NUMERICAL SIMULATION

OF MULTIPOLE CONFINEMENT (Revised)

by

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ABSTRACT[1]

Gun and microwave (ECRH) produced plasmas in toroidal multipoles are simulated by a fast general computer program which calculates the time dependent, spatially averaged density, electron temperatures, and ion temperature by solving three coupled, non-linear, time-dependent, first order differential equations from which the spatial dependence has been removed by averaging over profiles assumed to be constant in shape. Mechanisms included in the calculations are microwave heating, ionization, atomic and molecular excitations, bremmstrahlung, synchrotron radiation, charge exchange, electron-ion collisions, classical diffusion, obstacle losses, and field decay. Proper treatment of reflux neutrals is important. A program listing and discussion of program usage are included.

[1]This PLP is an expanded version of a talk given at the Philadelphia APS meeting on 2 Nov. 1973. It is also an updated version of PLP 505 by Sprott and is the promised PLP cited by Sprott in PLP 535. Examples of results of use of this program - the remainder of the APS talk - will be presented in a separate PLP.

I. Introduction

This paper describes a fast, simple, time dependent, spatially independent computer model of gun injected and/or microwave ECRH plasmas, confined in a toroidal device. It consists of three coupled differential equations - one each for charged particle density and electron and ion temperatures - that are simultaneously solved by a second order iterative technique.

Since it was motivated by an attempt to understand energy and particle loss mechanisms in toroidal devices, it included only physically justifiable loss mechanisms, expressed in approximate but physically justifiable forms. Of course, this means that not all losses are treated - but the program philosophy has been to omit those phenomena that we can't include properly (without, for example, adding more differential equations), rather than to include them in some ad-hoc form simply to tailor program predictions to fit experimental results.

Everything in the program is described in terms of (possibly time dependent) quantities that have no dependence on spatial coordinates, which are removed by proper averaging or approximating. The end products are particle density and electron and ion temperatures that are somehow average quantities. This technique may be continued to handle any machine which can be approximated by cylinder (see next section) as long as the proper loss mechanisms are included.

II. General Method

To develop this model, the effects of simple models of various loss mechanisms are approximated or averaged over the volume of the toroid. Where possible the plasma is taken to be a cylinder, with electrons and ions having equal densities and each having a maxwellian velocity distribution.

Since the loss and gain mechanisms all refer to the time rate of change of something, and since this "something" may also depend on position - for instance, electron density may vary from region to region in the device, suitable approximations or averages must be done to get rid of these spatial dependences, to get our spatially independent code. (For example, classical diffusion needs a density gradient. So, $\nabla n = 0$, except that we allow $\nabla n = n/a$ for diffusion, where n = average electron density and a = plasma minor radius. This crude approximation hasn't bothered us, for classical diffusion has been virtually negligible in cases considered so far.) In this way, the time rates of change of particle density and electron and ion energy density due to various loss or gain mechanisms, become simple algebraic quantities, functions only of time and some initial parameters, and now wholly independent of spatial coordinates.

Expressions "conditioned" in this way are magnetic field, neutral density and all the particle and energy loss and gain mechanisms: ionization, classical diffusion, obstacle losses, field decay, microwave heating, classical electron-ion collisions, neutral excitation by inelastic electron collisions, bremmstrahlung, synchrotron radiation, thermal conduction ignoring temperature gradients, and charge exchange. Further descriptions will be found in the next section.

These expressions were then combined into the three differential equations seen below - one each for average electron(= ion) density and average electron and ion energy densities. They form a system of three first order, coupled, ordinary, non-linear, time dependent, spatially independent differential equations.

The equations are as follows:

$$\frac{dn}{dt} = \frac{dn}{dt}(n,n_o,T_e,\text{gas})\Big|_{\text{ionization}}$$

$$- \frac{dn}{dt}(n,\ n_o,T_e,a,B)\Big|_{\text{diffusion (= dif)}}$$

$$- \frac{dn}{dt}(n,T_e,T_i,a,L,A_o)\Big|_{\text{obstacle loss (= o.l.)}}$$

$$- \frac{dn}{dt}(n,B,\dot{B})\Big|_{\text{field decay (= f.d.)}}$$

$$\frac{dU_e}{dt} = \frac{dU_e}{dt}(n,a,L,B,P,f,Q_o)\Big|_{\text{microwaves}}$$

$$- \frac{dU_e}{dt}(n,T_e,T_i)\Big|_{\text{electron-ion collisions}}$$

$$- \frac{dU_e}{dt}(T_e,\dot{n}|_{\text{ionization}})\Big|_{\text{excitation}}$$

$$- \frac{dU_e}{dt}(n,T_e)\Big|_{\text{bremmstrahlung}}$$

$$- \frac{dU_e}{dt}(n,T_e,B)\Big|_{\text{synchrotron radiation}}$$

$$- \frac{dU_e}{dt}(n,T_e,T_w,\dot{n}|_{\text{dif}},\dot{n}|_{\text{o.l.}},\dot{n}|_{\text{f.d.}})\Big|_{\text{thermal radiation}}$$

$$\frac{dU_i}{dt} = \frac{dU_i}{dt}(n,T_e,T_i)\Big|_{\text{electron-ion collision}}$$

$$- \frac{dU_i}{dt}(n,T_i,T_w)\Big|_{\text{charge exchange}}$$

$$- \frac{dU_i}{dt}(n,T_i,T_w,\dot{n}|_{dif},\dot{n}|_{o.l.},\dot{n}|_{f.d.})\Big|_{\text{thermal conduction}}$$

where

n = averaged electron (= ion) density ($10^9/cm^3$)

n_o = averaged neutral density ($10^9/cm^3$)

U_e = averaged electron energy density (eV/cm^3)

U_i = averaged ion energy density (eV/cm^3)

T_e = averaged electron temperature (eV)

T_i = averaged ion temperature (eV)

B = time dependent, average magnetic field (kG)

$\dot{B}$ = dB/dt (kG/sec)

a = plasma radius (toroid minor radius) (cm)

L = plasma length (toroid circumference) (cm)

A_o = obstacle area (cm^2) (A_o is slightly larger than the geometric area)

P = microwave power (watts)

f = microwave frequency (GHz)

Q_o = unperturbed microwave cavity Q

T_w = toroid wall temperature (eV)

t = time (sec)

dt = iteration time step (sec)

These three equations are then solved simultaneously by the following second order method. Given a time step dt and the time derivatives $\dot{n}$, $\dot{T}_e$, $\dot{T}_i$ at time t, then calculate n, T_e, T_i at time t+dt. First calculate B, P, n_o at time t. Second increment n, T_e, T_i to approximate them at t+.5dt (x is any of n, T_e, T_i):

$$x(t+.5dt) = x(t) + (.5dt)(\dot{x}|_{t-.5dt}).$$

Third, calculate $\dot{n}$, $\dot{U}_e$, $\dot{U}_i$ at t+.5dt, using values of B, P, n_o at time t and n_e, T_e, T_i at t+.5dt. Fourth, calculate $\dot{T}_e$, $\dot{T}_i$ from

$$\dot{T}_{e,i} = (\frac{2}{3} \dot{U}_{e,i} \qquad \dot{}_{e,i}$$

Finally, using $\dot{n}$, $\dot{T}_e$, $\dot{T}_i$ at t+.5dt, increment the original n, T_e, T_i at time t to get (x is any of n, T_e, T_i)

$$x(t+dt) = x(t) + (dt)(\dot{x}|_{t+.5dt}).$$

III. The terms

After the averaging and approximating the final terms that go into the program are detailed below. The labels in parentheses are the corresponding variable names in the program.

Gun Injection

If gun injection is used, n, T_e and T_i all change abruptly at $t = t_{gun}$. For the old gun on the Barn octupole, the parameters at $t = t_{gun}$ are $n = 10^9/cm^3$, $T_e = 10$ eV, $T_i = 40$ eV. Turbulence effects from the filling process are ignored and can account for some differences between experimental and program results at times close to injection time.

Magnetic Field

Any time dependent magnetic field can be specified. For the UW equipment (both octupoles and the quadrupole), the uncrowbarred vacuum field is

$$B_{VAC} = B_o e^{-t/\tau} \sin(\omega t)/.7887 + 10^{-5} .$$

For the Barn octupole, $\tau = 10^{-2}$, $\omega = 200\pi$ sec^{-1}

PSL octupole, $\tau = .086$, $\omega = (\pi/.043)$ sec^{-1}

quadrupole, $\tau = .004$, $\omega = 500\pi$ sec^{-1}

The 10^{-5} term prevents 1/B from blowing up; 10^{-5} is smaller than the typical field of the earth.

For crowbarred fields, B_{VAC} after crowbar is given by

$$B_{VAC} = B_{CRO} e^{-(t-t_c)/\tau_d}$$

where t_c is crowbar time after start of run, and τ_d is field decay time, and B_{CRO} is the value of the uncrowbarred magnetic field at $t = t_{CRO}$. For the PSL octupole, $\tau_d = .08$ sec,

quadrupole, $\tau_d = .005$ sec.

In either vacuum case, B is corrected for finite β by

$$B = \sqrt{B_{VAC}^2 - 2.70 \times 10^{-8} n(T_e + T_i)} \ .$$

Microwave Power

Any time dependent power waveform may be used. In the program listing at the end of this PLP, there are 7 standard choices: 1 constant power, 5 step-type powers, and one used on the small octupole (PLP 494):

$$T(t) = P_o \max(0,\ 2B/B_o - 1)$$

where P_o is the maximum power, B_o is the maximum magnetic field, and $B = B(t)$.

Ion Saturation Current

J^+ in mA/cm^2 to a Langmuir probe is calculated at each iteration step by

$$J^+ = 0.104 n \sqrt{\max(T_e,\ T_i)} \ .$$

Neutral Density

For molecular hydrogen, the neutral density is calculated at each time step from the pressure p as follows:

$$n_{TH} = (322p + \Delta n_{WR}) \exp\left(- \frac{4.1 \times 10^{-7} a}{\sqrt{T_W}} \frac{1}{n_o} \frac{dn}{dt}\bigg|_{ionization} \right)$$

$$n_{FC} = 0.04(322p + \Delta n_{WR}) \exp\left(-1.09 \times 10^{-7} a \frac{1}{n_o} \frac{dn}{dt}\bigg|_{ionization} \right)$$

$$n_o = n_{TH} + n_{FC} \ .$$

n_{TH} represents thermal (0.025 eV) neutrals and n_{FC} represents Franck Condon (7 eV) neutrals. The exponential factors account for the finite penetration depth of neutrals into the plasma. Δn_{WR} is a kind of running total of the net gain or loss of neutrals from the plasma, and takes into account neutrals used to make up the plasma and the reflux neutrals knocked off the walls by energetic lost electrons:

$$\Delta n_{WR}(t) = \Delta n_{WR}(t-dt) + (g \cdot (D_{dif}+D_{o.l.}+D_{f.d.}) - D_{ion})dt \ .$$

g represents the number of reflux neutrals created by each lost electron-ion pair when it strikes either a wall or obstacle. It is an experimental factor from preliminary results of work by Etzweiler and Sprott (PLP 552):

$$g = 1 + .002T_e$$

When the neutral density is increasing in time, the rate of increase of each component is limited to

$$dn_{TH}/dt \le 10^{-6}\sqrt{T_W}\, n_{TH}/a$$

$$dn_{FC}/dt \le 3.4 \times 10^{-6} n_{FC}/a$$

representing the neutral's transit time from the plasma edge to the center. The thermal neutrals are assumed to be at wall temperature (T_W). The experiment is assumed to take place on a time scale short compared with the pumping time so that no neutrals are lost to the vacuum pumps.

