXP1(3)=EXP1(1)*0.54426274+0.45573726                             1696
      RPN=RPN*EXP1(1)                                                   1697
      CALL KUTTA(RPN1,RPN,XN,DRPDE,H)                                   1698
      FRP(1)=FRP(4)                                                     1699
      FRP(4)=RPN1                                                       1700
      FRP(2)=FRP(1)*0.6+FRP(4)*0.4                                      1701
      FRP(3)=FRP(1)*0.54426274+FRP(4)*0.45573726                        1702
      CALL KUTTA(RCN1,RCN,XN,DRCDE,H)                                   1703
      CALL KUTTA(X2N1,X2N,XN,DX2DE,H)                                   1704
      EXP2(1)=DEXP(X2N-X2N1)                                            1705
      EXP2(2)=EXP2(1)*0.6+0.4                                           1706
      EXP2(3)=EXP2(1)*0.54426274+0.45573726                             1707
      RRN=RRN*EXP2(1)                                                   1708
      CALL KUTTA(RRN1,RRN,XN,DRRDE,H)                                   1709
      IF (RRN-1.0E-12) 840,840,850                                      1710
  840 IF (RRN1-1.0E-12) 850,850,841                                     1711
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841 IF (XN-.0001) 850,850,842                                    1712
842 RRN1=(3*RPN1*RPN1-RCN1)/2.                                   1713
    IF (RRN1) 843,850,850                                        1714
843 RRN1=0.0                                                     1715
850 XN=XN+H                                                      1716
    RPN=RPN1                                                     1717
    RCN=RCN1                                                     1718
    RRN=RRN1                                                     1719
    RMN=RMN1                                                     1720
    X1N=X1N1                                                     1721
    X2N=X2N1                                                     1722
824 RDN=RDN1                                                     1723
    IK=1                                                         1724
    RP(I)=FRP(4)                                                 1725
    RC(I)=RCN1                                                   1726
    RR(I)=RRN1                                                   1727
    RM(I)=RMN1                                                   1728
    RD(I)=RDN1                                                   1729
    SNEL(I)=SNSN(4)                                              1730
825 SEEL(I)=SNSE(4)                                              1731
829 IF (IND .EQ. 1)  GO TO 801                                   1732
301 DO 650 I=IJ,II                                               1733
    IE=EE*I                                                      1734
    TT=RP(I)                                                     1735
    TV=(2.0*RR(I)+RC(I))/3.0-TT*TT                               1736
    TP=RM(I)                                                     1737
    TQ=RD(I)                                                     1738
    TR=SNEL(I)                                                   1739
    TS=SEEL(I)                                                   1740
    IF (TV) 601,602,602                                          1741
601 TV=-TV                                                       1742
    TV=SQRT(TV)                                                  1743
    TV=-TV                                                       1744
    GO TO 603                                                    1745
602 TV=SQRT(TV)                                                  1746
603 IF (TQ) 604,605,605                                          1747
604 TQ=-TQ                                                       1748
    TQ=SQRT(TQ)                                                  1749
    TQ=-TQ                                                       1750
    GO TO 606                                                    1751
605 TQ=SQRT(TQ)                                                  1752
606 CONTINUE                                                      48C
    W =(-RR(I) + RC(I))/3.0                                       49C
    IF(W) 607,608,608                                             50C
607 W = -W                                                        51C
    WX = SQRT(W)                                                  52C
    WX = -WX                                                      53C
    GO TO 609                                                     54C
608 WX = SQRT(W)                                                  55C
609 CONTINUE                                                      56C
    I1=I1+1                                                       57C
    EMEV(I1)= IE/ 1000.                                          1754
    RNP(I1)=TT                                                   1755
    DRNP(I1)=TV                                                  1756
    YPERP(I1) = WX                                                59C
    RN(I1)=TP                                                    1757
    DRN(I1)=TQ                                                   1758
    ANSN(I1)=TR /1000.                                           1759
    AANSE(I1)=TS /1000.                                          1760
637 IF (EP2)  651,640,640                                        1761
```

```
  640 IF (EMEV(I1) .GE. EMAX1)  GO TO 651                                1155D
  650 CONTINUE                                                            1763
      GO TO (801,802,803,804,806,5806,5807,5808,651,5802,5809),IND        802D
  651 EERR=EP2/1000.                                                      1765
      NJOGIB=I1                                                           1766
      RETURN                                                              1767
      END                                                                 1768
      SUBROUTINE KUTTA(YN1,YN,XN,FUNC,H)                                  1769
C     SUB 319   P1.03          KUTTA                                      1770
C                                                                         1771
C    ******************************************************************   1772
C    **   SUBROUTINE KUTTA AND THE SEVEN FUNCTIONS FOLLOWING IT (DRPDE,   1773
C    **   DX1DE, DRRDE, DX2DE, DRCDE, DRMDE AND DRDDE) ARE TAKEN, WITH    1774
C    **   NO SUBSTANTIAL CHANGES, FROM THE JOHNSON-GIBBONS CODE.  DX1DE   1775
C    **   AND DX2DE WERE REENTRY PORTIONS OF DRPDE AND DRRDE,             1776
C    **   RESPECTIVELY.  WE HAVE MADE THEM INTO SEPARATE SUBPROGRAMS.     1777
C    **   WE LINKED THEM TO DRPDE AND DRRDE BY ADDING THE RELEVANT        1778
C    **   VARIABLES TO THE CM5 COMMON STATEMENT.                          1779
C    ******************************************************************   1780
C                                                                         1781
C    ..................................................................   1782
      REAL*8 YN1,YN,CK1,CK2,CK3,CK4,YNT1,YNT2,YNT3                        1130D
C    ..................................................................   1784
C                                                                         1785
      CK1=H*FUNC(YN,1)                                                    1786
      YNT1=YN+0.4*CK1                                                     1787
      CK2=H*FUNC(YNT1,2)                                                  1788
      YNT2=YN+0.29697760*CK1+0.15875966*CK2                               1789
      CK3=H*FUNC(YNT2,3)                                                  1790
      YNT3=YN+0.21810038*CK1-3.05096470*CK2+3.83286432*CK3                1791
      CK4=H*FUNC(YNT3,4)                                                  1792
      YN1=YN+0.17476028*CK1-0.55148053*CK2+1.20553547*CK3+0.17118478*CK4  1793
      RETURN                                                              1794
      END                                                                 1795
      FUNCTION DRCDE(RC,IE)                                               1796
C     FCN 325   P1.02          DRCDE                                      1797
C                                                                         1798
C    ******************************************************************   1799
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                     1800
C    ******************************************************************   1801
C                                                                         1802
C    ..................................................................   1803
      REAL*8 RC,FRP                                                       1132D
C    ..................................................................   1805
                                                                          1806
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,  1807
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),               1089D
     2 IDN1(4),IDN2(4)                                                    1090D
      DRCDE=2*FRP(IE)/(SNSN(IE)+SNSE(IE))                                 1810
      RETURN                                                              1811
      END                                                                 1812
      FUNCTION DRDDE(RD,IE)                                               1813
C     FCN 327   P1.02          DRDDE                                      1814
C                                                                         1815
C    ******************************************************************   1816
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                     1817
C    ******************************************************************   1818
C                                                                         1819
C    ..................................................................   1820
      REAL*8 RD,FRP                                                       1134D
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C     ..................................................................  1135D
C                                                                          1822
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,   1823
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),              1092D
     2 IDN1(4),IDN2(4)                                                   1093D
      DRDDE=SOMG(IE)/(SNSN(IE)+SNSE(IE))**3                               1826
      RETURN                                                              1827
      END                                                                 1828
      FUNCTION DRMDE(RM,IE)                                               1829
C     FCN 326   P1.02          DRMDE                                     1830
C                                                                          1831
C    ******************************************************************  1832
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                    1833
C    ******************************************************************  1834
C                                                                          1835
C     ..................................................................  1836
      REAL*8 RM,FRP                                                      1137D
C     ..................................................................  1838
C                                                                          1839
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,   1840
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),              1095D
     2 IDN1(4),IDN2(4)                                                   1096D
      DRMDE=1.0/(SNSN(IE)+SNSE(IE))                                       1843
      RETURN                                                              1844
      END                                                                 1845
      FUNCTION DRPDE(RP,IE)                                               1846
C     FCN 321   P1.02          DRPDE                                     1847
C                                                                          1848
C    ******************************************************************  1849
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                    1850
C    ******************************************************************  1851
C                                                                          1852
C     ..................................................................  1853
      REAL*8 RP,FRP,EXP1,EXP2                                            1139D
C     ..................................................................  1855
C                                                                          1856
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,   1857
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),              1098D
     2 IDN1(4),IDN2(4)                                                   10990D
 1210 IF (IDN1(IE)) 1211,1211,1212                                         1860
 1211 DRPDE=0.0                                                            1861
      RETURN                                                              1862
 1212 DRPDE=EXP1(IE)/BETA1(IE)                                             1863
      RETURN                                                              1864
      END                                                                 1865
      FUNCTION DRRDE(RR,IE)                                               1866
C     FCN 323   P1.02          DRRDE                                     1867
C                                                                          1868
C    ******************************************************************  1869
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                    1870
C    ******************************************************************  1871
C                                                                          1872
C     ..................................................................  1873
      REAL*8 RR,FRP,EXP1,EXP2                                            1141D
C     ..................................................................  1875
C                                                                          1876
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2,   1877
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),              1101D
     2 IDN1(4),IDN2(4)                                                   1102D
 1410 IF (IDN2(IE)) 1411,1411,1412                                         1880
```

```
 1411 DRRDE=0.0                                                          1881
      GO TO 1490                                                         1882
 1412 DRRDE=2*FRP(IE)*EXP2(IE)/BETA2(IE)                                 1883
 1490 RETURN                                                             1884
      END                                                                1885