Ionization (D1)

The ionization rate for a Maxwellian electron distribution in a cold neutral gas, can be written in a form given by Drawin.[1] For H_2, the electron-neutral collisional ionization rate is

$$\left.\frac{dn}{dt}\right|_{ionization} = \frac{371e^{-S}}{1 + S\sqrt{T_e}}\left(\frac{1}{20} + \ln(1.25$$

where $S = 15.6/T_e$. For different gasses, the numerator in S, the coefficient 371, and the 1.25

coming PLP will further discuss this point.

Diffusion (D2)

Classical diffusion due to electron-ion and electron-neutral collisions is given by

$$\left.\frac{dn}{dt}\right|_{diffusion} = 0.33\frac{n^2}{B^2a^2T_e^{\frac{1}{2}}} + 10^{-3}\frac{nn_oT_e}{B^2a^2} .$$

The ambipolar electric field has been considered, but ion-neutral collisions have been neglected, since they amount to only a 1.2% correction to the diffusion.

Obstacle Loss (D3)

Hoop supports and probes which intercept the plasma are assumed to collect particles at a rate given by

$$\left.\frac{dn}{dt}\right|_{obstacle} = 2 \times 10^{5}\frac{nA_o\sqrt{T_e + T_i}}{a^2L}$$

where in practice A_o is an effective obstacle area calculated from lifetime measurements of ions and hot electrons.

Field Decay (D4)

When $dB/dt = \dot{B}$ is negative, field lines leave the machine, and plasma is assumed to leave at the same rate:

$$\left.\frac{dn}{dt}\right|_{\text{field decay}} = -C \cdot \min[0, \frac{\dot{B}}{B} n] = C \cdot \max[0, \frac{-\dot{B}}{B} n]$$

where C is a coefficient whose value depends on the number of hoops in the machine.

For octupoles, C = 0.5

quadrupoles, C = 1.0.

Microwave Heating (PE1)

The microwave heating rate is given by

$$\left.\frac{dU_e}{dt}\right|_{\text{microwaves}} = \frac{2 \times 10^9 P}{(1 + n_c/n)a^2 L}$$

where n_c is the density above which microwaves are totally absorbed. From PLP 282, this correction for finite cavity Q can be estimated from

$$n_c = \frac{f^2}{Q} [0.0045(f/B)^4 + 123(B/f)^{2/3}].$$

In this program, Q is allowed to be frequency dependent by setting its value relative to the Q at 2.45 GHz:

$$Q = Q_{2.45\ \text{GHz}} \sqrt{f/2.45}\ .$$

Ion Collisions (PE2)

Classical electron-ion collisions result in an energy loss

$$\left.\frac{dU_e}{dt}\right|_{\text{ionization}} = \frac{2.3n^2(T_e - T_i)}{T_e^{3/2}} \ln\left[\frac{5.2 \times 10^{10} T_e^3}{(40 + T_e)n}\right].$$

Excitation (PE3)

Energy lost by inelastic electron-neutral collisions is given by

$$\left.\frac{dU_e}{dt}\right|_{excitation} = R(T_e) \left.\frac{dn}{dt}\right|_{ionization} .$$

All neutrals are assumed in their ground state. Excited neutrals are assumed to undergo radiative deexcitation before it is again excited. Collisional deexcitation is ignored. $R(T_e)$ is an analytic fit to the total energy loss rate for the various excitation processes, divided by the ionization rate.

For H_2,

$$R(T_e) = .95T^{1.096}[\exp(11.99T_e^{-.738}) - 1.036].$$

How this was obtained, plus $R(T_e)$ for H and H_e are subjects of a forthcoming PLP.

Bremmstrahlung (PE4)

Electron-ion Bremmstrahlung losses are given by (Rose and Clark, p. 233)

$$\left.\frac{dU_e}{dt}\right|_{bremmstrahlung} = 10^{-4}n^2T_e^{1/2} .$$

Synchrotron Radiation (PE5)

Electron synchrotron radiation, neglecting reabsorption, is given by (Rose and Clark, p. 25)

$$\left.\frac{dU_e}{dt}\right|_{synchrotron} = 3.87 \times 10^{-3}nB^2T_e(1 + T_e/2.04 \times 10^5) .$$

Electron Thermal Conduction (PE6)

Heat conduction loss, neglecting temperature gradients, is given by the energy carried from the plasma by particles lost due to diffusion, to obstacles and to field decay:

$$\left.\frac{dU_e}{dt}\right|_{\text{thermal conduction}} = [2.5\dot{n}|_{dif} + 2.0\dot{n}|_{o.1.} + \dot{n}|_{f.d.}](T_e - T_{wall}).$$

Electron Collisions (PE2)

Ions are heated by classical electron-ion collisions:

$$\left.\frac{dU_i}{dt}\right|_{\text{electron collisions}} = \frac{2.3n^2(T_e - T_i)}{T_e^{3/2}} \ln\left[\frac{5.2\text{x } 10^{11}T_e^3}{(40 + T_e)n}\right].$$

Charge Exchange (PI3)

Charge exchange losses are represented by the approximate analytic form:

$$\left.\frac{dU_i}{dt}\right|_{\text{charge exchange}} = \frac{0.0186nn_oT_i^2(T_i - T_w)}{T_i + 100}$$

Ion Thermal Conduction (PI6)

Heat conduction, neglecting temperature gradients, is given by the energy carried from the plasma by particles lost to diffusion, obstacles and field decay:

$$\left.\frac{dU_i}{dt}\right|_{\text{thermal conduction}} = [2.5\dot{n}|_{dif} + 2.0\dot{n}|_{o.1.} + \dot{n}|_{f.d.}](T_i - T_{wall}).$$

The following pages are a listing of the long version of SIMULT. It exists as a deck, and the first 4 pages tell how to use the program plus some further description of it. At the end is some typical output, using the Calcomp plotter. The page printer output is the same as in the previous PLP (Sprott, PLP 505)

EXPLANATION AND USE

.EXPLAIN
[redacted]

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C     H O W   T O   U S E   P R O G R A M   S I M U L T

C     DEFINITIONS
C        FREE FORMAT-NUMERICAL VALUES APPEAR ON THE CARD,FROM LEFT TO RIGHT
C            IN THEIR CORRECT ORDER,WITH NO IMBEDDED BLANKS,BUT WITH AT
C            LEAST ONE BLANK SEPARATING ADJACENT DATA.DATA MAY BE WRITTEN
C            IN INTEGER,DECIMAL OR EXPONENTIAL NOTATION.
C        CONTROL VALUES-EITHER A SET OF NUMBERS OR THE SET OF CARDS HOLDING
C            THOSE NUMBERS(CONTEXT SHOULD MAKE CLEAR WHICH ONE)WHICH SELECT
C            THE OPTIONS AND SET INITIAL CONDITIONS FOR ONE SET OF
C            ITERATIONS FOR ONE 'SIMULATION'.
C        RUN CONTROL-ONE,POSSIBLY TWO,CARDS SPECIFYING,FIRST,HOW MANY SETS
C            OF CONTROL VALUES(HOW MANY 'SIMULATIONS')ARE TO BE PROCESSED
C            BY THIS PROGRAM EXECUTION AND,SECOND,THE SIMULATED-MACHINE'S
C            PARAMETERS,EITHER THROUGH PRE-SELECTED OR USER-SELECTED DATA.

C     O U T P U T
C        THE OUTPUT GENERATED NORMALLY FOR EACH DATA SET (SIMULATION)
C           CONSISTS OF A HEADING BLOCK GIVING ALL THE INPUT DATA AND
C           SEVEN COLUMNS OF CALCULATED OUTPUT, PLUS 2 COLUMNS GIVING THE
C           ITERATION STEP AND TIME STEP AT WHICH THE PRINTED VALUES ARE
C           CALCULATED. TIME INTERVAL BETWEEN PRINTED VALUES IS GIVEN BY
C           (TSTOP/IPTS)-SEE CARD A BELOW. ALSO SEE CARD A BELOW UNDER
C           'NP' FOR OTHER POSSIBLE OUTPUT FROM THIS PROGRAM.
C        THE NORMAL OUTPUT VARIABLES ARE, IN THE ORDER PRINTED,
C            ITERATION STEP
C            TIME (IN MILLISECONDS)
C            ELECTRON DENSITY (IN 10**9/CM**3)
C            ELECTRON TEMPERATURE (IN EV)
C            ION TEMPERATURE (IN EV)
C            NEUTRAL DENSITY (IN 10**9/CM**3)
C            MAGNETIC FIELD (IN KGAUSS)
C            MICROWAVE POWER (IN WATTS)
C            ION SATURATION CURRENT (IN MILLIAMPS/CM**2)
C        AFTER THESE VALUES ARE PRINTED, THREE LINES ARE PRINTED GIVING
C        THEIR MAXIMUM VALUES, TIME OF MAXIMA, AND VALUE AT TIME OF MAX
C        ION SAT CURRENT. (FOR NEUT DENS, MIN AND TIME OF MIN ARE PRINTED.)


C     DATA CARD ORDERING
C        (@XQT)
C        CARD 1-ALWAYS NEEDED.
C            COLUMNS 1 TO 3--THREE DIGIT NUMBER,RIGHT JUSTIFIED,SPECIFYING
C               NUMBER OF DATA SETS TO FOLLOW.
C            COLUMNS 4 TO 9--ONE OF THE FOLLOWING 6 LETTER WORDS,SPECIFIES
C               MACHINE BEING SIMULATED.
C                  BIGLEV-PSL OCTUPOLE,LEVITATED
C                  BIGSUP-PSL OCTUPOLE,SUPPORTED
C                  LITTLE-BARN OCTUPOLE
C                  QUADXX-BARN QUADRUPOLE
C                  OTHERX-ANY OTHER MACHINE,OR ANY OF THE ABOVE MACHINES
C                         WITH NON-STANDARD PARAMETERS.IF 'OTHERX',THEN
C                         CARD 2 MUST APPEAR.
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C     CARD 2-APPEARS IF AND ONLY IF 'OTHERX' IS USED ON CARD 1.
C          DATA IS FREE FORMAT.BELOW ARE,FIRST,THE DATA ORDER FOR THIS
C          CARD,AND,SECOND,THEIR NORMAL VALUES FOR THE VARIOUS 6 LETTER
C          WORDS ON CARD 1.
C                 TMAX  =LENGTH OF MAGNETIC FIELD HALF-SINE WAVE IN MS.
C                        IF IB=3, THEN TMAX IS ARBITRARY.
C                 A     =PLASMA (MINOR) RADIUS IN CM.
C                 AL    =PLASMA LENGTH (CIRCUMFERENCE,IF TOROID) IN CM.
C                 AO    =OBSTACLE AREA (HOOP SUPPORTS,PROBES) IN SQ CM.
C                 QO    =MICROWAVE CAVITY Q AT 2.45 GHZ.
C                 D4CC  =NUMBER-OF-HOOPS DEPENDENT COEFFICIENT OF D4.
C                 DECAY =DECAY TIME OF CROWBARRED MAGNETIC FIELD IN SEC.

C                       THEIR NORMAL VALUES
C                              BIGLEV     BIGSUP     LITTLE     QUADXX
C                 TMAX(SEC)       .043       .043       .005       .002
C                 A(CM)            50.        50.        18.         6.
C                 AL(CM)          800.       800.       270.       160.
C                 AO(CM**2)         0.       700.        90.         3.
C                 QO            20000.     20000.      2000.       500.
C                 D4CC              .5         .5         .5         1.
C                 DECAY(SEC)       .08        .08         0.       .005

C    DATA SET ORGANIZATION--(CARD A,AND B AND C,IF USED, MAKE UP
C                              THE DATA FOR ONE SIMULATION.)
C     CARD 1-ALWAYS NEEDED
C          HOLDS THE 16 OPTION FLAGS AND INITIAL VALUES IN THE ORDER AND
C          UNITS SHOWN BELOW.FIRST 6 ARE INTEGER,LAST 10 ARE DECIMAL
C          (E OR F FORMAT).ANY OF THE LAST 10 THAT ARE UNUSED OR UNWANTED
C          MUST BE INPUT AS DECIMAL ZERO.
C     IPWR IS A FLAG FOR THE SHAPE OF THE INPUT MICROWAVE POWER.
C          = 1 MEANS A NON-SQUARE SHAPE. P=MAX OF (0,2*PO*(B/BO-.5))
C          = 2 MEANS P=PO FOR ALL TIME.
C          = 3 MEANS P=0. TIL TMO,THEN P=PO.
C          = 4 MEANS P=PO TIL TMO,THEN P=0.
C          = 5 MEANS P=0. TIL TMO,P=PO TIL TMO+TMW,THEN P=0.
C          = 6 MEANS P=PO TIL TMO,P=0. TIL TMO+TMW,THEN P=PO.
C          = 7 MEANS IPWR=1 AS B INCREASES,THEN P=0. AS B DECREASES.
C     IB IS A FLAG FOR CROWBARRING THE MAGNETIC FIELD.
C        = 1 MEANS B IS NOT CROWBARRED.
C        = 2 MEANS B IS CROWBARRED AT TIME=TCRO.
C        = 3 MEANS B=BO ALWAYS.
C     NGI IS A FLAG FOR GUN INJECTION.
C        = 1 FOR NO GUN INJECTION.
C        = 2 FOR GUN INJECTION AT TIME=TGI.USE PROGRAM-SET VALUES (FOR
C                DEAGUN,TEAGUN,TIAGUN) FOR THE BARN OCTUPOLE'S GUN.
C        = 3 FOR GUN INJECTION AT TIME=TGI, USE USER-SUPPLIED VALUES
C                FOR DEAGUN,TEAGUN,TIAGUN.(SEE CARD A.)
C     NP=XYZ=A THREE DIGIT FLAG.YZ CONTROLS IF AND HOW THE VARIOUS
C               DERIVATIVE VALUES(D1 TO PI6)ARE PRINTED. X CONTROLS
C               IF AND HOW DEA TO SJI ARE PLOTTED.
C          Z= 1 MEANS DO NOT PRINT DERIVATIVE VALUES.
C           = 2 MEANS PRINT THE DERIVATIVE VALUES.
C           = 3 MEANS PRINT THE DERIVATIVES' MAXIMUM VALUES.
C           = 4 MEANS PRINT BOTH Z=2 AND Z=3.
C          Y= 1 MEANS DO NOT PRINT A TWO LETTER SYMBOL REPRESENTING THE
C                DOMINANT LOSS MECHANISM.
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C              = 2 MEANS PRINT A 2 LETTER SYMBOL REPRESENTING THE DOMINANT
C                   (FOR DENSITY--CD=CLASS.DIFF.,OL=OBS.LOSS,FD=FIELD DECAY
C                   LOSS (DERIVATIVE WITH LARGEST ABS.VAL.) FOR THE THESE
C                   VARIABLES,AT THE TIMES DISCUSSED UNDER 'IPTS' BELOW.
C                    FOR ELEC TEMP--IC=ION COLL.,EX=EXCITATION,
C                       BR=BREMMSTRAHLUNG,SR=SYNCH.RAD.,TC=THERMAL COND.
C                    FOR ION TEMP--CX=CHARGE EXCHANGE,TC=THERMAL COND.
C             X= 1 MEANS DO NOT PLOT.
C              = 2 MEANS PLOT ON THE CALCOMP PLOTTER.
C                    IF X=2,THEN TWO CARDS MUST APPEAR AFTER @RUN.THEY ARE-
C                          @GSP
C                          PLOTTER (OPTIONS-SEE MACC 'GRAPH' ROUTINE.)
C                       WITH NO OPTIONS LISTED,GRAPH WILL BE IN
C                       BLACK BALLPOINT. DO  N O T  SELECT 30 INCH PAPER.
C              = 3 MEANS PLOT ON THE OUTPUT PAGE PRINTER.
C         IIMAX IS NUMBER OF ITERATIONS IN AN INTERVAL TIME=0 TO TIME=TSTOP.
C             SET IIMAX.LT.0, TO LET USER SET INITIAL VALUES OF DEA,TEA,TIA.
C             (SEE CARD B) IF IIMAX.LT.0,NUMBER OF ITERATIONS=ABSVAL(IIMAX).
C         IPTS IS THE NUMBER OF PRINTED AND/OR GRAPHED POINTS IN
C             AN INTERVAL TIME=0 TO TIME=TSTOP. ACTUAL NUMBER OF SUCH
C             POINTS IS (IPTS+1),SINCE TIME=0 VALUES ARE PRINTED FREE.
C                 SAVING INTERVALS ARE (TSTOP-TSTART)/IPTS.
C             NOTE--IPTS MUST BE LESS THAN OR EQUAL TO 100.
C         PRES IS NEUTRAL PRESSURE IN 10**-5 TORR.
C             IF INPUT AS NEG NUMBER,IT IS TAKEN TO BE GAUGE PRESSURE,AND
C                IS MULTIPLIED BY (-2.5) TO GET CORRESPONDING TRUE PRESSURE.
C             IF INPUT AS A POS NUMBER,IT IS TAKEN TO BE TRUE PRESSURE,AND
C                IS USED AS IS.
C         PO IS PEAK MICROWAVE POWER IN WATTS.
C         F IS MICROWAVE FREQUENCY IN GHZ.MUST BE NON-ZERO.
C             IF PO=0.,PUT IN F=1.
C         BO IS THE MAXIMUM MAGNETIC FIELD AT WALL, IN KGAUSS.
C         THE FOLLOWING TIMES ARE INPUT IN MS.,THEN CONVERTED TO SEC.
C             TSTOP IS THE END OF A SOLUTION INTERVAL TIME=0 TO TIME=TSTOP.
C                 TSTOP DOES NOT HAVE TO EQUAL TMAX,BUT IT USUALLY DOES.
C                 TSTOP AND IIMAX SET TIME INTERVAL PER ITERATION (=DT)
C                 EQUAL TO (TSTOP/IIMAX).
C             TMO -MICROWAVE TURN-ON TIME-SEE IPWR.
C             TMW -MICROWAVE PULSE WIDTH -SEE IPWR.
C             TGI -GUN INJECTION TIME    -SEE NGI.
C             TCRO-B FIELD CROWBAR TIME  -SEE IB.
C         BOHMC-A VARIABLE COEFFICIENT FOR THE BOHM DIFFUSION TERM.
C             BOHMC=0. USUALLY.

C         CARD B-NEEDED IF AND ONLY IF IIMAX.LT.0. SEE CARD A.
C             NORMAL INITIAL VALUES AFFECTED BY THIS CARD ARE
C                  DEA=ELECTRON DENSITY(IN UNITS OF 10**9/CM**3)=.001
C                  TEA=ELECTRON TEMPERATURE(UNITS OF EV)        =.1
C                  TIA=ION TEMPERATURE      (UNITS OF EV)       =.025
C             INPUT NEW VALUES IN ABOVE ORDER AND UNITS,IN FREE FORMAT.

C         CARD C-NEEDED IF AND ONLY IF NGI=. SEE CARD A.
C             NORMAL GUN INJECTION PARAMETERS,VALID FOR THE BARN OCTUPOLE,
C             THAT ARE AFFECTED BY THIS CARD ARE
C                  DEAGUN=GUN INJECTED ELECTRON DENSITY(10**9/CM**3)= 1.
C                  TEAGUN=GUN INJECTED ELECTRON TEMPERATURE(EV)     =10.
C                  TIAGUN=GUN INJECTED ION TEMPERATURE(EV)          =40.
```

```
C          INPUT NEW VALUES IN ABOVE ORDER AND UNITS,IN FREE FORMAT.


C    REPEAT CARDS A TO C FOR EACH SIMULATION. ALL SIMULATIONS WILL BE FOR
C    THE MACHINE SPECIFIED IN CARD 1(AND CARD 2,IF USED).IF CARD 2 IS NOT
C    USED,OMIT IT-DO NOT PUT IN A BLANK CARD.LIKEWISE,IF FOR ANY
C    SIMULATION,CARDS B AND C ARE NOT USED,OMIT THEM-DO NOT USE
C    BLANK CARDS.


C    FOR MOST RUNS,THE ONLY CARDS NEEDED ARE CARDS 1 AND A-
C    CARDS 2,B AND C EXIST TO EXTEND THE FLEXIBILITY OF THE PROGRAM.

C    A TYPICAL NUMBER FOR IIMAX IS 2000.1500 IS QUITE GOOD,ESPECIALLY FOR
C    MEDIUM TO LOW POWER LEVELS AND/OR NO GUN INJECTION(NGI=1),BUT FOR
C    IIMAX BELOW 1500, ACCURACY BEGINS TO DROP DRASTICALLY. FOR 1500 ITERATIONS
         WITH 'NP' = 111, COST IS ABOUT 17¢ PER SIMULATION.
C    IF,IN 'NP',Z=2,3,4-THE COLUMN HEADINGS PRINTED FOR DERIVATIVES ARE--
C       DENSITY-D1=IONIZATION,D2=CLASS.DIF.,D3=OBS.LOSS,D4=FIELD DECAY
C       ELECTRON ENERGY-PE1=MICROWAVE HTG.,PE2=ION COLL.,PE3=EXCITATION,
C              PE4=BREMMSTRAHLUNG,PE5=SYNCH.RAD.,PE6=THERMAL CONDUCTION
C       ION ENERGY-PI3=CHARGE EXCHANGE,PI6=THERMAL CONDUCTION
C      THE SIGN CONVENTION OF THE PRINTED NUMBERS IS THAT D1 IS POS FOR
C      PARTICLE GAIN,PE1 IS POS FOR MICROWAVE POWER INPUT.IF PE2 IS POS.,
C      ENERGY GOES FROM ELECTRONS TO IONS.ALL OTHER DERIVATIVES,IF POS,
C      INDICATE A L O S S.

C    C A U T I O N---PLOTTING GETS EXPENSIVE. CALCOMP PLOTTER TIME ALONE
C      COSTS $.70-.80 FOR ONE PLOT. PAGE PLOTTER IS CHEAPER-BUT BOTH
C      PLOTTING METHODS ADD A LARGE COST SIMPLY BY FORCING INCLUSION OF
C      THE WHOLE,ENORMOUS GRAPHICS PACKAGE INTO THE PROGRAM EXECUTABLE
C      ELEMENT. FOR THIS REASON,THIS PROGRAM DOES ITS PLOTTING VIA A
C      SEPARATE SUBROUTINE WHICH MAY BE OMITTED ENTIRELY BY THE FOLLOWING
C      METHOD:
C                1. IF INPUT IS FROM CARDS,REMOVE PLOTTING ROUTINE.
C                2. RIGHT AFTER '@MAP,IX' CARD, PUT ANOTHER CARD:
C                          (@MAP,IX       )
C                           REF GRAFF
C                          (@XQT          )
C      THE EXECUTABLE PROGRAM IS NOW 1/3 THE SIZE OF THE PLOTTING
C      VERSION--AND THUS MUCH CHEAPER TO COMPILE,MAP,AND EXECUTE.