      FUNCTION DX1DE(RP,IE)                                              1886
C     FCN 322    P1.02          DX1DE                                   1887
C                                                                        1888
C    ****************************************************************   1889
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                   1890
C    ****************************************************************   1891
C                                                                        1892
C    ................................................................   1893
      REAL*8 RP,FRP,EXP1,EXP2                                           1143D
C    ................................................................   1895
C                                                                        1896
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2, 1897
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),             1104D
     2 IDN1(4),IDN2(4)                                                  1105D
      IDN1(IE)=1                                                         1900
      BETA1(IE)=SNSN(IE)+SNSE(IE)-SNOM(IE)/2                             1901
      ALPH1(IE)=SMNS(IE)/2                                               1902
      IF (BETA1(IE)-1.0E-06) 1204,1205,1205                              1903
 1204 IDN1(IE)=0                                                         1904
      DX1DE=0.0                                                          1905
      RETURN                                                             1906
 1205 DX1DE=ALPH1(IE)/BETA1(IE)                                          1907
      RETURN                                                             1908
      END                                                                1909
      FUNCTION DX2DE(RR,IE)                                              1910
C     FCN 324    P1.02          DX2DE                                   1911
C                                                                        1912
C    ****************************************************************   1913
C    **   SEE THE COMMENTS CARDS IN SUBROUTINE KUTTA.                   1914
C    ****************************************************************   1915
C                                                                        1916
C    ................................................................   1917
      REAL*8 RR,FRP,EXP1,EXP2                                           1145D
C    ................................................................   1919
C                                                                        1920
      COMMON/CM5/SNSN(4), SNSE(4),SNOM(4),SMNS(4),SOMG(4),FRP(4),EN,EP2, 1921
     1 EXP1(4),EXP2(4),ALPH1(4),BETA1(4),ALPH2(4),BETA2(4),             1107D
     2 IDN1(4),IDN2(4)                                                  1108D
      IDN2(IE)=1                                                         1924
      BETA2(IE)=SNSN(IE)+SNSE(IE)-3*SNOM(IE)/2                           1925
      ALPH2(IE)=SMNS(IE)                                                 1926
      IF (BETA2(IE)-1.0E-06) 1404,1405,1405                              1927
 1404 IDN2(IE)=0                                                         1928
      DX2DE=0.0                                                          1929
      EP2=EN                                                             1930
      RETURN                                                             1931
 1405 DX2DE=1.5*ALPH2(IE)/BETA2(IE)                                      1932
      RETURN                                                             1933
      END                                                                1934
      SUBROUTINE TFXS(E,IS)                                               43D
C     SUB 316    P1.04          TFXS                                     7A
C                                                                       1937
C    ****************************************************************  1938
C    **   THIS ROUTINE GENERATES THE FUNCTIONS S(EPSILON) AND W(EPSILON).  45D
C    **                                                                  46D
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C     **    IF EMAX IS READ IN AS NEGATIVE, IS=0, AND                          47D
C     **    THE FUNCTIONS ARE DEFINED BY EQS. (4.7)-(4.9) OF LNS AND ARE       48D
C     **    PRESENTED IN TABULAR FORM IN TABLE 2B OF THAT PAPER.               49D
C     **                                                                      1942
C     **    THIS PART IS DUE TO JOHNSON AND GIBBONS, BUT THE COMMON            51D
C     **    AND DATA STATEMENTS ARE CHANGED AS DISCUSSED ABOVE AND THERE IS   1944
C     **    THE FOLLOWING MODIFICATION OF THE ROUTINE---JOHNSON AND           1945
C     **    GIBBONS INTERPOLATE S AND W ON THE UNEVENLY SPACED DIMENSION-     1946
C     **    LESS ENERGY EPSILON.  THIS PROCEDURE INTRODUCES AN ERROR OF UP    1947
C     **    TO NINE PER CENT INTO S, FOR CERTAIN VALUES OF EPSILON.  WE       1948
C     **    MODIFIED THE PROCEDURE SO THAT THE INTERPOLATION IS ON THE        1949
C     **    MORE EVENLY SPACED VARIABLE LOG10(EPSILON), WHICH REMOVES THIS    1950
C     **    SOURCE OF ERROR.                                                  1951
C     **                                                                      1952
C     **    THE NEW STATEMENTS IN THIS ROUTINE ARE THE COMMON AND             1953
C     **    DIMENSION STATEMENTS (ARRAY ZA REPLACES ARRAY AE), STATEMENT      1954
C     **    1104 AND THE THIRD FROM LAST.                                     1955
C     **    IN TERMS OF THE ORIGINAL JG DECK, THE FOLLOWING OF THEIR          1956
C     **    STATEMEMTS REMAIN---(7-15), (18-22), (23-25), (36-45),            1957
C     **    AND (47-48).                                                      1958
C     **                                                                      1959
C     **    WE ALSO MADE A MINOR IMPROVEMENT (THE FOUR CARDS PRECEEDING       1960
C     **    STATEMENT 1110) IN THE JG INTERPOLATION PROCEDURE.                1961
C     **                                                                       53D
C     **                                                                       54D
C     **    IF EMAX IS READ IN AS POSITIVE, IS=1, AND                          55D
C     **    THE FUNCTIONS ARE DEFINED BY EQS. (14) AND (16) OF WHB.            56D
C     **    THE AVERAGE FITTED CONSTANTS GIVEN IN TABLE II OF THAT PAPER       57D
C     **    ARE USED AS THE CONSTANTS IN THE EQUATIONS.                        58D
C     ******************************************************************     1962
C                                                                            1963
      REAL MU,NSN,NOM,NSE                                                   1233D
C                                                                            1965
      DIMENSION ZA(15),AS(15),AW(15)                                         1966
C                                                                            1967
      COMMON/B52/  CRHO,CEPS,CNSE,GAMA,MU,NSN,NSE,NOM,IX                     1968
      COMMON/C TFXS/CEPSF,CRHOF,AEPSF(6),ARHOF(6)                           1308D
C                                                                            1969
C     ..................................................................     1970
      DATA ZA/  -2.69897,-2.39794,-2.   ,-1.69897,-1.39794,-1.,-.823909,    1208D
     1  -.69897,-.39794,0.,.30103,.60206,1.,1.30103,1.60206/                1209D
C                                                                           1210D
      DATA  AS/0.120,0.154.0.211,0.261,0.311,0.372,0.393,0.403,             1211D
     10.405,0.356,0.291,0.214,0.128,0.0813,0.0493/                          1212D
C                                                                           1213D
      DATA  AW/0.000097,0.00025,0.00085,0.00206,0.00479,0.0138,0.0214,      1214D
     10.0287,0.0542,0.105,0.152,0.189,0.228,0.245,0.249/                    1215D
C                                                                            60D
      DATA A/.56258/,B/1.1776/,C/.62680/                                     61D
      DATA A1/.37492/,B1/1.6119/,C1/4.9822/,D1/1.0965/                       62D
C     ..................................................................     1985
C                                                                            1986
      IF(IS.EQ.1)GO TO 1200                                                  64D
C                                                                            65D
C LNS CALCULATION                                                            66D
      EPS=CEPS*E                                                            1311D
      IF (EPS-.002) 1101,1101,1102                                           1988
 1101 S=1.43/1.35*EPS**0.35                                                  1989
      W=1.43/3.35*EPS**1.35                                                  1990
      GO TO 1120                                                             68D
```

```
 1102 IF (EPS-40.) 1104,1104,1103                                  1992
 1103 S=ALOG(1.294*EPS)/(2*EPS)                                    1993
      W=0.250                                                      1994
      GO TO 1120                                                    70D
 1104 Z=ALOG10(EPS)                                                1996
      DO 1106 I=IX,15                                              1997
      IF (Z-ZA(I) ) 1105,1105,1106                                 1998
 1105 IY=I                                                         1999
      GO TO 1107                                                   2000
 1106 CONTINUE                                                     2001
 1107 IX=IY                                                        2002
      IF (IX .GT. 14) IX=14                                        2003
 1108 I1=IX-1                                                      2004
      I2=IX                                                        2005
      I3=IX+1                                                      2006
      IF (IX .LT. 3) GOTO 1110                                      9A
      IF (ABS(ZA(IX-1)-Z) .GT. ABS(Z-ZA(IX))) GO TO 1110           2007
      I1=IX-2                                                      2008
      I2=IX-1                                                      2009
      I3=IX                                                        2010
 1110 X1=Z  -ZA(I1)                                                2011
      X2=Z  -ZA(I2)                                                2012
      X3=Z  -ZA(I3)                                                2013
      XD1=ZA(I1)-ZA(I2)                                            2014
      XD2=ZA(I2)-ZA(I3)                                            2015
      XD3=ZA(I3)-ZA(I1)                                            2016
      D1=XD1*(-XD3)                                                2017
      D2=(-XD1)*XD2                                                2018
      D3=XD3*(-XD2)                                                2019
      C1=X2*X3/D1                                                  2020
      C2=X1*X3/D2                                                  2021
      C3=X1*X2/D3                                                  2022
      S=C1*AS(I1)+C2*AS(I2)+C3*AS(I3)                              2023
      W=C1*AW(I1)+C2*AW(I2)+C3*AW(I3)                              2024
 1120 NSN=CRHO/CEPS*S                                             1313D
      NOM=CRHO*GAMA/(CEPS*CEPS)*W                                 1314D
      GO TO 1230                                                    72D
C                                                                   73D
C  WHB CALCULATION                                                  74D
C  USE FIRSOV UNITS RATHER THAN LSS UNITS                          1316D
 1200 EPS=CEPSF*E                                                 1317D
C  COMPUTE S                                                        75D
      U=B*EPS                                                     1319D
      DX=U-1.0                                                      77D
      IF(ABS(DX).LT.1.0E-5)GO TO 1210                               78D
      DO=U-U**(-C)                                                  79D
      S=A*ALOG(U)/DO                                                80D
      GO TO 1220                                                    81D
 1210 DNUM=A*(1.0-0.5*DX)                                           82D
      DENOM=(1.0+C)*(1.0-(C/2.0)*DX)                                83D
      S=DNUM/DENOM                                                  84D
C  COMPUTE W                                                        85D
 1220 WR=4.0+A1*EPS**(-B1)+C1*EPS**(-D1)                            86D
      W=1/WR                                                        87D
      NSN=CRHOF/CEPSF*S                                           1321D
      NOM=CRHOF*GAMA/(CEPSF*CEPSF)*W                              1322D
C  GET ELECTRONIC STOPPING CROSS SECTION                           1323D
 1230 NSE=ELCLAW(E)                                               1324D
      RETURN                                                       2028
      END                                                          2029
```

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Appendix B
SAMPLE-RUN DATA

```
0 0 1                                                                  2033
THIS IS A TEST RUN OF E-DEP-1.                                         2034
CU ON TYPE 316 STAINLESS STEEL                                         2035
10.0      0.000                                                        2036
   29.000     63.540     6                                             2037
   26.000     55.847 5.7590E22      0.00                               2038
   24.000     51.996 1.5690E22      0.00                               2039
   28.000     58.710 9.8110E21      0.00                               2040
   42.000     95.940 1.2510E21      0.00                               2041
   25.000     54.938 8.7370E20      0.00                               2042
   14.000     28.086 8.5450E20      0.00                               2043
    5.000      0.000                                                   2044
   -1.000      0.000                                                   2045
0 1 0                                                                   63C
SAMPLE RUN OF E-DEP-1 P5.00, RANGE TABLE ONLY                         1265D
ARSENIC INCIDENT ON SILICON                                             65C
 0.1                                                                    66C
     33.0     74.92      1                                             67C
     14.0     28.086   4.98E22                                         68C
1 0 0                                                                   69C
```

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Appendix C

OUTPUT USING SAMPLE-RUN DATA

E-DEP-1 VERSION P5.00 (10 OCT. 1985)
INCORPORATES REVISION DECKS A AND B, AND ADAPTATION DECKS C AND D.