C    SUBROUTINE ADDED IS CALLED AT THE END OF EVERY SIMULATION. IT HAS
C      NO ARGUMENTS. THIS SUBROUTINE MUST BE PROVIDED BY THE USER.
C      AT A MIMIMUM, AT MAY BE THE FOLLOWING:
C             @FOR,IS  ,URNAME
C                   SUBROUTINE ADDED
C                   RETURN
C                   END
C      HOWEVER, THE USER MAY REPLACE IT WITH ANYTHING HE LIKES, TO
C      PASS VALUES ON TO ANOTHER PROGRAM, TO USE HIS OWN PLOTTING
C      ROUTINE, TO SAVE VALUES FROM SEVERAL SIMULATIONS AND PRINT THEM
C      IN ONE TABLE AT THE END, OR TO PUNCH OUTPUT. VIRTUALLY ALL
C      CALCULATION RESULTS ARE EASILY ACCESSED THRU THE MANY COMMON
C      BLOCKS IN THE PROGRAM. ONLY THESE RESTRICTIONS APPLY.
C      1. NEVER CHANGE THE VARIABLES NN (OR NNN) IN BLOCK 'CALOUT'.
C      2. NEVER CHANGE THE 7 ELEMENT ARRAY DEVPAR IN BLOCK 'ALLES'.
C      3. IF PLOTTING IS DONE, THEN NO VARIABLES IN BLOCK 'CALOUT'
C              MAY BE CHANGED, SINCE 'CALOUT' FEEDS THE PLOTTING
C              ROUTINE, WHICH IS CALLED AFTER S.R. ADDED.
```

```
      C          PROGRAM SIMULT-NO PLOT/14 NOV 73
                 DIMENSION ILOOP(102),D(15),NAMA(4),NAMB(6),NAMC(3)
                 COMMON/ALLES/ICONST(6),Z(20),DEVPAR(7),GUN(3)
                 COMMON/CALOUT/SAVE(102,7),SATE(102,15),TIMES(102),VMAX(8),IZ,NN
                 COMMON/MAXIMA/VMAXT(8),VSJMAX(7),DDMAX(15),DDMAXT(15)
                 COMMON/DISIBP/STORE(9),S(15)
                 COMMON/BDB2DT/BDOT,B2,DT
                 EQUIVALENCE(D( 1),DDENS ),(D( 2),DTE   ),(D( 3),DTI   ),
                +           (D( 4),DDENDT),(D( 5),DTEDT ),(D( 6),DTIDT ),
                +           (D( 7),DEAT  ),(D( 8),TEAT  ),(D( 9),TIAT  ),
                +           (D(10),DEAL  ),(D(11),TEAL  ),(D(12),TIAL  ),
                +           (D(12),TDUMA ),(D(14),TDUMB ),(D(15),TDUMC )
                 EQUIVALENCE(Z( 1),PRES  ),(Z( 2),PO    ),(Z( 3),F     ),
                +           (Z( 4),BO    ),(Z( 5),TSTOP ),(Z( 6),TMO   ),
                +           (Z( 7),TMW   ),(Z( 8),TGI   ),(Z( 9),TCRO  ),
                +           (Z(10),BOHMC )
                 EQUIVALENCE(ICONST(1),IPWR ),(ICONST(2),IB   ),(ICONST(3),NGI  ),
                +           (ICONST(4),NP   ),(ICONST(5),IIMAX),(ICONST(6),IPTS )
                 EQUIVALENCE(S( 1),DNWRP),(S( 2),DNT  ),(S( 3),DFC  ),(S( 4),D1   ),
                +           (S( 5),D2   ),(S( 6),D3   ),(S( 7),D4   ),(S( 8),PE1  ),
                +           (S( 9),PE2  ),(S(10),PE3  ),(S(11),PE4  ),(S(12),PE5  ),
                +           (S(13),PE6  ),(S(14),PI3  ),(S(15),PI6  )
                 EQUIVALENCE(STORE(1),DEA  ),(STORE(2),TEA  ),(STORE(3),TIA  ),
                +           (STORE(4),B    ),(STORE(5),P    ),(STORE(6),SJI  ),
                +           (STORE(7),DNEUT),(STORE(8),TIME ),(STORE(9),DNWR)
                 EQUIVALENCE(DEVPAR(1),TMAX  ),(DEVPAR(2),A    ),(DEVPAR(3),AL  ),
                +           (DEVPAR(4),AO    ),(DEVPAR(5),QO   ),(DEVPAR(6),D4CC),
                +           (DEVPAR(7),DECAY )
                 EQUIVALENCE(VMAX(1),DEMAX),(VMAX(2),TEMAX),(VMAX(3),TIMAX),
                +           (VMAX(4),BPMAX),(VMAX(5),PPMAX),(VMAX(6),SJMAX),
                +           (VMAX(7),DNMIN),(VMAX(8),DNMAX)
                 EQUIVALENCE(GUN(1),DEAGUN),(GUN(2),TEAGUN),(GUN(3),TIAGUN)
                 DATA NAMA/'     CD     OL     FD        '/
                +     NAMB/'     IC     EX     BR     SR     TC        '/
                +     NAMC/'     CX     TC        '/

                 BZ     =     1.0
                 RSVC   =   371.0
                 TEION  =    15.6
                 XABS=2.0
                 YABS=0.0
                 ISKIPP=1

      C          ***************************************************************
      C          ***** SELECT MACHINE PARAMETERS *******************************
      C          ***************************************************************


      C          NN IS TOTAL NUMBER OF DATA RUNS TO BE DONE.
      C          SPECIFY DEVICE PARAMETERS.

                 CALL SETSUP(IERR)
                 IF(IERR.EQ.1) GO TO 4999

```

```
      CALL NFTCH
      DO 5000   II=1,NN
C     ****************************************************************
C     ***** MAIN DATA INPUT--SEE S.R. VALIN FOR DATA MEANINGS **********
C     ***** INITIALIZIATION ALSO OCCURS IN S.R. VALIN ******************
C     ****************************************************************

      III=II
      CALL VALIN(III,Q,TWALL)

C     SET SOME INTERNAL FLAGS
      IGRAPQ= NP/100
      NP    = NP-100*IGRAPQ
      LOSSPT= NP/10
      NP    = NP-10*LOSSPT
      ISAVE = IIMAX/IPTS
      ICOUNT= ISAVE
      ITERS = 0
      IZ    = 0
      NPVAL = 0
      NPMAX = 0
      IF((NP.EQ.2).OR.(NP.EQ.4)) NPVAL=1
      IF(NP.GE.3) NPMAX=1

C     CLEAR SOME ARRAYS.
      DO 1080 IQT=1,15
      IF(IQT.GE.4) S(IQT)=0.0
      D(IQT)       =0.0
      DDMAX (IQT)=0.0
      DDMAXT(IQT)=0.0
 1080 CONTINUE
      DO 1081 IQT=1,7
      VMAXT (IQT)=0.0
      VSJMAX(IQT)=0.0
 1081 CONTINUE
C     INITIALIZE MAXIMUM VALUES
      DEMAX = DEA
      TEMAX = TEA
      TIMAX = TIA
      DNMIN = 335.0*PRES
      DNMAX = 315.0*PRES
      BPMAX = 0.1*BO
      PPMAX = 0.1*PO
      SJMAX = 0.104*DEA*SQRT(TEA)
      GO TO 5001
C     ****************************************************************
C     ***** SECOND ORDER METHOD:  AT TIME T,EVALUATE B,P,DNEUT,DEO *****
C     ***** AS FUNCTIONS OF (DEA(T),TEA(T),TIA(T),T). *****************
C     ***** THEN INCREMENT DEA,TEA,TIA BY,E.G. FOR DEA, THE SCHEME *****
C     *****       DEA(T+.5*DT)=DEA(T)+(DDENS/DT)*(.5*DT)    *************
C     *****                   =DEA(T)+.5*DDENS              *************
C     ***** AND THEN CALCULATING THE DERIVATIVES BY,E.G. FOR DEA, ******
C     *****       DDENS =(DDENS/DT)(B,P,DEO,DNEUT,DEA(T+.5*DT),...)*DT **
C     ***** AND FINALLY CALCULATE THE VALUE,E.G.,FOR DEA, **************
C     *****       DEA(T+DT)=DEA(T)+DDENS    ****************************
C     ****************************************************************
C     ****************************************************************
```

```
 8601 CONTINUE
C     INCREMENT ITERATION COUNTER. IF,UP TO THIS POINT,ITERS=I,
C     THEN WE ARE ABOUT TO DO THE (I+1)ST ITERATION. (THE INITIAL
C     JUMP TO 8601 DOES NOT COUNT AS AN ITERATION.)
      ITERS=ITERS+1

C     INCREMENT TIME
      TIME=SNGL((DBLE(FLOAT(ITERS))*DBLE(TSTOP))/DBLE(FLOAT(IIMAX)))
      IF(NGI.EQ.1) GO TO 1082
      IF((TGI-1.0E-10).GT.TIME) GO TO 1082
      NGI=1
      DEA=DEAGUN
      TEA=TEAGUN
      TIA=TIAGUN
 1082 CONTINUE
C     ******************************************************************
C     ***** CALCULATE FIELD ********************************************
C     ******************************************************************

      CALL MAGFLD

C     ******************************************************************
C     *****  CALCULATE POWER  ******************************************
C     ******************************************************************

      CALL MICPOW

C     ******************************************************************
C     ***** CALCULATE NEUTRAL DENSITY **********************************
C     ******************************************************************

      GLC=2.0E-3*TEA+1.0
      DC=TEION/TEA
      RA=RSVC*EXP(-DC)*(1./(20.+DC)+ALOG(1.25*BZ*(1.+1./DC)))/((1.+DC)*
     +SQRT(TEA))
      DRDA=RA*DEA*A
      DNWRP=DNWR
      DNTO=DNT
      DFCO=DFC
      DNT=      (322.0*PRES+DNWR)*EXP(-(4.1E-7/SQRT(TWALL))*DRDA)
      DFC=0.04*(322.0*PRES+DNWR)*EXP(-1.09E-7*DRDA)
      IF(DNT.GT.DNTO) DNT=DNT+(DNTO-DNT)*EXP(-1.0E6*SQRT(TWALL)*DT/A)
      IF(DFC.GT.DFCO) DFC=DFC+(DFCO-DFC)*EXP(-3.4E6*DT/A)
      DNEUT=DNT+DFC
      RA=RA*DNEUT
      RB=((.001/A/A)*((330.*DEA)/SQRT(TEA)+DNEUT*TEA))/B2
     ++((6250.*BOHMC/A/A)*TEA)/B
      RC=(2.0E5*AO/A/A/AL)*SQRT(TEA+TIA)
      RD=D4CC*AMAX1(0.0,-BDOT)/B
      DNWR=DNWR+(GLC*(RB+RC+RD)-RA)*DEA*DT

C     CHECK TO SEE IF ANY DIVISION BY ZERO HAS OCCURRED.
C     IF SO,PRINT A MESSAGE AND JUMP OUT. IF NOT,CONTINUE.
      IF QUOTIENT OVERFLOW 200,5001
  200 PRINT 201,ITERS
  201 FORMAT(15X,'++++DIVIDE  BY ZERO+++      ','I=',I3)
```

```
      GO TO 5003

C     IF TIME=0.0,THIS IS THE LOOP ENTRY POINT.
 5001 CONTINUE
      SJI=0.104*DEA*SQRT(AMAX1(TEA,TIA))
C     ******************************************************************
C     ***** IF TIME TO SAVE SOME THINGS,THEN SAVE THEM *****************
C     ******************************************************************
      IF(ICOUNT.NE.ISAVE) GO TO 1083
            ICOUNT=0
            IF(IZ.GE.101) GO TO 34
            IZ=IZ+1
            IF(NPVAL.EQ.0) GO TO 32
            DO 30 J=4,15
            SATE(IZ,J)=S(J)*DEAS
   30       CONTINUE
            DO 31 J=1,3
   31       SATE(IZ,J)=S(J)
   32       CONTINUE
            DO 33 INZ=1,7
            SAVE(IZ,INZ)=STORE(INZ)
   33       CONTINUE
            TIMES(IZ)=STORE(8)
            ILOOP(IZ)=ITERS
   34       CONTINUE
            NMAX=4
            NMBX=6
            NMCX=3
            IF(LESSPT.EQ.1) GO TO 345
            DMA=AMAX1(D2,D3,D4)
            DMB=AMAX1(ABS(PE2),PE3,PE4,PE5,ABS(PE6))
            DMC=AMAX1(ABS(PI3),ABS(PI6))
            IF(DMA.GT.0.) NMAX =INT(D2/DMA)+2*INT(D3/DMA)
     +                        +3*INT(D4/DMA)
            IF(DMB.GT.0.) NMBX= INT(ABS(PE2)/DMB)+2*INT(PE3/DMB)
     +                        +3*INT(PE4/DMB)+4*INT(PE5/DMB)
     +                        +5*INT(ABS(PE6)/DMB)
            IF(DMC.GT.0.) NMCX= INT(ABS(PI3)/DMC)+2*INT(ABS(PI6)/DMC)
  345       CONTINUE
            PRINT 2002,ITERS,TIME,DEA,TEA,TIA,DNEUT,B,P,SJI,
     +             NAMA(NMAX),NAMB(NMBX),NAMC(NMCX)
 2002       FORMAT(4X,I5,3PF11.2,7(0PF12.4),3A6)
 1083 CONTINUE
      ICOUNT=ICOUNT+1
C     ******************************************************************
C     ***** CHECK FOR MAXIMUM VALUES ***********************************
C     ******************************************************************
            KEYSJ=0
            DO 35 M=1,6
            IF(STORE(M).LE.VMAX(M)) GO TO 35
            VMAX(M)  =STORE(M)
            VMAXT(M) =TIME
            IF(M.EQ.6) KEYSJ=1
   35       CONTINUE
            IF(KEYSJ.NE.1) GO TO 37
            DO 36 M=1,7
            VSJMAX(M)=STORE(M)
```

```
 36               CONTINUE
                  KEYSJ=0
 37               CONTINUE
                  IF(STORE(7).LT.VMAX(8)) GO TO 375
                  VMAX(8)=STORE(7)
                  VMAXT(8)=STORE(8)
 375              IF(STORE(7).GE.VMAX(7)) GO TO 38
                  VMAX(7)=STORE(7)
                  VMAXT(7)=TIME
 38               CONTINUE
C      ***********************************************************************
C      ***********************************************************************

C      TEMPORARILY INCREMENT DEA,TEA,TIA TO GET VALUES AT (TIME+.5*DT).
       DEAT =DEA
       DEA  =DEA +0.5*DDENS
       DEAS =DEA
       TEAT =TEA
       TEA  =TEA +0.5*DTE
       TIAT =TIA
       TIA  =TIA +0.5*DTI
C      ***********************************************************************
C      ***** CALCULATE D()/DT'S CAUSED BY THE VARIOUS ********************
C      ***** PHYSICAL PROCESSES CONSIDERED ********************************
C      ***** THE EQUATIONS THAT FOLLOW ARE TO BE MULTIPLIED **************
C      ***** BY DEA TO GET THE ACTUAL FUNCTIONS. THAT COMMON ************
C      ***** FACTOR DEA HAS BEEN FACTORED OUT AND MOVED TO THE **********
C      ***** 'INCREMENT INDEPENDENT VARIABLES' STEP. *********************
C      ***********************************************************************

C      D1 TO D4 REPRESENT PARTICLE DENSITY CHANGE MECHANISMS.

       DC=TEION/TEA
       RSVMEX=RSVC*(1./(20.+DC)+ALOG(1.25*BZ*(1.+1./DC)))/((1.+DC)*
      +SQRT(TEA))
       RSV=RSVMEX*EXP(-DC)
C         D1 IS DN/DT DUE TO IONIZATION
       D1=RSV*DNEUT
C         D2 IS DN/DT DUE TO DIFFUSION
       D2A=((.001/A/A)*((330.0*DEA)/SQRT(TEA)+DNEUT*TEA))/B2
       D2B=((6250.0*BOHMC/A/A)*TEA)/B
       D2 =D2A+D2B
C         D3 IS DN/DT DUE TO OBSTACLE LOSSES
       D3=(2.0E5*AO/A/A/AL)*SQRT(TEA+TIA)
C         D4 IS DN/DT DUE TO FIELD DECAY
       D4=D4CC*AMAX1(0.0,-BDOT)/B

C      PE1 TO PE6 REPRESENT ELECTRON ENERGY DENSITY CHANGE MECHANISMS.

C      DEO IS A CORRECTION FOR FINITE CAVITY Q.
       DEO=F*F*((0.0045*((F/B)**4.))+123.0*((B/F)**0.66667))/Q
C         PE1 IS DUE/DT DUE TO MICROWAVES
       PE1=((2.0E9/A/A/AL)*P)/(DEA+DEO)
C         PE2 IS DUEDT DUE TO ION COLLISIONS
       PE2=2.3*DEA*(TEA-TIA)*ALOG(5.2E11*TEA**3/(ABS(DEA)*(40.0+TEA)))/
      +TEA**1.5
C         PE3 IS DUE/DT DUE TO ALL EXCITATION PROCESSES.
```

See note to left

```
      PE3=[illegible]
     +[illegible]
C        PE4 IS DUE/DT DUE TO BREMSSTRAHLUNG
      PE4=(1.0E-4)*DEA*SQRT(TEA)
C        PE5 IS DUE/DT DUE TO SYNCHROTRON RADIATION
      PE5=((3.87E-3/2.04E5)*B2*TEA)*(TEA+2.04E5)
C        PE6 IS DUE/DT DUE TO THERMAL CONDUCTION
      PE6=(2.5*D2A+2.0*D3+D4)*(TEA-TWALL)

C     PE2,PI3,PI6 REPRESENT ION ENERGY DENSITY CHANGE MECHANISMS.

C        PI3 IS DUE/DT DUE TO CHARGE EXCHANGE
      PI3=(0.0186*DNEUT*TIA*TIA*(TIA-TWALL))/(TIA+100.)
C        PI6 IS DUE/DT DUE TO THERMAL CONDUCTION
      PI6=(2.5*D2A+2.0*D3+D4)*(TIA-TWALL)

C     IF OPTION FOR PRINT-OUT OF MAXIMUM ABSOLUTE VALUES OF DERIVATIVES
C     IS SELECTED (NP=2 OR NP=4) THEN CHECK FOR THEIR MAXIMUM VALUES.
      IF(NPMAX.EQ.0) GO TO 40
                DO 39  IDMAX=1,15
                IF(ABS(S(IDMAX)*DEAS).LE.DDMAX(IDMAX)) GO TO 39
                DDMAX (IDMAX)=ABS(S(IDMAX)*DEAS)
                DDMAXT(IDMAX)=TIME
   39           CONTINUE
   40 CONTINUE
C     ***************************************************************
C     ***** INCREMENT DEPENDENT VARIABLES ****************************
C     ***************************************************************
C     CALCULATE D(DENSITY)/DT
      DDENDT=(D1-D2-D3-D4)*DEA
      DEAL=DEA/(2.0*DT)
      IF(ABS(DDENDT).GT.DEAL) DDENDT=SIGN(DEAL,DDENDT)

C     CALCULATE D(ELECTRON TEMPERATURE)/DT
      DUEDT=(PE1-PE2-PE3-PE4-PE5-PE6)*DEA
      DTEDT=((2./3.)*DUEDT-TEA*DDENDT)/DEA
      TEAL=TEA/(2.0*DT)
      IF(ABS(DTEDT).GT.TEAL) DTEDT=SIGN(TEAL,DTEDT)

C     CALCULATE D(ION TEMPERATURE)/DT
      DUIDT=(PE2-PI3-PI6)*DEA
      DTIDT=((2./3.)*DUIDT-TIA*DDENDT)/DEA
      TIAL=TIA/(2.0*DT)
      IF(ABS(DTIDT).GT.TIAL) DTIDT=SIGN(TIAL,DTIDT)

C     INCREMENT DENSITY
      DDENS =DDENDT*DT
      DEA   =DEA   +DDENS

C     INCREMENT ELECTRON TEMPERATURE
      DTE   =DTEDT *DT
      TEA   =TEA   +DTE

C     INCREMENT ION TEMPERATURE
      DTI   =DTIDT *DT
      TIA   =TIA   +DTI
```

PE3 WAS CORRECTED TO .95* DNEUT*RSVMEX *(TEA ** 1.096) *(EXP(11.99/(TEA**.738) -DC)-1.036*EXP(-DC))

```
      C      END OF LOOP.
      C      AT THIS TIME,ALTHOUGH TIME=TIME, WE HAVE JUST FINISHED
      C      CALCULATING DEA,TEA,TIA FOR TIME=TIME+DT.
             IF(ITERS.LT.IIMAX) GO TO 8601
      5003   CONTINUE
      C      ***************************************************************
      C      ***** PRINTING ************************************************
      C      ***************************************************************
      C      RECORD MAXIMUM VALUES
             PRINT 2003,(VMAX(I),I=1,3),VMAX(7),(VMAX(J),J=4,6),
            2(VMAXT(K),K=1,3),VMAXT(7),(VMAXT(L),L=4,6),(VSJMAX(M),M=1,3),
            3VSJMAX(7),(VSJMAX(N),N=4,6)
      2003   FORMAT(1H0,5X,'MAXIMUM VALUES',7(1PE12.4),/,6X,'AT TIME        ',
            +7(1PE12.4),/,6X,'VALUE AT SJMAX',7(1PE12.4))
             IF(NP.EQ.1) GO TO 743
             PRINT 2004
      2004   FORMAT(1H1,30X,'FUNCTIONAL VALUES USED IN CALCULATING DERIVATIVES'
            2,/,1X,'TIME=MS      DNWR      DNT      DFC      D1      D2      D3
            3    D4      PE1      PE2      PE3      PE4      PE5      PE6      PI3
            4 PI6')
             IF(NPVAL.EQ.0) GO TO 742
             DO 19 ML=1,IZ
             PRINT 2005,TIMES(ML),(SATE(ML,NL),NL=1,15)
      2005   FORMAT(1X,3PF7.3,2X,15(1PE8.2))
      19     CONTINUE
      742    CONTINUE
             IF(NPMAX.EQ.0) GO TO 743
             PRINT 2006,(DDMAX(MY),MY=1,13),(DDMAXT(MM),MM=1,13)
      2006   FORMAT(1H0,'MAX VALUE  ',12(1PE9.3,),/,2X,'AT TIME    ',
            213(1PE9.3))
      743    CONTINUE
             CALL ADDED
             IF(IGRAPQ.EQ.1) GO TO 5000
             IF((IGRAPQ.EQ.2).AND.(ISKIPP.EQ.2)) GO TO 744
             ISKIPP=2
             CALL INITPL(DUMDUM,10.8)
      744    CONTINUE
             CALL GRAFF(XABS,YABS,IGRAPQ)
      5000   CONTINUE
             IF(IGRAPQ.NE.2) GO TO 4998
             CALL ENDPLT
      4998   CONTINUE
      4999   CONTINUE
             STOP
             END
```

EF,STL A'.SIMIN

INPUT ROUTINE (Also most initialization)

LE 8 CROSS-REFERENCED BY XREF-1 AT [redacted]