THE FOLLOWING MESSAGE WAS READ IN WITH THE DATA.

THIS IS A TEST RUN OF E-DEP-1.
CU ON TYPE 316 STAINLESS STEEL

THE PARAMETER SET THAT CONTROLS THE RUNNING OF THE CODE IS LIX(3)= 0 0 1

BEAM AND TARGET CHARACTERISTICS---

	CHARGE	MASS (AMU)	DENSITY (ATOMS/CC)	K	K VALUE GIVEN BY	X LIND (MICRONS)	E LIND (KEV)	X FIRS (MICRONS)	E FIRS (KEV)
INCOMING BEAM ION	29.	63.540							
TARGET COMPONENT 1	26.	55.847	5.7590E+22	1.0107E-01	LB	0.046060	211.443	0.058023	237.317
TARGET COMPONENT 2	24.	51.996	1.5690E+22	1.0183E-01	LB	0.165803	200.316	0.208794	224.791
TARGET COMPONENT 3	28.	58.710	9.8110E+21	9.7031E-02	LB	0.276251	224.487	0.348048	251.977
TARGET COMPONENT 4	42.	95.940	1.2510E+21	1.4572E-01	LB	2.602288	288.694	3.272473	323.741
TARGET COMPONENT 5	25.	54.938	8.7370E+20	1.0362E-01	LB	3.001698	203.821	3.780747	228.747
TARGET COMPONENT 6	14.	28.086	8.5450E+20	1.0025E-01	LB	3.043445	158.966	3.806984	177.792
SUBSTRATE AVERAGE FOR EQ.(7),	25.967	55.769	8.6070E+22	1.2563E-01	SUB(LB)	0.029549	173.577		

K IS THE ELECTRONIC STOPPING PARAMETER OF EQ.(14).
THIS ELECTRONIC STOPPING LAW REQUIRES THAT THE BEAM ION ENERGY BE LESS THAN ELIM, GIVEN BY EQ.(15).
FOR THE BEAM AND TARGET JUST DESCRIBED, ELIM= 140.404 MEV.

NOTATION IN COLUMN 6 ABOVE

USER - POSITIVE K VALUE HAS BEEN INPUT ON DATA CARD. PROGRAM HAS USED THIS VALUE.

LSS - PROGRAM HAS COMPUTED K VALUE ACCORDING TO THE LSS EXPRESSION EQ.(10).
EITHER NEGATIVE K VALUE HAS BEEN INPUT ON DATA CARD OR Z VALUES ARE NOT COVERED BY LAND AND BRENNAN TABLES.

LB - ZERO K VALUE HAS BEEN INPUT ON DATA CARD. PROGRAM HAS SUPPLIED K VALUE ACCORDING TO TABLES GIVEN BY
D. LAND AND J. BRENNAN, ATOMIC DATA AND NUCLEAR TABLES VOL. 22, (1978), PP. 235 - 247, AND SUBSEQUENT NSWC REPORT.

SUB(LB) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).
LAND-BRENNAN VALUES ARE USED WHENEVER POSSIBLE. IF THE PARTICULAR COMBINATION IS NOT IN THE LAND-BRENNAN TABLES,
THEN LSS VALUES ARE USED.

SUB(LSS) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).
THE USER HAS SELECTED THE LSS OPTION FOR ALL BEAM-TARGET COMBINATIONS, AND LSS VALUES ARE USED IN THIS
SUBSTRATE AVERAGE AS WELL.

X LIND IS THE LINDHARD DISTANCE UNIT USED BY LSS (DANSKE VIDENSKAB. SELSKAB 33, NO.14 (1963)).

E LIND IS THE LINDHARD ENERGY UNIT USED BY LSS.

X FIRS IS THE FIRSOV DISTANCE UNIT USED BY WHB (PHYS. REV. B, VOL.15 P.2458 (1977)).

E FIRS IS THE FIRSOV ENERGY UNIT USED BY WHB.

THE ENERGY CUTOFF APPEARING IN EQ.(10) IS ε1= 0. EV.

ELASTIC COLLISIONS ARE CALCULATED ACCORDING TO WILSON,HAGGMARK,AND BIERSACK, PHYS. REV. B, VOL 15, P.2458 (1977), USING EQUATIONS (14) AND (16) AND THE AVERAGE FITTED CONSTANTS GIVEN IN TABLE II OF THAT PAPER.

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THERE FOLLOWS THE OUTPUT OF THE JOHNSON-GIBBONS SUBROUTINE FOR THE PARAMETERS GIVEN ABOVE.
UNITS OF RANGE AND ENERGY ARE MICRONS AND MEV, RESPECTIVELY.

```
     E = ION ENERGY.
    XM = AVERAGE PROJECTED RANGE.
   DXM = RMS PROJECTED RANGE.
 YPERP= LATERAL RANGE.
    RM = AVERAGE TOTAL RANGE.
   DRM = RMS TOTAL RANGE.
 SN(E) = (DE/DR)NUCLEAR, AS GIVEN BY LSS.
 SL(E) = (DE/DR)NUCLEAR, AS GIVEN BY LNST.
         THIS TERM IS SUPPLIED BY MANNING AND MUELLER, RATHER THAN BY THE JOHNSON-GIBBONS SUBROUTINE.
 SE(E) = (DE/DR)ELECTRONIC.  (DE/DR)ELECTRONIC = K*SQRT(EPSILON, WHERE EPSILON IS THE LSS REDUCED ENERGY.
         THE ELECTRONIC STOPPING PARAMETER, K, IS GIVEN ON THE PREVIOUS PAGE.
 DR/DX = DERIVATIVE OF TOTAL RANGE WITH RESPECT TO PROJECTED RANGE.

 E ERR = A JOHNSON-GIBBONS PARAMETER.  THE TABULAR JOHNSON-GIBBONS ENTRIES ARE UNRELIABLE FOR ENERGIES LESS THAN E ERR.
         FOR THIS RUN
 E ERR =  0.000 MEV.
```

NOTE--AS DESCRIBED IN THE LONG WRITE-UP, ONE SHOULD TAKE DXM = MAX(DXM,DRM).