```
              SUBROUTINE SETSUP(IERR)
              DIMENSION PARAMS(4,7),MACTYP(5)
              COMMON/DISIBP/STORE(9),S(15)
              COMMON/ALLES/ICONST(6),Z(20),DEVPAR(7),GUN(3)
              COMMON/CALOUT/SAVE(102,7),SATE(102,15),TIMES(102),VMAX(8),IZ,NN
              COMMON/BDB2DT/BDOT,B2,DT
              DATA MACTYP/'BIGLEVBIGSUPLITTLEQUADXXOTHERX'/
        C                        BIGLEV     BIGSUP     LITTLE     QUADXX
              DATA PARAMS/           .043,      .043,      .005,      .002,
             +                    50.   ,    50.   ,    18.   ,     6.   ,
             +                   800.   ,   800.   ,   270.   ,   160.   ,
             +                     0.   ,   700.   ,    90.   ,     3.   ,
             +                 20000.   , 20000.   ,  2000.   ,   500.   ,
             +                      .5  ,      .5  ,      .5  ,     1.   ,
             +                      .08 ,      .08 ,      .0  ,      .005 /
        C     NN IS TOTAL NUMBER OF DATA RUNS TO BE DONE.
        C     MACHIN IS A SIX-LETTER WORD DESIGNATING CONFINEMENT DEVICE USED.
        C     SEE 'EXPLAIN' ROUTINE FOR OPTIONS.
              IERR=0
              READ 1000,NN,MACHIN
        1000  FORMAT(I3,A6)
              IF(NN.EQ.0) GO TO 4999
              DO 1001 J=1,5
              IF(MACHIN.NE.MACTYP(J)) GO TO 1001
              IF(J.EQ.5) GO TO 1003
              JT=J
              GO TO 1005
        1001  CONTINUE
              PRINT 1002
        1002  FORMAT(1X,'       COLUMNS 4-9 OF FIRST CARD FOLLOWING XQT CARD MUST
             +HOLD A 6 LETTER WORD DESIGNATING MACHINE TYPE',/,1X,'       --USE ON
             +E OF THE WORDS BIGLEV,BIGSUP,LITTLE,QUADXX,OTHERX,')
        4999  IERR=1
              RETURN

        C     SPECIFY DEVICE PARAMETERS.
        C     SEE 'EXPLAIN' ROUTINE,UNDER CARD 2.THE 7 VARIABLES
        C     LISTED THERE ARE EQUIVALENCED TO DEVPAR(1)-DEVPAR(7).
        1003  READ 1004,(DEVPAR(K),K=1,7)
        1004  FORMAT()
              GO TO 1007
        1005  DO 1006 J=1,7
        1006  DEVPAR(J)=PARAMS(JT,J)
        1007  CONTINUE
              RETURN

              ENTRY VALIN(II,Q,TWALL)

        C     SEE 'EXPLAIN' ROUTINE,UNDER CARD A FOR THE INPUT VARIABLES AND
        C     THEIR DEFINITIONS.IN THE ORDER LISTED THERE,THEY ARE EQUIVALENCED
        C     TO THE 6 ELEMENTS OF MATRIX 'ICONST' AND THE FIRST 10 ELEMENTS
        C     OF MATRIX 'Z'(ONLY 10 ELEMENTS OF Z ARE USED AT THIS TIME.).

              READ 2001,(ICONST(I),I=1, 6),(Z(J),J=1,10)
```

```
      2001  FORMAT()

      C     CONDITION SOME INPUT VALUES
      C     PRES=Z(1)
            IF(Z(1).LT.0.0) Z(1)=-2.5*Z(1)
      C     TSTOP THRU (Z(5) THRU Z(9)) ARE INPUT IN MILLISECONDS.
      C     THE FOLLOWING LOOP CONVERTS THEM TO SECONDS.
            DO 2101 MXX=5,9
            Z(MXX)=Z(MXX)/1000.
      2101  CONTINUE
      C     REDEFINE TMW SO IT GIVES MICROWAVE OFF TIME RATHER THAN
      C     MICROWAVE PULSE WIDTH. (NEW TMW=TMO+(OLD TMW)).
            Z(7)=Z(6)+Z(7)
      C     ACTUAL Q IS A FUNCTION OF MICROWAVE FREQUENCY--Q=Q0*SQRT(F/2.45).
            Q=DEVPAR(5)*SQRT(Z(3)/2.45)

      C     RECORD INPUT PARAMETERS AND FLAGS.
            PRINT 2010,II,MACHIN,(DEVPAR(IL),IL=1,5),DEVPAR(7)
            PRINT 2011,(ICONST(IJ),IJ=1, 6)
            PRINT 2012,(Z(JI),JI=1,4)
            PRINT 2013,(Z(JI),JI=5,9)
            PRINT 2014,Z(10)
      2010  FORMAT(1H1,5(1H*),' RUN ',I2,2X,A6,' PARAMETERS-TMAX(MS)=',3PF4.0,
           +'  PLAS RAD =',0PF4.0,'  PLAS LENGTH=',0PF4.0,'  OBS AREA=',0PF4.0
           +,'  Q=',0PF6.0,'  FLD DECAY(SEC)=',1PE7.1)
      2011  FORMAT(1X,12(1H*),'OPTIONS-POWER SHAPE=',I2,'    MAG FLD=',I2,'    G
           +UN INJ=',I2,'    PRINT=',I3,'    ITERATIONS=',I5,23H   NUM OF PRT'D
           +POINTS= ,I3)
      2012  FORMAT(1X,12(1H*),7X,'EXPER PARAMS-TRUE PRESSURE=',1PE8.2,'TORR
           +POWER IS',1PE8.2,'WATTS AT',0PF5.2,'GHZ   MAG FIELD=',0PF5.2,'KG')
      2013  FORMAT(1X,12(1H*),20X,'TSTOP(MS)=',3PF6.3,3X,'TMO(MS)=',3PF6.3,3X
           +,'TMW(MS) =',3PF6.3,3X,'TGI(MS) =',3PF6.3,3X,'TCRO(MS) =',3PF6.3)
      2014  FORMAT(1X,12(1H*),20X,'BOHM COEF=',1PE8.2,'       NOTE THAT GAUGE PR
           +ESSURE IS 2.5*TRUE PRESSURE FOR H2')

      C     SET SOME INITIAL CONDITIONS

      C     STORE(1)=DEA=INITIAL DENSITY IN 10**9/CC
      C     STORE(2)=TEA=INITIAL ELECTRON TEMPERATURE IN EV
      C     STORE(3)=TIA=INITIAL ION TEMPERATURE IN EV
            STORE(1) = 0.001
            STORE(2) = 0.1
            STORE(3) = 0.025
      C     IF ICONST(5)=IIMAX.LT.0, READ IN NEW VALUES FOR DEA,TEA,TIA
            IF(ICONST(5).GT.0) GO TO 2102
            READ 2001,(STORE(IJB),IJB=1,3)
            IIMAX=-IIMAX
      2102  CONTINUE

      C     STORE(4)=B     =1.0E-5 KG  INITIALLY
            STORE(4)= 1.0E-5

      C     STORE(5)=P
            STORE(5)= Z(2)
            IF((ICONST(1).EQ.3).OR.(ICONST(1).EQ.5)) STORE(5)=0.0

      C     STORE(6)=SJI   =0.104*DEA*SQRT(AMAX1(TEA,TIA))
```

```
      STORE(6)= 0.104*STORE(1)*SQRT(AMAX1(STORE(2),STORE(3)))

C     STORE(9)=DNWR  =0.0  INITIALLY
C     S(2)    =DNT   =     (322.0*PRES)  INITIALLY
C     S(3)    =DFC   =0.04*(322.0*PRES)  INITIALLY
C     STORE(7)=DNEUT =DNT+DFC  INITIALLY
      STORE(9)= 0.0
      S(2)    =      (322.0*Z(1))
      S(3)    = 0.04*(322.0*Z(1))
      STORE(7)= S(2)+S(3)

C     STORE(8)=TIME  =0.0  INITIALLY
      STORE(8)= 0.0

C     TWALL IS WALL TEMPERATURE IN EV
      TWALL= 0.025

C     DT IS ITERATION STEP SIZE,=TSTOP/IIMAX
      DT= Z(5)/FLOAT(ICONST(5))

C     SET GUN INJECTION PARAMETERS.
C     GUN(1)=DEAGUN=GUN INJECTION DENSITY IN 10**9/CC
C     GUN(2)=TEAGUN=GUN INJECTION ELECTRON TEMPERATURE IN EV
C     GUN(3)=TIAGUN=GUN INJECTION ION TEMPERATURE IN EV
      GUN(1)   = 1.0
      GUN(2)   =10.0
      GUN(3)   =40.0
C     IF ICONST(3)=NGI=3, READ IN NEW VALUES FOR DEAGUN,TEAGUN,TIAGUN
      IF(ICONST(3).NE.3) GO TO 2103
      READ 2001,(GUN(IJA), IJA=1,3)
2103  CONTINUE


C     PRINT MAIN OUTPUT HEADING
      PRINT 2002
2002  FORMAT(104X,'    DOMINANT LOSS',/,5X,'STEP   TIME(MS)     DENSITY
     +         TE           TI        DNEUT              B        POWER
     + JSAT  DENS     TE     TI')
      RETURN
      END
```

REF,STL A'.BPOWER *CALCULATION OF B & P*

LE 15 CROSS-REFERENCED BY XREF-1 AT [redacted]

```
      SUBROUTINE MAGFLD
      COMMON/DISIBP/STORE(9),S(15)
      COMMON/ALLES/ICONST(6),Z(20),DEVPAR(7),GUN(3)
      COMMON/BDB2DT/BDOT,B2,DT
      EQUIVALENCE(Z( 1),PRES  ),(Z( 2),PO    ),(Z( 3),F     ),
     +           (Z( 4),BO    ),(Z( 5),TSTOP ),(Z( 6),TMO   ),
     +           (Z( 7),TMW   ),(Z( 8),TGI   ),(Z( 9),TCRO  ),
     +           (Z(10),BOHMC )
      EQUIVALENCE(ICONST(1),IPWR ),(ICONST(2),IB   ),(ICONST(3),NGI  ),
     +           (ICONST(4),NP   ),(ICONST(5),IIMAX),(ICONST(6),IPTS )
      EQUIVALENCE(STORE(1),DEA  ),(STORE(2),TEA  ),(STORE(3),TIA  ),
     +           (STORE(4),B    ),(STORE(5),P    ),(STORE(6),SJI  ),
     +           (STORE(7),DNEUT),(STORE(8),TIME ),(STORE(9),DNWR)
      EQUIVALENCE(DEVPAR(1),TMAX  ),(DEVPAR(2),A    ),(DEVPAR(3),AL  ),
     +           (DEVPAR(4),AO    ),(DEVPAR(5),QO   ),(DEVPAR(6),D4CC),
     +           (DEVPAR(7),DECAY )
C     ******************************************************************
C     ***** CALCULATE FIELD ********************************************
C     ******************************************************************
      PI=3.1415926
      BOLD=B
      GO TO (110,111,112),IB
  110 CONTINUE
      B=BO*SIN((PI/TMAX)*TIME)*EXP(-(0.5/TMAX)*TIME)/.7887+1.0E-5
      B=SQRT(ABS(B*B-(4.05E-8)*DEA*(TEA+TIA)))
      GO TO 113          —BCRO = B
  111 CONTINUE
      IF(TIME.LE.TCRO) GO TO 110
B = BCRO* [redacted]EXP(-(TIME-TCRO)/DECAY)
      B=SQRT(ABS(B*B-(4.05E-8)*DEA*(TEA+TIA)))
      GO TO 113
  112 B=BO
      B=SQRT(ABS(B*B-(4.05E-8)*DEA*(TEA+TIA)))
  113 CONTINUE
      BDOT=(B-BOLD)/DT
      B2=B*B
      RETURN

      ENTRY MICPOW
C     ******************************************************************
C     *****  CALCULATE POWER   *****************************************
C     ******************************************************************
      TP1=TIME+1.0E-10
      TM1=TIME-1.0E-10
      GO TO (608,606,601,602,603,604,607),IPWR
  601 CONTINUE
      IF(TP1.GE.TMO) GO TO 606
      GO TO 605
  602 CONTINUE
      IF(TM1.LE.TMO) GO TO 606
      GO TO 605
  603 CONTINUE
      IF((TP1.LT.TMO).OR.(TM1.GT.TMW)) GO TO 605
      GO TO 606
```