E	XM	DXM	YPERP	RM	DRM	SN(E)	SL(E)	SE(E)	DR/DX
0.001	0.0017010	0.0007728	0.0007348	0.0026352	0.0009389	0.65445E+00	0.51876E+00	0.47722E-01	0.15573E+01
0.002	0.0024752	0.0010936	0.0010707	0.0038438	0.0013489	0.87882E+00	0.85084E+00	0.67488E-01	0.15540E+01
0.003	0.0031008	0.0013513	0.0013362	0.0048117	0.0016727	0.10340E+01	0.10361E+01	0.82656E-01	0.15413E+01
0.004	0.0036504	0.0015751	0.0015661	0.0056560	0.0019527	0.11544E+01	0.11141E+01	0.95443E-01	0.15313E+01
0.005	0.0041520	0.0017772	0.0017733	0.0064220	0.0022052	0.12530E+01	0.11916E+01	0.10671E+00	0.15225E+01
0.006	0.0046201	0.0019641	0.0019645	0.0071327	0.0024385	0.13365E+01	0.12684E+01	0.11689E+00	0.15145E+01
0.007	0.0050629	0.0021396	0.0021434	0.0078017	0.0026574	0.14088E+01	0.13328E+01	0.12626E+00	0.15072E+01
0.008	0.0054860	0.0023062	0.0023126	0.0084380	0.0028652	0.14724E+01	0.13860E+01	0.13498E+00	0.15004E+01
0.009	0.0058932	0.0024655	0.0024738	0.0090477	0.0030640	0.15290E+01	0.14296E+01	0.14316E+00	0.14941E+01
0.010	0.0062873	0.0026189	0.0026284	0.0096353	0.0032554	0.15799E+01	0.14653E+01	0.15091E+00	0.14882E+01
0.011	0.0066703	0.0027673	0.0027773	0.0102042	0.0034406	0.16260E+01	0.15009E+01	0.15827E+00	0.14826E+01
0.012	0.0070439	0.0029113	0.0029212	0.0107570	0.0036205	0.16680E+01	0.15383E+01	0.16531E+00	0.14773E+01
0.013	0.0074092	0.0030516	0.0030608	0.0112958	0.0037959	0.17065E+01	0.15723E+01	0.17206E+00	0.14722E+01
0.014	0.0077673	0.0031887	0.0031965	0.0118222	0.0039672	0.17419E+01	0.16026E+01	0.17856E+00	0.14674E+01
0.015	0.0081191	0.0033228	0.0033288	0.0123376	0.0041350	0.17745E+01	0.16298E+01	0.18482E+00	0.14628E+01
0.016	0.0084653	0.0034543	0.0034579	0.0128433	0.0042996	0.18048E+01	0.16539E+01	0.19089E+00	0.14584E+01
0.017	0.0088065	0.0035835	0.0035842	0.0133401	0.0044615	0.18330E+01	0.16754E+01	0.19676E+00	0.14542E+01
0.018	0.0091431	0.0037106	0.0037080	0.0138289	0.0046208	0.18592E+01	0.16943E+01	0.20247E+00	0.14501E+01
0.019	0.0094756	0.0038358	0.0038293	0.0143104	0.0047779	0.18837E+01	0.17109E+01	0.20801E+00	0.14462E+01
0.020	0.0098043	0.0039593	0.0039485	0.0147852	0.0049328	0.19066E+01	0.17255E+01	0.21342E+00	0.14424E+01
0.030	0.0129429	0.0051256	0.0050469	0.0192607	0.0063994	0.20730E+01	0.18533E+01	0.26138E+00	0.14106E+01
0.040	0.0159155	0.0062071	0.0060326	0.0234162	0.0077716	0.21687E+01	0.19107E+01	0.30182E+00	0.13860E+01
0.050	0.0188006	0.0072403	0.0069465	0.0273856	0.0090909	0.22256E+01	0.19432E+01	0.33744E+00	0.13662E+01
0.060	0.0216362	0.0082421	0.0078101	0.0312357	0.0103770	0.22587E+01	0.19575E+01	0.36965E+00	0.13497E+01
0.070	0.0244436	0.0092216	0.0086367	0.0350048	0.0116405	0.22763E+01	0.19569E+01	0.39927E+00	0.13357E+01
0.080	0.0272360	0.0101844	0.0094349	0.0387172	0.0128877	0.22832E+01	0.19503E+01	0.42683E+00	0.13235E+01
0.090	0.0300217	0.0111339	0.0102107	0.0423891	0.0141224	0.22827E+01	0.19395E+01	0.45273E+00	0.13129E+01
0.100	0.0328065	0.0120726	0.0109687	0.0460318	0.0153472	0.22768E+01	0.19244E+01	0.47722E+00	0.13035E+01
0.110	0.0355942	0.0130022	0.0117121	0.0496534	0.0165637	0.22670E+01	0.19071E+01	0.50051E+00	0.12950E+01
0.120	0.0383875	0.0139237	0.0124438	0.0532601	0.0177731	0.22544E+01	0.18885E+01	0.52276E+00	0.12874E+01

0.130	0.0411886	0.0148380	0.0131658	0.0568564	0.0189759	0.22396E+01	0.18686E+01	0.54411E+00	0.12805E+01
0.140	0.0439986	0.0157457	0.0138798	0.0604458	0.0201728	0.22233E+01	0.18479E+01	0.56465E+00	0.12743E+01
0.150	0.0468187	0.0166472	0.0145872	0.0640310	0.0213640	0.22058E+01	0.18267E+01	0.58447E+00	0.12685E+01
0.160	0.0496494	0.0175431	0.0152893	0.0676141	0.0225498	0.21876E+01	0.18057E+01	0.60364E+00	0.12632E+01
0.170	0.0524912	0.0184334	0.0159869	0.0711968	0.0237301	0.21688E+01	0.17846E+01	0.62221E+00	0.12583E+01
0.180	0.0553444	0.0193184	0.0166809	0.0747804	0.0249051	0.21496E+01	0.17635E+01	0.64025E+00	0.12537E+01
0.190	0.0582092	0.0201983	0.0173719	0.0783660	0.0260748	0.21302E+01	0.17424E+01	0.65780E+00	0.12495E+01
0.200	0.0610856	0.0210731	0.0180607	0.0819542	0.0272392	0.21107E+01	0.17215E+01	0.67488E+00	0.12455E+01
0.220	0.0668732	0.0228084	0.0194330	0.0891414	0.0295516	0.20718E+01	0.16809E+01	0.70783E+00	0.12383E+01
0.240	0.0727064	0.0245247	0.0208010	0.0963455	0.0318420	0.20333E+01	0.16423E+01	0.73930E+00	0.12319E+01
0.260	0.0785838	0.0262224	0.0221670	0.1035685	0.0341098	0.19957E+01	0.16050E+01	0.76949E+00	0.12261E+01
0.280	0.0845037	0.0279020	0.0235327	0.1108114	0.0363545	0.19590E+01	0.15691E+01	0.79853E+00	0.12209E+01
0.300	0.0904644	0.0295638	0.0248990	0.1180744	0.0385755	0.19233E+01	0.15345E+01	0.82656E+00	0.12162E+01
0.320	0.0964638	0.0312080	0.0262669	0.1253573	0.0407725	0.18888E+01	0.15012E+01	0.85367E+00	0.12118E+01
0.340	0.1024999	0.0328347	0.0276368	0.1326594	0.0429450	0.18555E+01	0.14692E+01	0.87994E+00	0.12078E+01
0.360	0.1085707	0.0344443	0.0290090	0.1399800	0.0450929	0.18233E+01	0.14384E+01	0.90545E+00	0.12040E+01
0.380	0.1146744	0.0360369	0.0303837	0.1473180	0.0472158	0.17922E+01	0.14088E+01	0.93026E+00	0.12005E+01
0.400	0.1208089	0.0376128	0.0317610	0.1546724	0.0493135	0.17622E+01	0.13803E+01	0.95443E+00	0.11972E+01
0.420	0.1269724	0.0391720	0.0331407	0.1620419	0.0513861	0.17332E+01	0.13531E+01	0.97800E+00	0.11941E+01
0.440	0.1331632	0.0407149	0.0345226	0.1694255	0.0534335	0.17053E+01	0.13275E+01	0.10010E+01	0.11912E+01
0.460	0.1393795	0.0422416	0.0359067	0.1768219	0.0554556	0.16783E+01	0.13030E+01	0.10235E+01	0.11885E+01
0.480	0.1456197	0.0437522	0.0372927	0.1842299	0.0574525	0.16523E+01	0.12795E+01	0.10455E+01	0.11858E+01
0.500	0.1518822	0.0452471	0.0386803	0.1916484	0.0594243	0.16271E+01	0.12569E+01	0.10671E+01	0.11833E+01
0.550	0.1676265	0.0489165	0.0421546	0.2102328	0.0642449	0.15679E+01	0.12040E+01	0.11192E+01	0.11776E+01
0.600	0.1834795	0.0524915	0.0456327	0.2288584	0.0689124	0.15134E+01	0.11556E+01	0.11689E+01	0.11723E+01
0.650	0.1994223	0.0559752	0.0491103	0.2475094	0.0734302	0.14630E+01	0.11112E+01	0.12167E+01	0.11675E+01
0.700	0.2154378	0.0593705	0.0525829	0.2661718	0.0778025	0.14164E+01	0.10703E+01	0.12626E+01	0.11631E+01
0.750	0.2315110	0.0626804	0.0560465	0.2848329	0.0820339	0.13731E+01	0.10325E+01	0.13069E+01	0.11590E+01
0.800	0.2476286	0.0659078	0.0594978	0.3034816	0.0861292	0.13328E+01	0.99745E+00	0.13498E+01	0.11551E+01
0.850	0.2637789	0.0690556	0.0629334	0.3221079	0.0900933	0.12951E+01	0.96503E+00	0.13913E+01	0.11515E+01
0.900	0.2799514	0.0721264	0.0663506	0.3407030	0.0939310	0.12599E+01	0.93509E+00	0.14316E+01	0.11481E+01
0.950	0.2961368	0.0751229	0.0697470	0.3592593	0.0976474	0.12268E+01	0.90718E+00	0.14709E+01	0.11449E+01
1.000	0.3123269	0.0780478	0.0731205	0.3777702	0.1012471	0.11957E+01	0.88105E+00	0.15091E+01	0.11418E+01
1.050	0.3285144	0.0809034	0.0764693	0.3962295	0.1047350	0.11663E+01	0.85653E+00	0.15464E+01	0.11389E+01
1.100	0.3446928	0.0836919	0.0797920	0.4146324	0.1081154	0.11386E+01	0.83347E+00	0.15827E+01	0.11361E+01
1.150	0.3608562	0.0864162	0.0830872	0.4329742	0.1113929	0.11124E+01	0.81174E+00	0.16183E+01	0.11335E+01
1.200	0.3769996	0.0890777	0.0863539	0.4512511	0.1145716	0.10876E+01	0.79123E+00	0.16531E+01	0.11309E+01
1.250	0.3931183	0.0916792	0.0895913	0.4694597	0.1176556	0.10640E+01	0.77184E+00	0.16872E+01	0.11284E+01
1.300	0.4092082	0.0942224	0.0927986	0.4875973	0.1206489	0.10416E+01	0.75347E+00	0.17206E+01	0.11261E+01
1.350	0.4252658	0.0967092	0.0959752	0.5056613	0.1235551	0.10203E+01	0.73605E+00	0.17534E+01	0.11238E+01
1.400	0.4412879	0.0991415	0.0991209	0.5236496	0.1263778	0.99995E+00	0.71951E+00	0.17856E+01	0.11216E+01
1.450	0.4572715	0.1015213	0.1022353	0.5415605	0.1291204	0.98054E+00	0.70379E+00	0.18172E+01	0.11195E+01
1.500	0.4732141	0.1038502	0.1053181	0.5593926	0.1317861	0.96198E+00	0.68881E+00	0.18482E+01	0.11175E+01
1.550	0.4891135	0.1061297	0.1083693	0.5771445	0.1343781	0.94422E+00	0.67453E+00	0.18788E+01	0.11155E+01
1.600	0.5049677	0.1083615	0.1113888	0.5948154	0.1368993	0.92720E+00	0.66088E+00	0.19089E+01	0.11136E+01
1.650	0.5207750	0.1105475	0.1143766	0.6124044	0.1393525	0.91089E+00	0.64784E+00	0.19385E+01	0.11118E+01
1.700	0.5365338	0.1126882	0.1173328	0.6299110	0.1417404	0.89522E+00	0.63535E+00	0.19676E+01	0.11100E+01
1.750	0.5522426	0.1147863	0.1202575	0.6473347	0.1440655	0.88017E+00	0.62338E+00	0.19963E+01	0.11083E+01
1.800	0.5679005	0.1168423	0.1231510	0.6646753	0.1463303	0.86570E+00	0.61190E+00	0.20247E+01	0.11066E+01
1.850	0.5835064	0.1188572	0.1260133	0.6819326	0.1485370	0.85176E+00	0.60088E+00	0.20526E+01	0.11050E+01
1.900	0.5990593	0.1208331	0.1288448	0.6991065	0.1506879	0.83834E+00	0.59029E+00	0.20801E+01	0.11034E+01
1.950	0.6145586	0.1227706	0.1316458	0.7161971	0.1527851	0.82539E+00	0.58010E+00	0.21073E+01	0.11019E+01
2.000	0.6300035	0.1246715	0.1344164	0.7332045	0.1548306	0.81290E+00	0.57030E+00	0.21342E+01	0.11004E+01
2.050	0.6453936	0.1265359	0.1371571	0.7501291	0.1568262	0.80084E+00	0.56086E+00	0.21607E+01	0.10990E+01
2.100	0.6607283	0.1283659	0.1398681	0.7669710	0.1587738	0.78919E+00	0.55176E+00	0.21869E+01	0.10976E+01
2.150	0.6760074	0.1301615	0.1425498	0.7837306	0.1606752	0.77792E+00	0.54298E+00	0.22128E+01	0.10962E+01
2.200	0.6912306	0.1319245	0.1452026	0.8004084	0.1625320	0.76702E+00	0.53450E+00	0.22383E+01	0.10949E+01
2.250	0.7063975	0.1336557	0.1478267	0.8170047	0.1643457	0.75646E+00	0.52631E+00	0.22636E+01	0.10936E+01
2.300	0.7215081	0.1353557	0.1504227	0.8335201	0.1661180	0.74624E+00	0.51839E+00	0.22886E+01	0.10923E+01
2.350	0.7365624	0.1370258	0.1529908	0.8499550	0.1678501	0.73633E+00	0.51073E+00	0.23134E+01	0.10911E+01

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2.400	0.7515602	0.1386661	0.1555314	0.8663102	0.1695435	0.72671E+00	0.50331E+00	0.23379E+01	0.10899E+01
2.450	0.7665014	0.1402783	0.1580448	0.8825861	0.1711996	0.71738E+00	0.49613E+00	0.23621E+01	0.10887E+01
2.500	0.7813863	0.1418625	0.1605316	0.8987834	0.1728195	0.70832E+00	0.48917E+00	0.23861E+01	0.10876E+01
2.550	0.7962148	0.1434201	0.1629920	0.9149027	0.1744045	0.69953E+00	0.48242E+00	0.24098E+01	0.10865E+01
2.600	0.8109872	0.1449509	0.1654265	0.9309447	0.1759557	0.69098E+00	0.47588E+00	0.24333E+01	0.10854E+01
2.650	0.8257034	0.1464567	0.1678354	0.9469101	0.1774743	0.68266E+00	0.46953E+00	0.24566E+01	0.10844E+01
2.700	0.8403637	0.1479373	0.1702191	0.9627994	0.1789612	0.67457E+00	0.46336E+00	0.24797E+01	0.10833E+01
2.750	0.8549684	0.1493935	0.1725780	0.9786134	0.1804176	0.66670E+00	0.45737E+00	0.25025E+01	0.10823E+01
2.800	0.8695176	0.1508263	0.1749124	0.9943529	0.1818443	0.65904E+00	0.45154E+00	0.25252E+01	0.10813E+01
2.850	0.8840116	0.1522365	0.1772228	1.0100185	0.1832422	0.65158E+00	0.44588E+00	0.25476E+01	0.10804E+01
2.900	0.8984506	0.1536238	0.1795094	1.0256108	0.1846124	0.64431E+00	0.44037E+00	0.25699E+01	0.10794E+01
2.950	0.9128349	0.1549895	0.1817726	1.0411307	0.1859556	0.63722E+00	0.43501E+00	0.25919E+01	0.10785E+01
3.000	0.9271648	0.1563339	0.1840129	1.0565789	0.1872726	0.63031E+00	0.42979E+00	0.26138E+01	0.10776E+01
3.050	0.9414406	0.1576576	0.1862305	1.0719559	0.1885643	0.62357E+00	0.42471E+00	0.26355E+01	0.10767E+01
3.100	0.9556627	0.1589607	0.1884259	1.0872626	0.1898314	0.61699E+00	0.41975E+00	0.26570E+01	0.10758E+01
3.150	0.9698314	0.1602441	0.1905993	1.1024997	0.1910746	0.61056E+00	0.41493E+00	0.26784E+01	0.10750E+01
3.200	0.9839469	0.1615088	0.1927510	1.1176679	0.1922946	0.60429E+00	0.41022E+00	0.26995E+01	0.10742E+01
3.250	0.9980097	0.1627541	0.1948815	1.1327678	0.1934921	0.59817E+00	0.40563E+00	0.27205E+01	0.10733E+01
3.300	1.0120201	0.1639815	0.1969910	1.1478002	0.1946678	0.59218E+00	0.40115E+00	0.27414E+01	0.10726E+01
3.350	1.0259786	0.1651900	0.1990800	1.1627659	0.1958222	0.58633E+00	0.39678E+00	0.27621E+01	0.10718E+01
3.400	1.0398852	0.1663821	0.2011485	1.1776654	0.1969559	0.58061E+00	0.39251E+00	0.27826E+01	0.10710E+01
3.450	1.0537406	0.1675563	0.2031971	1.1924994	0.1980696	0.57502E+00	0.38834E+00	0.28030E+01	0.10703E+01
3.500	1.0675451	0.1687141	0.2052260	1.2072686	0.1991638	0.56955E+00	0.38427E+00	0.28232E+01	0.10695E+01
3.550	1.0812989	0.1698559	0.2072354	1.2219738	0.2002390	0.56419E+00	0.38028E+00	0.28433E+01	0.10688E+01
3.600	1.0950027	0.1709814	0.2092258	1.2366155	0.2012957	0.55895E+00	0.37639E+00	0.28633E+01	0.10681E+01
3.650	1.1086565	0.1720916	0.2111975	1.2511946	0.2023344	0.55382E+00	0.37259E+00	0.28831E+01	0.10674E+01
3.700	1.1222610	0.1731861	0.2131505	1.2657115	0.2033556	0.54880E+00	0.36887E+00	0.29028E+01	0.10667E+01
3.750	1.1358165	0.1742661	0.2150854	1.2801670	0.2043598	0.54388E+00	0.36523E+00	0.29223E+01	0.10661E+01
3.800	1.1493233	0.1753304	0.2170023	1.2945616	0.2053474	0.53905E+00	0.36166E+00	0.29418E+01	0.10654E+01
3.850	1.1627818	0.1763814	0.2189014	1.3088962	0.2063189	0.53433E+00	0.35818E+00	0.29610E+01	0.10648E+01
3.900	1.1761925	0.1774182	0.2207832	1.3231711	0.2072746	0.52969E+00	0.35476E+00	0.29802E+01	0.10641E+01
3.950	1.1895556	0.1784409	0.2226479	1.3373872	0.2082149	0.52515E+00	0.35142E+00	0.29993E+01	0.10635E+01
4.000	1.2028716	0.1794512	0.2244957	1.3515449	0.2091403	0.52070E+00	0.34815E+00	0.30182E+01	0.10629E+01
4.050	1.2161409	0.1804475	0.2263267	1.3656449	0.2100511	0.51633E+00	0.34494E+00	0.30370E+01	0.10623E+01
4.100	1.2293637	0.1814318	0.2281414	1.3796879	0.2109477	0.51204E+00	0.34179E+00	0.30557E+01	0.10617E+01
4.150	1.2425406	0.1824030	0.2299399	1.3936743	0.2118304	0.50784E+00	0.33871E+00	0.30742E+01	0.10611E+01
4.200	1.2556719	0.1833618	0.2317225	1.4076048	0.2126995	0.50371E+00	0.33569E+00	0.30927E+01	0.10606E+01
4.250	1.2687578	0.1843089	0.2334894	1.4214799	0.2135555	0.49965E+00	0.33272E+00	0.31111E+01	0.10600E+01
4.300	1.2817990	0.1852437	0.2352409	1.4353004	0.2143985	0.49567E+00	0.32982E+00	0.31293E+01	0.10595E+01
4.350	1.2947955	0.1861677	0.2369771	1.4490664	0.2152290	0.49176E+00	0.32696E+00	0.31475E+01	0.10589E+01