```
  604 CONTINUE
      IF((TP1.LT.TMO).OR.(TM1.GT.TMW)) GO TO 606
  605 CONTINUE
      P=0.0
      GO TO 609
  606 CONTINUE
      P=PO
      GO TO 609
  607 CONTINUE
      IF((IPWR.EQ.7).AND.(BDOT.LT.0.0)) GO TO 605
  608 P=AMAX1(0.0,2.0*PO*(B/BO-0.5))
  609 CONTINUE
      RETURN
      END
```

EF,STL A.NUPLOT

PLOTTING ROUTINE

LE 1 CROSS-REFERENCED BY XREF=1 AT [redacted]

```
                 SUBROUTINE GRAFF(XABS,YABS,IGRAPQ)
                 DIMENSION NMIN(7),SCDATT(10),SCDATY(10,7),TBDS(2),YBDS(2,7),
                +          LABL(5),LABLE(3,7),IK(7),XDEM(7),XLABL(7),II(3),
                +          IJ(3),JDASH(7),YLABL(7),S(102,7),LABLH(9),LHDG(7,4),
                +          YHDG(4),XHDG(4),HDGH(4),LBPEN(5),XBL(5),XBH(5)
                 COMMON/CALOUT/SAVE(102,7),SATE(102,15),TIMES(102),VMAX(8),IZ,NNN
                 DATA LABLE/'ELEC DENS$$          TES$$                TIS$$
                +NEUT DENS$$         ION SAT CURS$$     POWERS$$            MAG FIELDS$$
                +      '/LABL/5*'        '/LABLH/9*'        '/YBDS/14*0./
                 DATA LHDG/'MULTIPOLE SIMULATIONS$$                          DENSITY=10**9
                +/CM**3    SAT CUR=MA/CM**2$$ TEMPERATURE=EV          POWER=WATTS
                +  $$                       MAG FIELD=KGAUSS$$$ '/
                 DATA JDASH/5HSOLID,1,5HSOLID,1,5HSOLID,1,4/LBPEN/2HUP,4HDOWN,2HUP,
                +     2*4HDOWN/XLABL/.55,5.425,.55,5.425,.55,5.425,6.225/II/1,3,5/
                +     IJ/2,4,7/IK/1,2,3,7,6,5,4/XDEM/.7,5.1,.7,5.1,.7,5.1,5.9/
                +     XBL/5.7,5.8,5.7,2*5.8/XBH/2*.6,2*3.2,.6/
                +     YHDG/.575,.35,.2,.05/HDGH/.175,3*.1/XHDG/1.75,2*1.55,1.6/
                +     YLABL/1.1125,2*1.725,1.1125,.9375,1.4625,1.1125/
                 TEMP=VMAX(7)
                 VMAX(7)=VMAX(8)
                 VMAX(8)=TEMP
                 GO TO (3000,1000,2000),IGRAPQ
         1000    XABS=XABS+9.
                 YABS=0.0
                 UMINN=XABS
                 VMINN=YABS
                 UMAXX=UMINN+7.
                 VMAXX=VMINN+3.3
                 TBDS(1)=TIMES(1)
                 TBDS(2)=TIMES(IZ)
                 DO 10000 IPAGEZ=1,3
                 CALL PAGDEF(UMINN,VMINN,UMAXX,VMAXX,6HNORMAL,6HBORDER)
                 I1=II(IPAGEZ)
                 I2=IJ(IPAGEZ)
                 CALL SCALE(TBDS,2,SCDATT,6HLINEAR,1,10)
                 DO 100 I=I1,I2
                 K=IK(I)
                 YBDS(1,K)=VMAX(K)
         C       LABLE THE GRAPH
                 DO 20 J=1,3
         20      LABL(J)=LABLE(J,I)
                 CALL PLTEXT(XLABL(I),YLABL(I),LABL,.175,90.)
         C       PUT IN DEMONSTRATION LINES
                 CALL PLOT(XDEM(I),1.4,2HUP)
                 CALL DSHMOD(4HPERM,JDASH(I))
                 CALL PLOT(XDEM(I),2.4,DASH(0.))
         C       DEVELOP SCALING PARAMETERS.
                 CALL SCALE(YBDS(1,K),2,SCDATY(1,K),6HLINEAR,1,NMIN(K))
                 CALL BASIS(.8,.6,SCDATT,4.2,0.,SCDATY(1,K),2.6,90.)
         C       NOW DRAW THE ACTUAL GRAPH.
                 CALL DSHCLR(5HCLEAR)
         100     CALL LINE(TIMES,SCDATT,SAVE(1,K),SCDATY(1,K),IZ,4HNONE,
                +          JDASH(I),6HCLOSED)
         C       NOW DRAW AXES.
```

```
      I3=I1+1
      IA=IK(I1)
      IB=IK(I3)
      CALL DSHMOD(4HPERM,5HSOLID)
      CALL AXES(.8,.6,SCDATT,4.2,'TIME$$',SCDATY(1,IA),2.6,0,4HNONE)
      CALL AXLIN(SCDATY(1,IB),SCDATT,4HTERM,6HINSIDE,5HTRNSP,4HNONE,
     +            4HNONE,'$$')
      IF(IPAGEZ.NE.3) GO TO 102
C     DRAW AND LABLE THE MAG FIELD AXIS.
      DO 77 I=1,5
77    CALL PLOT(XBL(I),XBH(I),LBPEN(I))
      K=NMIN(4)-1
      AZ=.6
      IF(K.LE.0) GO TO 79
      DZ=2.6/FLOAT(K+1)
      DO 78 I=1,K
      AZ=AZ+DZ
      CALL PLOT(5.75,AZ,2HUP)
78    CALL PLOT(5.8,AZ,4HDOWN)
79    CALL PLNUMB(5.95,.55,0.,4HF*.1,.1,0.)
      CALL PLNUMB(5.95,3.1,YBDS(2,7),4HF*.3,.1,0.)
C     CHANGE PAGE PARAMETERS AND GET READY TO DEFINE THE NEXT PAGE.
102   VMINN=VMAXX
10000 VMAXX=VMAXX+3.3
C     PRINT GRAPH HEADING AND GRAPHING UNITS.
      CALL DSHCLR(5HCLEAR)
      CALL PAGDEF(UMINN,9.9,UMAXX,10.7,6HNORMAL,6HBORDER)
      DO 1084 I=1,4
      DO 1082 J=1,7
1082  LABLH(J)=LHDG(J,I)
1084  CALL PLTEXT(XHDG(I),YHDG(I),LABLH,HDGH(I),0.)
      GO TO 3000
2000  DO 194 J=1,7
194   IF(VMAX(J).LE.0.0) VMAX(J)=1.
      DO 195 I=1,7
      DO 195 J=1,IZ
195   S(J,I)=SAVE(J,I)/VMAX(I)
      CALL GRAPH2(TIMES,'R',S(1,1),IZ,'6X6','NONE','MULTIPOLE SIMULATIO
     +N..','TIME..','DENSITY AND TEMP (NORMALIZED)..','D')
      CALL GRPH2V(TIMES,'R',S(1,2),'R',IZ,'NONE','E')
      CALL GRPH2V(TIMES,'R',S(1,3),'R',IZ,'NONE','I')
      CALL GRPH2V(TIMES,'R',S(1,7),'R',IZ,'NONE','N')
      CALL GRAPH2(TIMES,'R',S(1,4),IZ,'6X6','NONE','MULTIPOLE SIMULATIO
     +N..','TIME..','FIELD AND POWER(NORMALIZED','B')
      CALL GRPH2V(TIMES,'R',S(1,5),'R',IZ,'NONE','P')
      CALL GRPH2V(TIMES,'R',S(1,6),'R',IZ,'NONE','J')
      CALL GRPHND
3000  RETURN
      END
```