4.400	1.3077480	0.1870799	0.2386983	1.4627789	0.2160471	0.48793E+00	0.32417E+00	0.31655E+01	0.10584E+01
4.450	1.3206567	0.1879813	0.2404047	1.4764383	0.2168533	0.48415E+00	0.32142E+00	0.31834E+01	0.10579E+01
4.500	1.3335220	0.1888705	0.2420965	1.4900451	0.2176477	0.48045E+00	0.31872E+00	0.32013E+01	0.10574E+01
4.550	1.3463441	0.1897505	0.2437740	1.5035998	0.2184307	0.47681E+00	0.31608E+00	0.32190E+01	0.10569E+01
4.600	1.3591237	0.1906193	0.2454372	1.5171030	0.2192024	0.47322E+00	0.31348E+00	0.32366E+01	0.10564E+01
4.650	1.3718607	0.1914785	0.2470866	1.5305551	0.2199633	0.46970E+00	0.31092E+00	0.32542E+01	0.10559E+01
4.700	1.3845559	0.1923264	0.2487221	1.5439568	0.2207134	0.46624E+00	0.30842E+00	0.32716E+01	0.10554E+01
4.750	1.3972094	0.1931651	0.2503441	1.5573084	0.2214530	0.46284E+00	0.30595E+00	0.32890E+01	0.10549E+01
4.800	1.4098216	0.1939940	0.2519527	1.5706106	0.2221825	0.45949E+00	0.30353E+00	0.33062E+01	0.10545E+01
4.850	1.4223927	0.1948144	0.2535482	1.5838639	0.2229019	0.45620E+00	0.30115E+00	0.33234E+01	0.10540E+01
4.900	1.4349233	0.1956241	0.2551304	1.5970685	0.2236115	0.45296E+00	0.29881E+00	0.33405E+01	0.10536E+01
4.950	1.4474136	0.1964245	0.2566999	1.6102251	0.2243115	0.44977E+00	0.29651E+00	0.33575E+01	0.10531E+01
5.000	1.4598638	0.1972167	0.2582569	1.6233342	0.2250022	0.44663E+00	0.29425E+00	0.33744E+01	0.10527E+01
5.100	1.4846457	0.1987742	0.2613334	1.6494113	0.2263562	0.44050E+00	0.28984E+00	0.34080E+01	0.10518E+01
5.200	1.5092716	0.2002971	0.2643612	1.6753036	0.2276750	0.43456E+00	0.28557E+00	0.34413E+01	0.10510E+01
5.300	1.5337441	0.2017878	0.2673417	1.7010146	0.2289600	0.42879E+00	0.28143E+00	0.34742E+01	0.10502E+01
5.400	1.5580657	0.2032453	0.2702764	1.7265477	0.2302127	0.42320E+00	0.27743E+00	0.35068E+01	0.10494E+01
5.500	1.5822386	0.2046737	0.2731660	1.7519063	0.2314343	0.41776E+00	0.27355E+00	0.35391E+01	0.10487E+01
5.600	1.6062653	0.2060720	0.2760120	1.7770935	0.2326259	0.41249E+00	0.26978E+00	0.35712E+01	0.10479E+01
5.700	1.6301482	0.2074414	0.2788154	1.8021126	0.2337889	0.40736E+00	0.26612E+00	0.36029E+01	0.10472E+01

5.800	1.6538895	0.2087829	0.2815774	1.8269666	0.2349242	0.40237E+00	0.26258E+00	0.36344E+01	0.10465E+01
5.900	1.6774915	0.2100977	0.2842989	1.8516586	0.2360329	0.39752E+00	0.25913E+00	0.36656E+01	0.10459E+01
6.000	1.7009563	0.2113869	0.2869812	1.8761914	0.2371161	0.39280E+00	0.25578E+00	0.36965E+01	0.10452E+01
6.100	1.7242862	0.2126508	0.2896248	1.9005678	0.2381745	0.38820E+00	0.25252E+00	0.37272E+01	0.10445E+01
6.200	1.7474830	0.2138911	0.2922311	1.9247905	0.2392091	0.38372E+00	0.24936E+00	0.37576E+01	0.10439E+01
6.300	1.7705491	0.2151066	0.2948007	1.9488624	0.2402209	0.37936E+00	0.24628E+00	0.37878E+01	0.10433E+01
6.400	1.7934862	0.2162998	0.2973347	1.9727859	0.2412104	0.37510E+00	0.24328E+00	0.38177E+01	0.10427E+01
6.500	1.8162965	0.2174700	0.2998337	1.9965637	0.2421786	0.37096E+00	0.24035E+00	0.38474E+01	0.10421E+01
6.600	1.8389816	0.2186192	0.3022988	2.0201981	0.2431262	0.36691E+00	0.23751E+00	0.38769E+01	0.10416E+01
6.700	1.8615437	0.2197483	0.3047308	2.0436916	0.2440539	0.36296E+00	0.23474E+00	0.39062E+01	0.10410E+01
6.800	1.8839843	0.2208559	0.3071302	2.0670466	0.2449623	0.35911E+00	0.23203E+00	0.39352E+01	0.10405E+01
6.900	1.9063056	0.2219446	0.3094979	2.0902655	0.2458521	0.35535E+00	0.22940E+00	0.39641E+01	0.10400E+01
7.000	1.9285089	0.2230147	0.3118346	2.1133502	0.2467238	0.35167E+00	0.22682E+00	0.39927E+01	0.10394E+01
7.100	1.9505962	0.2240658	0.3141410	2.1363029	0.2475781	0.34808E+00	0.22431E+00	0.40211E+01	0.10389E+01
7.200	1.9725692	0.2250977	0.3164178	2.1591260	0.2484155	0.34457E+00	0.22186E+00	0.40493E+01	0.10384E+01
7.300	1.9944293	0.2261138	0.3186657	2.1818216	0.2492366	0.34114E+00	0.21947E+00	0.40773E+01	0.10380E+01
7.400	2.0161784	0.2271122	0.3208851	2.2043912	0.2500418	0.33779E+00	0.21713E+00	0.41052E+01	0.10375E+01
7.500	2.0378180	0.2280927	0.3230769	2.2268374	0.2508317	0.33451E+00	0.21485E+00	0.41328E+01	0.10371E+01
7.600	2.0593493	0.2290586	0.3252420	2.2491615	0.2516066	0.33129E+00	0.21262E+00	0.41603E+01	0.10366E+01
7.700	2.0807741	0.2300090	0.3273801	2.2713659	0.2523672	0.32815E+00	0.21044E+00	0.41876E+01	0.10362E+01
7.800	2.1020939	0.2309431	0.3294923	2.2934520	0.2531137	0.32508E+00	0.20830E+00	0.42147E+01	0.10357E+01
7.900	2.1233101	0.2318632	0.3315791	2.3154218	0.2538466	0.32206E+00	0.20621E+00	0.42416E+01	0.10353E+01
8.000	2.1444242	0.2327663	0.3336411	2.3372772	0.2545663	0.31911E+00	0.20417E+00	0.42683E+01	0.10349E+01
8.100	2.1654372	0.2336588	0.3356786	2.3590195	0.2552732	0.31622E+00	0.20217E+00	0.42949E+01	0.10345E+01
8.200	2.1863508	0.2345347	0.3376923	2.3806508	0.2559676	0.31339E+00	0.20022E+00	0.43214E+01	0.10341E+01
8.300	2.2071662	0.2354002	0.3396826	2.4021723	0.2566499	0.31061E+00	0.19830E+00	0.43476E+01	0.10337E+01
8.400	2.2278848	0.2362504	0.3416501	2.4235859	0.2573205	0.30789E+00	0.19642E+00	0.43738E+01	0.10333E+01
8.500	2.2485080	0.2370866	0.3435948	2.4448929	0.2579796	0.30522E+00	0.19459E+00	0.43997E+01	0.10330E+01
8.600	2.2690365	0.2379128	0.3455178	2.4660950	0.2586276	0.30260E+00	0.19279E+00	0.44255E+01	0.10326E+01
8.700	2.2894721	0.2387251	0.3474191	2.4871936	0.2592647	0.30003E+00	0.19102E+00	0.44512E+01	0.10323E+01
8.800	2.3098156	0.2395247	0.3492994	2.5081899	0.2598914	0.29751E+00	0.18929E+00	0.44767E+01	0.10319E+01
8.900	2.3300683	0.2403167	0.3511588	2.5290859	0.2605077	0.29504E+00	0.18759E+00	0.45020E+01	0.10316E+01
9.000	2.3502316	0.2410933	0.3529980	2.5498824	0.2611141	0.29261E+00	0.18593E+00	0.45273E+01	0.10312E+01
9.100	2.3703063	0.2418614	0.3548169	2.5705812	0.2617107	0.29022E+00	0.18430E+00	0.45523E+01	0.10309E+01
9.200	2.3902936	0.2426163	0.3566167	2.5911832	0.2622978	0.28788E+00	0.18269E+00	0.45773E+01	0.10306E+01
9.300	2.4101944	0.2433640	0.3583969	2.6116900	0.2628757	0.28558E+00	0.18112E+00	0.46021E+01	0.10303E+01
9.400	2.4300103	0.2440967	0.3601585	2.6321030	0.2634446	0.28333E+00	0.17958E+00	0.46268E+01	0.10300E+01
9.500	2.4497416	0.2448242	0.3619013	2.6524229	0.2640047	0.28111E+00	0.17807E+00	0.46513E+01	0.10297E+01
9.600	2.4693899	0.2455399	0.3636261	2.6726513	0.2645563	0.27893E+00	0.17658E+00	0.46757E+01	0.10294E+01
9.700	2.4889562	0.2462439	0.3653329	2.6927893	0.2650995	0.27678E+00	0.17512E+00	0.47000E+01	0.10291E+01
9.800	2.5084410	0.2469419	0.3670223	2.7128379	0.2656345	0.27468E+00	0.17369E+00	0.47242E+01	0.10288E+01
9.900	2.5278456	0.2476274	0.3686943	2.7327986	0.2661617	0.27261E+00	0.17228E+00	0.47482E+01	0.00000E+00
10.000	2.5471709	0.2483072	0.3703494	2.7526722	0.2666810	0.27057E+00	0.17089E+00	0.47722E+01	0.00000E+00

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BEAM ENERGY = 5.000 MEV BEAM ENERGY = 5.000 MEV BEAM ENERGY = 5.000 MEV

THE BEAM ION AND TARGET MATERIAL ARE DESCRIBED ABOVE.
X REPRESENTS THE DEPTH(MICRONS) INTO THE TARGET MATERIAL.
SB(X) IS THE EFFECTIVE RATE OF ENERGY DEPOSITION AT THE DEPTH X ACCORDING TO EQ.(4) OF THE LONG WRITE-UP.
SD(X) IS THE EFFECTIVE RATE OF ENERGY DEPOSITION AT THE DEPTH X ACCORDING TO EQ. (5).
BOTH SB(X) AND SD(X) ARE IN UNITS OF MEV/MICRON.

X	SD(X)	SB(X)	X	SD(X)	SB(X)	X	SD(X)	SB(X)
0.0000	0.3098E+00	0.4702E+00	0.8800	0.7138E+00	0.9997E+00	1.7600	0.1858E+00	0.2239E+00
0.0200	0.3139E+00	0.4760E+00	0.9000	0.7344E+00	0.1025E+01	1.7800	0.1591E+00	0.1912E+00
0.0400	0.3182E+00	0.4819E+00	0.9200	0.7558E+00	0.1051E+01	1.8000	0.1353E+00	0.1622E+00
0.0600	0.3225E+00	0.4880E+00	0.9400	0.7779E+00	0.1078E+01	1.8200	0.1141E+00	0.1365E+00
0.0800	0.3270E+00	0.4942E+00	0.9600	0.8006E+00	0.1105E+01	1.8400	0.9560E-01	0.1141E+00
0.1000	0.3316E+00	0.5005E+00	0.9800	0.8238E+00	0.1132E+01	1.8600	0.7948E-01	0.9473E-01
0.1200	0.3363E+00	0.5071E+00	1.0000	0.8474E+00	0.1160E+01	1.8800	0.6558E-01	0.7806E-01
0.1400	0.3412E+00	0.5137E+00	1.0200	0.8711E+00	0.1188E+01	1.9000	0.5372E-01	0.6386E-01
0.1600	0.3461E+00	0.5206E+00	1.0400	0.8947E+00	0.1215E+01	1.9200	0.4368E-01	0.5186E-01
0.1800	0.3512E+00	0.5276E+00	1.0600	0.9179E+00	0.1241E+01	1.9400	0.3526E-01	0.4182E-01
0.2000	0.3565E+00	0.5348E+00	1.0800	0.9405E+00	0.1267E+01	1.9600	0.2828E-01	0.3347E-01
0.2200	0.3619E+00	0.5422E+00	1.1000	0.9621E+00	0.1290E+01	1.9800	0.2252E-01	0.2659E-01
0.2400	0.3674E+00	0.5498E+00	1.1200	0.9824E+00	0.1312E+01	2.0000	0.1779E-01	0.2097E-01
0.2600	0.3731E+00	0.5576E+00	1.1400	0.1001E+01	0.1332E+01	2.0200	0.1395E-01	0.1642E-01
0.2800	0.3790E+00	0.5657E+00	1.1600	0.1017E+01	0.1348E+01	2.0400	0.1086E-01	0.1276E-01
0.3000	0.3851E+00	0.5739E+00	1.1800	0.1031E+01	0.1361E+01	2.0600	0.8389E-02	0.9842E-02
0.3200	0.3913E+00	0.5824E+00	1.2000	0.1043E+01	0.1370E+01	2.0800	0.6431E-02	0.7535E-02
0.3400	0.3977E+00	0.5911E+00	1.2200	0.1050E+01	0.1375E+01	2.1000	0.4893E-02	0.5726E-02
0.3600	0.4044E+00	0.6001E+00	1.2400	0.1055E+01	0.1375E+01	2.1200	0.3695E-02	0.4319E-02
0.3800	0.4113E+00	0.6094E+00	1.2600	0.1055E+01	0.1370E+01	2.1400	0.2770E-02	0.3233E-02
0.4000	0.4184E+00	0.6190E+00	1.2800	0.1051E+01	0.1359E+01	2.1600	0.2060E-02	0.2402E-02
0.4200	0.4257E+00	0.6289E+00	1.3000	0.1042E+01	0.1343E+01	2.1800	0.1521E-02	0.1772E-02
0.4400	0.4333E+00	0.6391E+00	1.3200	0.1029E+01	0.1321E+01	2.2000	0.1115E-02	0.1297E-02
0.4600	0.4412E+00	0.6496E+00	1.3400	0.1012E+01	0.1294E+01	2.2200	0.8110E-03	0.9418E-03
0.4800	0.4493E+00	0.6605E+00	1.3600	0.9892E+00	0.1261E+01	2.2400	0.5855E-03	0.6790E-03
0.5000	0.4578E+00	0.6718E+00	1.3800	0.9623E+00	0.1223E+01	2.2600	0.4186E-03	0.4844E-03
0.5200	0.4666E+00	0.6835E+00	1.4000	0.9314E+00	0.1180E+01	2.2800	0.2979E-03	0.3439E-03
0.5400	0.4757E+00	0.6956E+00	1.4200	0.8968E+00	0.1133E+01	2.3000	0.2103E-03	0.2423E-03
0.5600	0.4852E+00	0.7082E+00	1.4400	0.8591E+00	0.1081E+01	2.3200	0.1473E-03	0.1694E-03
0.5800	0.4951E+00	0.7213E+00	1.4600	0.8174E+00	0.1026E+01	2.3400	0.1024E-03	0.1176E-03
0.6000	0.5055E+00	0.7348E+00	1.4800	0.7734E+00	0.9677E+00	2.3600	0.7063E-04	0.8095E-04
0.6200	0.5162E+00	0.7490E+00	1.5000	0.7270E+00	0.9076E+00	2.3800	0.4831E-04	0.5532E-04
0.6400	0.5275E+00	0.7637E+00	1.5200	0.6797E+00	0.8464E+00	2.4000	0.3196E-04	0.3646E-04
0.6600	0.5393E+00	0.7791E+00	1.5400	0.6332E+00	0.7864E+00	2.4200	0.2151E-04	0.2453E-04
0.6800	0.5517E+00	0.7951E+00	1.5600	0.6029E+00	0.7429E+00	2.4400	0.1436E-04	0.1637E-04
0.7000	0.5646E+00	0.8118E+00	1.5800	0.5527E+00	0.6792E+00	2.4600	0.9516E-05	0.1084E-04
0.7200	0.5782E+00	0.8293E+00	1.6000	0.5033E+00	0.6169E+00	2.4800	0.5500E-05	0.6200E-05
0.7400	0.5924E+00	0.8475E+00	1.6200	0.4552E+00	0.5566E+00	2.5000	0.3582E-05	0.4037E-05
0.7600	0.6074E+00	0.8666E+00	1.6400	0.4091E+00	0.4988E+00	2.5200	0.2314E-05	0.2609E-05
0.7800	0.6231E+00	0.8865E+00	1.6600	0.3651E+00	0.4441E+00	2.5400	0.9488E-06	0.1043E-05
0.8000	0.6396E+00	0.9074E+00	1.6800	0.3236E+00	0.3926E+00	2.5600	0.6003E-06	0.6610E-06
0.8200	0.6569E+00	0.9291E+00	1.7000	0.2845E+00	0.3448E+00	2.5800	0.8744E-07	0.9237E-07
0.8400	0.6750E+00	0.9517E+00	1.7200	0.2485E+00	0.3007E+00	2.6000	0.0000E+00	0.0000E+00
0.8600	0.6940E+00	0.9753E+00	1.7400	0.2156E+00	0.2604E+00	2.6200	0.0000E+00	0.0000E+00

RANGE AND DEPOSITED ENERGY CHARACTERISTICS
BEAM ENERGY = 5.000 MEV

RANGE (STOPPED ION)

XM	1.4599 MICRONS
DXM	0.2250 MICRONS

DEPOSITED ENERGY	SD(X) DISTRIBUTION	SB(X) DISTRIBUTION	SEE EQUATION
TOTAL	1.11048 MEV	1.50848 MEV	(19)
MEAN DEPTH	0.99789 MICRONS	0.96803 MICRONS	(20)
RMS STD. DEV.	0.44703 MICRONS	0.44985 MICRONS	(21)
SKEWNESS	-0.36579	-0.30087	(22)
KURTOSIS	2.32861	2.24900	(23)

UNCLASSIFIED

E-DEP-1 VERSION P5.00 (10 OCT. 1985)
INCORPORATES REVISION DECKS A AND B, AND ADAPTATION DECKS C AND D.

THE FOLLOWING MESSAGE WAS READ IN WITH THE DATA.

SAMPLE RUN OF E-DEP-1 P5.00, RANGE TABLE ONLY
ARSENIC INCIDENT ON SILICON

THE PARAMETER SET THAT CONTROLS THE RUNNING OF THE CODE IS LIX(3)= 0 1 0

BEAM AND TARGET CHARACTERISTICS---

	CHARGE	MASS (AMU)	DENSITY (ATOMS/CC)	K	K VALUE GIVEN BY	X LIND (MICRONS)	E LIND (KEV)	X FIRS (MICRONS)	E FIRS (KEV)
INCOMING BEAM ION	33.	74.920							
TARGET COMPONENT 1	14.	28.086	4.9800E+22	1.1001E-01	LB	0.059091	208.945	0.073717	233.375
SUBSTRATE AVERAGE FOR EQ.(7),	14.000	28.086	4.9800E+22	1.8025E-01	SUB(LB)	0.033831	41.066		

K IS THE ELECTRONIC STOPPING PARAMETER OF EQ.(14).
THIS ELECTRONIC STOPPING LAW REQUIRES THAT THE BEAM ION ENERGY BE LESS THAN ELIM, GIVEN BY EQ.(15).
FOR THE BEAM AND TARGET JUST DESCRIBED, ELIM= 196.676 MEV.

NOTATION IN COLUMN 6 ABOVE

USER - POSITIVE K VALUE HAS BEEN INPUT ON DATA CARD. PROGRAM HAS USED THIS VALUE.

LSS - PROGRAM HAS COMPUTED K VALUE ACCORDING TO THE LSS EXPRESSION EQ.(10).
EITHER NEGATIVE K VALUE HAS BEEN INPUT ON DATA CARD OR Z VALUES ARE NOT COVERED BY LAND AND BRENNAN TABLES.

LB - ZERO K VALUE HAS BEEN INPUT ON DATA CARD. PROGRAM HAS SUPPLIED K VALUE ACCORDING TO TABLES GIVEN BY
D. LAND AND J. BRENNAN, ATOMIC DATA AND NUCLEAR TABLES VOL. 22, (1978), PP. 235 - 247, AND SUBSEQUENT NSWC REPORT.

SUB(LB) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).
LAND-BRENNAN VALUES ARE USED WHENEVER POSSIBLE. IF THE PARTICULAR COMBINATION IS NOT IN THE LAND-BRENNAN TABLES,
THEN LSS VALUES ARE USED.

SUB(LSS) - K FOR THE SUBSTRATE AVERAGE, ACCORDING TO EQ.(11) OF DAVISSON AND MANNING, COMPUTER PHYS. COMMUN. (1986).
THE USER HAS SELECTED THE LSS OPTION FOR ALL BEAM-TARGET COMBINATIONS, AND LSS VALUES ARE USED IN THIS
SUBSTRATE AVERAGE AS WELL.

X LIND IS THE LINDHARD DISTANCE UNIT USED BY LSS (DANSKE VIDENSKAB. SELSKAB 33, NO.14 (1963)).

E LIND IS THE LINDHARD ENERGY UNIT USED BY LSS.

X FIRS IS THE FIRSOV DISTANCE UNIT USED BY WHB (PHYS. REV. B, VOL.15 P.2458 (1977)).

E FIRS IS THE FIRSOV ENERGY UNIT USED BY WHB.

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THE ENERGY CUTOFF APPEARING IN EQ.(10) IS·T1=      0. EV.


ELASTIC COLLISIONS ARE CALCULATED ACCORDING TO WILSON,HAGGMARK,AND BIERSACK,
PHYS. REV. B, VOL 15, P.2458 (1977), USING EQUATIONS (14) AND (16) AND THE
AVERAGE FITTED CONSTANTS GIVEN IN TABLE II OF THAT PAPER.


THIS RUN GENERATES RANGE TABLES ONLY.
ENERGY DEPOSITION IS NOT CALCULATED.
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UNCLASSIFIED

THERE FOLLOWS THE OUTPUT OF THE JOHNSON-GIBBONS SUBROUTINE FOR THE PARAMETERS GIVEN ABOVE.
UNITS OF RANGE AND ENERGY ARE MICRONS AND MEV, RESPECTIVELY.

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     E = ION ENERGY.
    XM = AVERAGE PROJECTED RANGE.
   DXM = RMS PROJECTED RANGE.
 YPERP= LATERAL RANGE.
    RM = AVERAGE TOTAL RANGE.
   DRM = RMS TOTAL RANGE.
 SN(E) = (DE/DR)NUCLEAR, AS GIVEN BY LSS.
 SL(E) = (DE/DR)NUCLEAR, AS GIVEN BY LNST.
         THIS TERM IS SUPPLIED BY MANNING AND MUELLER, RATHER THAN BY THE JOHNSON-GIBBONS SUBROUTINE.
 SE(E) = (DE/DR)ELECTRONIC.  (DE/DR)ELECTRONIC = K*SQRT(EPSILON, WHERE EPSILON IS THE LSS REDUCED ENERGY.
         THE ELECTRONIC STOPPING PARAMETER, K, IS GIVEN ON THE PREVIOUS PAGE.
 DR/DX = DERIVATIVE OF TOTAL RANGE WITH RESPECT TO PROJECTED RANGE.

 E ERR = A JOHNSON-GIBBONS PARAMETER.  THE TABULAR JOHNSON-GIBBONS ENTRIES ARE UNRELIABLE FOR ENERGIES LESS THAN E ERR.
         FOR THIS RUN
 E ERR =  0.000 MEV.
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NOTE--AS DESCRIBED IN THE LONG WRITE-UP, ONE SHOULD TAKE DXM = MAX(DXM,DRM).

E	XM	DXM	YPERP	RM	DRM	SN(E)	SL(E)	SE(E)	DR/DX
0.001	0.0040288	0.0010723	0.0012305	0.0050106	0.0015912	0.34225E+00	0.24555E+00	0.26910E-01	0.12516E+01
0.002	0.0058604	0.0015515	0.0017870	0.0073096	0.0022858	0.45940E+00	0.40040E+00	0.38057E-01	0.12525E+01
0.003	0.0073338	0.0019250	0.0022293	0.0091508	0.0028343	0.54036E+00	0.48410E+00	0.46610E-01	0.12472E+01
0.004	0.0086239	0.0022454	0.0026123	0.0107572	0.0033085	0.60311E+00	0.51566E+00	0.53821E-01	0.12431E+01
0.005	0.0097979	0.0025326	0.0029573	0.0122144	0.0037360	0.65449E+00	0.54979E+00	0.60174E-01	0.12394E+01
0.006	0.0108904	0.0027967	0.0032753	0.0135665	0.0041310	0.69797E+00	0.58330E+00	0.65917E-01	0.12360E+01
0.007	0.0119215	0.0030436	0.0035727	0.0148394	0.0045017	0.73561E+00	0.61082E+00	0.71198E-01	0.12330E+01
0.008	0.0129045	0.0032769	0.0038538	0.0160500	0.0048534	0.76869E+00	0.63314E+00	0.76114E-01	0.12301E+01
0.009	0.0138486	0.0034994	0.0041215	0.0172101	0.0051900	0.79814E+00	0.65102E+00	0.80731E-01	0.12275E+01
0.010	0.0147603	0.0037129	0.0043781	0.0183281	0.0055139	0.82459E+00	0.66523E+00	0.85098E-01	0.12250E+01
0.011	0.0156448	0.0039187	0.0046251	0.0194105	0.0058274	0.84853E+00	0.68000E+00	0.89252E-01	0.12227E+01
0.012	0.0165058	0.0041180	0.0048638	0.0204623	0.0061319	0.87033E+00	0.69559E+00	0.93221E-01	0.12204E+01
0.013	0.0173464	0.0043117	0.0050952	0.0214873	0.0064285	0.89030E+00	0.70947E+00	0.97027E-01	0.12183E+01
0.014	0.0181692	0.0045004	0.0053202	0.0224889	0.0067184	0.90866E+00	0.72174E+00	0.10069E+00	0.12163E+01
0.015	0.0189762	0.0046847	0.0055394	0.0234696	0.0070023	0.92561E+00	0.73253E+00	0.10422E+00	0.12144E+01
0.016	0.0197690	0.0048650	0.0057535	0.0244316	0.0072809	0.94131E+00	0.74195E+00	0.10764E+00	0.12125E+01
0.017	0.0205491	0.0050418	0.0059627	0.0253768	0.0075547	0.95589E+00	0.75013E+00	0.11095E+00	0.12107E+01
0.018	0.0213178	0.0052155	0.0061677	0.0263068	0.0078242	0.96947E+00	0.75717E+00	0.11417E+00	0.12090E+01
0.019	0.0220760	0.0053861	0.0063687	0.0272229	0.0080898	0.98215E+00	0.76318E+00	0.11730E+00	0.12073E+01
0.020	0.0228247	0.0055542	0.0065661	0.0281263	0.0083519	0.99400E+00	0.76826E+00	0.12035E+00	0.12058E+01
0.030	0.0299270	0.0071245	0.0083864	0.0366402	0.0108310	0.10798E+01	0.81428E+00	0.14739E+00	0.11922E+01
0.040	0.0365869	0.0085663	0.0100171	0.0445439	0.0131484	0.11289E+01	0.82969E+00	0.17020E+00	0.11816E+01
0.050	0.0429986	0.0099308	0.0115281	0.0520916	0.0153745	0.11578E+01	0.83609E+00	0.19029E+00	0.11730E+01
0.060	0.0492579	0.0112432	0.0129556	0.0594103	0.0175424	0.11744E+01	0.83519E+00	0.20845E+00	0.11657E+01
0.070	0.0554192	0.0125177	0.0143210	0.0665729	0.0196700	0.11830E+01	0.82853E+00	0.22515E+00	0.11594E+01
0.080	0.0615165	0.0137630	0.0156383	0.0736253	0.0217680	0.11861E+01	0.82024E+00	0.24069E+00	0.11540E+01
0.090	0.0675720	0.0149850	0.0169174	0.0805984	0.0238429	0.11854E+01	0.81064E+00	0.25529E+00	0.00000E+00
0.100	0.0736012	0.0161874	0.0181652	0.0875134	0.0258989	0.11819E+01	0.79969E+00	0.26910E+00	0.00000E+00