```
***** RUN  1  BIGSUP PARAMETERS-TMAX(MS)= 43.  PLAS.RAD.= 50.  PLAS.LENGTH=800.  OBS.
*************OPTIONS-POWER SHAPE= 2   MAG.FLD= 1   GUN INJ= 1   PRINT=222   ITERATIONS
************         EXPER PARAMS-TRUE PRESSURE= 2.50-01TORR   POWER IS 1.00+02WATTS AT
************                       TSTOP(MS)=43.000   TMD(MS)=  .000   TMW(MS) =  .000
************                       BOHM COEF= 0.00        NOTE THAT GAUGE PRESSURE IS 2.
```

STEP	TIME(MS)	DENSITY	TE	TI	DNEUT	B	
0	.00	.0010	.1000	.0250	83.7200	.0000	1
30	.86	.0010	8.8538	.0262	83.7200	.0788	1
60	1.72	.0149	70.4449	.0044	83.7016	.1558	1
90	2.58	.7673	16.3194	.0066	83.0519	.2306	1
120	3.44	1.7858	9.9250	.0234	82.3610	.3030	1
150	4.30	2.5417	8.4143	.0489	81.8497	.3727	1
180	5.16	3.1146	7.7114	.0788	81.4642	.4396	1
210	6.02	3.5539	7.3064	.1102	81.1707	.5034	1
240	6.88	3.8927	7.0472	.1412	80.9466	.5639	1
270	7.74	4.1550	6.8709	.1705	80.7755	.6209	1
300	8.60	4.3581	6.7463	.1974	80.6452	.6743	1
330	9.46	4.5155	6.6560	.2215	80.5466	.7240	1
360	10.32	4.6374	6.5894	.2427	80.4727	.7698	1
390	11.18	4.7316	6.5398	.2611	80.4179	.8116	1
420	12.04	4.8043	6.5024	.2768	80.3779	.8493	1
450	12.90	4.8604	6.4741	.2901	80.3495	.8829	1
480	13.76	4.9035	6.4526	.3012	80.3301	.9123	1
510	14.62	4.9366	6.4362	.3104	80.3176	.9374	1
540	15.48	4.9619	6.4237	.3180	80.3105	.9583	1
570	16.34	4.9813	6.4141	.3241	80.3076	.9749	1
600	17.20	4.9961	6.4068	.3292	80.3075	.9873	1
630	18.06	5.0074	6.4012	.3332	80.3094	.9955	1
660	18.92	5.0159	6.3968	.3365	80.3133	.9995	1
690	19.78	5.0209	6.3942	.3391	80.3193	.9995	1
720	20.64	5.0128	6.3977	.3412	80.3324	.9954	1
750	21.50	4.9930	6.4066	.3426	80.3541	.9875	1
780	22.36	4.9643	6.4198	.3430	80.3828	.9757	1
810	23.22	4.9288	6.4364	.3425	80.4167	.9603	1
840	24.08	4.8882	6.4557	.3411	80.4546	.9413	1
870	24.94	4.8436	6.4772	.3389	80.4956	.9189	1
900	25.80	4.7958	6.5006	.3360	80.5390	.8933	1
930	26.66	4.7456	6.5257	.3324	80.5843	.8646	1
960	27.52	4.6931	6.5524	.3284	80.6314	.8331	1
990	28.38	4.6384	6.5807	.3240	80.6801	.7988	1
1020	29.24	4.5816	6.6107	.3191	80.7303	.7620	1
1050	30.10	4.5224	6.6427	.3140	80.7822	.7229	1
1080	30.96	4.4604	6.6770	.3086	80.8360	.6816	1
1110	31.82	4.3951	6.7140	.3028	80.8922	.6384	1
1140	32.68	4.3256	6.7543	.2968	80.9512	.5936	1
1170	33.54	4.2511	6.7987	.2905	81.0136	.5472	1
1200	34.40	4.1700	6.8484	.2838	81.0803	.4996	1
1230	35.26	4.0808	6.9050	.2767	81.1525	.4509	1
1260	36.12	3.9808	6.9706	.2691	81.2318	.4013	1
1290	36.98	3.8667	7.0485	.2608	81.3203	.3512	1
1320	37.84	3.7333	7.1437	.2517	81.4214	.3006	1
1350	38.70	3.5724	7.2636	.2415	81.5401	.2498	1
1380	39.56	3.3698	7.4193	.2300	81.6850	.1991	1
1410	40.42	3.0967	7.6167	.2170	81.8736	.1485	1
1440	41.28	2.6704	7.7122	.2073	82.1539	.0983	1
1470	42.14	1.7507	5.8931	.2161	82.7284	.0488	1
1500	43.00	.0648	5.3633	.5812	83.8052	.0001	1

MAXIMUM VALUES	5.0209+00	8.1768+01	5.8125-01	8.0307+01	9.9999-01	1.
AT TIME	1.9723-02	1.8920-03	4.3000-02	1.6684-02	1.9350-02	0.
VALUE AT SJMAX	5.0209+00	6.3942+00	3.3893-01	8.0319+01	9.9959-01	1.

PLAS.RAD.= 50. PLAS.LENGTH=800. OBS.AREA=700. Q=20000. FLD.DECAY(SEC)= 8.0-02
1 GUN INJ= 1 PRINT=222 ITERATIONS= 1500 NUM.OF PRT'D POINTS= 50
= 2.50-01TORR POWER IS 1.00+02WATTS AT 2.45GHZ MAG FIELD= 1.00KG
000 TMO(MS)= .000 TMW(MS) = .000 TGI(MS) = .000 TCRO(MS) = .000
00 NOTE THAT GAUGE PRESSURE IS 2.5*TRUE PRESSURE FOR H2

TI	DNEUT	B	POWER	JSAT	DOMINANT LOSS DENS	TE	TI
.0250	83.7200	.0000	100.0000	.0000			
.0262	83.7200	.0788	100.0000	.0003	OL	EX	TC
.0044	83.7016	.1558	100.0000	.0130	OL	EX	TC
.0066	83.0519	.2306	100.0000	.3224	OL	EX	TC
.0234	82.3610	.3030	100.0000	.5851	OL	EX	TC
.0489	81.8497	.3727	100.0000	.7668	OL	EX	TC
.0788	81.4642	.4396	100.0000	.8995	OL	EX	TC
.1102	81.1707	.5034	100.0000	.9990	OL	EX	TC
.1412	80.9466	.5639	100.0000	1.0747	OL	EX	TC
.1705	80.7755	.6209	100.0000	1.1327	OL	EX	TC
.1974	80.6452	.6743	100.0000	1.1772	OL	EX	TC
.2215	80.5466	.7240	100.0000	1.2116	OL	EX	TC
.2427	80.4727	.7698	100.0000	1.2380	OL	EX	TC
.2611	80.4179	.8116	100.0000	1.2584	OL	EX	TC
.2768	80.3779	.8493	100.0000	1.2741	OL	EX	TC
.2901	80.3495	.8829	100.0000	1.2862	OL	EX	TC
.3012	80.3301	.9123	100.0000	1.2954	OL	EX	TC
.3104	80.3176	.9374	100.0000	1.3025	OL	EX	TC
.3180	80.3105	.9583	100.0000	1.3079	OL	EX	TC
.3241	80.3076	.9749	100.0000	1.3120	OL	EX	TC
.3292	80.3075	.9873	100.0000	1.3152	OL	EX	TC
.3332	80.3094	.9955	100.0000	1.3176	OL	EX	TC
.3365	80.3133	.9995	100.0000	1.3194	OL	EX	TC
.3391	80.3193	.9995	100.0000	1.3204	OL	EX	TC
.3412	80.3324	.9954	100.0000	1.3186	OL	EX	TC
.3426	80.3541	.9875	100.0000	1.3144	OL	EX	TC
.3430	80.3828	.9757	100.0000	1.3081	OL	EX	TC
.3425	80.4167	.9603	100.0000	1.3005	OL	EX	TC
.3411	80.4546	.9413	100.0000	1.2917	OL	EX	TC
.3389	80.4956	.9189	100.0000	1.2820	OL	EX	TC
.3360	80.5390	.8933	100.0000	1.2717	OL	EX	TC
.3324	80.5843	.8646	100.0000	1.2608	OL	EX	TC
.3284	80.6314	.8331	100.0000	1.2494	OL	EX	TC
.3240	80.6801	.7983	100.0000	1.2375	OL	EX	TC
.3191	80.7303	.7620	100.0000	1.2251	OL	EX	TC
.3140	80.7822	.7229	100.0000	1.2122	OL	EX	TC
.3086	80.8360	.6816	100.0000	1.1987	OL	EX	TC
.3028	80.8922	.6384	100.0000	1.1844	OL	EX	TC
.2968	80.9512	.5936	100.0000	1.1692	OL	EX	TC
.2905	81.0136	.5472	100.0000	1.1528	OL	EX	TC
.2838	81.0803	.4996	100.0000	1.1349	OL	EX	TC
.2767	81.1525	.4509	100.0000	1.1152	OL	EX	TC
.2691	81.2318	.4013	100.0000	1.0931	OL	EX	TC
.2608	81.3203	.3512	100.0000	1.0676	OL	EX	TC
.2517	81.4214	.3006	100.0000	1.0377	OL	EX	TC
.2415	81.5401	.2498	100.0000	1.0013	OL	EX	TC
.2300	81.6850	.1991	100.0000	.9546	OL	EX	TC
.2170	81.8736	.1485	100.0000	.8888	OL	EX	TC
.2043	82.1539	.0983	100.0000	.7713	FD	EX	TC
.2161	82.7284	.0488	100.0000	.4420	FD	EX	TC
.5812	83.8052	.0001	100.0000	.0156	FD	TC	TC

5.8125-01	8.0307+01	9.9999-01	1.0000+02	1.3204+00
4.3000-02	1.6684-02	1.9350-02	0.0000	1.9723-02
3.3893-01	8.0319+01	9.7959-01	1.0000+02	1.3204+00

FUNCTIONAL VALUES USED IN CALCULATING DERI

TIME-MS	DNWR	DNT	DFC	D1	D2	D3	D4	PE
.000	0.00	8.05+01	3.22+00	0.00	0.00	0.00	0.00	0.00
.860	3.21-05	8.05+01	3.22+00	3.75-01	4.52-05	1.91-01	0.00	6.55+0
1.720	-9.10-03	8.05+01	3.22+00	6.31+01	1.29-03	7.67+00	0.00	1.24+0
2.580	-5.06-01	7.99+01	3.20+00	1.14+03	8.26-03	2.12+02	0.00	9.67+0
3.440	-1.18+00	7.92+01	3.17+00	1.07+03	7.87-03	3.91+02	0.00	9.72+0
4.300	-1.68+00	7.87+01	3.15+00	1.02+03	7.20-03	5.15+02	0.00	9.95+0
5.160	-2.05+00	7.83+01	3.14+00	9.95+02	6.47-03	6.07+02	0.00	9.96+0
6.020	-2.33+00	7.80+01	3.13+00	9.75+02	5.79-03	6.76+02	0.00	9.96+0
6.880	-2.55+00	7.78+01	3.12+00	9.60+02	5.19-03	7.30+02	0.00	9.96+0
7.740	-2.72+00	7.77+01	3.11+00	9.50+02	4.67-03	7.71+02	0.00	9.96+0
8.600	-2.84+00	7.75+01	3.11+00	9.42+02	4.22-03	8.03+02	0.00	9.96+0
9.460	-2.94+00	7.74+01	3.10+00	9.36+02	3.85-03	8.28+02	0.00	9.96+0
10.320	-3.01+00	7.74+01	3.10+00	9.31+02	3.54-03	8.48+02	0.00	9.96+0
11.180	-3.06+00	7.73+01	3.10+00	9.28+02	3.27-03	8.63+02	0.00	9.96+0
12.040	-3.10+00	7.73+01	3.10+00	9.25+02	3.06-03	8.75+02	0.00	9.96+0
12.900	-3.13+00	7.73+01	3.09+00	9.23+02	2.88-03	8.85+02	0.00	9.96+0
13.760	-3.15+00	7.72+01	3.09+00	9.21+02	2.73-03	8.92+02	0.00	9.96+0
14.620	-3.16+00	7.72+01	3.09+00	9.20+02	2.61-03	8.97+02	0.00	9.96+0
15.480	-3.17+00	7.72+01	3.09+00	9.19+02	2.51-03	9.02+02	0.00	9.96+0
16.340	-3.17+00	7.72+01	3.09+00	9.18+02	2.44-03	9.05+02	0.00	9.96+0
17.200	-3.17+00	7.72+01	3.09+00	9.18+02	2.39-03	9.08+02	0.00	9.96+0
18.060	-3.17+00	7.72+01	3.09+00	9.17+02	2.36-03	9.10+02	0.00	9.96+0
18.920	-3.16+00	7.72+01	3.09+00	9.17+02	2.35-03	9.11+02	0.00	9.96+0
19.780	-3.16+00	7.72+01	3.09+00	9.17+02	2.35-03	9.12+02	5.44+00	9.96+0
20.640	-3.14+00	7.72+01	3.09+00	9.17+02	2.36-03	9.11+02	1.70+01	9.96+0
21.500	-3.12+00	7.73+01	3.10+00	9.17+02	2.39-03	9.08+02	2.85+01	9.96+0
22.360	-3.09+00	7.73+01	3.10+00	9.18+02	2.42-03	9.04+02	3.97+01	9.96+0
23.220	-3.05+00	7.73+01	3.10+00	9.20+02	2.48-03	8.98+02	5.09+01	9.96+0
24.080	-3.02+00	7.74+01	3.10+00	9.21+02	2.54-03	8.92+02	6.19+01	9.96+0
24.940	-2.98+00	7.74+01	3.10+00	9.23+02	2.63-03	8.85+02	7.30+01	9.96+0
25.800	-2.93+00	7.74+01	3.10+00	9.24+02	2.75-03	8.78+02	8.43+01	9.96+0
26.660	-2.89+00	7.75+01	3.10+00	9.26+02	2.89-03	8.70+02	9.57+01	9.96+0
27.520	-2.84+00	7.75+01	3.11+00	9.28+02	3.06-03	8.62+02	1.07+02	9.96+0
28.380	-2.80+00	7.76+01	3.11+00	9.30+02	3.27-03	8.53+02	1.20+02	9.96+0
29.240	-2.75+00	7.76+01	3.11+00	9.32+02	3.53-03	8.44+02	1.32+02	9.96+0
30.100	-2.70+00	7.77+01	3.11+00	9.34+02	3.85-03	8.35+02	1.46+02	9.96+0
30.960	-2.64+00	7.77+01	3.11+00	9.36+02	4.24-03	8.25+02	1.60+02	9.96+0
31.820	-2.59+00	7.78+01	3.12+00	9.39+02	4.74-03	8.15+02	1.76+02	9.97+0
32.680	-2.53+00	7.78+01	3.12+00	9.41+02	5.36-03	8.04+02	1.93+02	9.97+0
33.540	-2.47+00	7.79+01	3.12+00	9.44+02	6.15-03	7.93+02	2.12+02	9.97+0
34.400	-2.40+00	7.80+01	3.12+00	9.47+02	7.18-03	7.80+02	2.33+02	9.97+0
35.260	-2.33+00	7.80+01	3.13+00	9.51+02	8.56-03	7.66+02	2.58+02	9.97+0
36.120	-2.25+00	7.81+01	3.13+00	9.54+02	1.04-02	7.50+02	2.86+02	9.97+0
36.980	-2.16+00	7.82+01	3.13+00	9.58+02	1.31-02	7.32+02	3.21+02	9.97+0
37.840	-2.06+00	7.83+01	3.14+00	9.63+02	1.71-02	7.11+02	3.64+02	9.96+0
38.700	-1.94+00	7.84+01	3.14+00	9.67+02	2.33-02	6.86+02	4.20+02	9.94+0
39.560	-1.79+00	7.85+01	3.15+00	9.70+02	3.40-02	6.53+02	4.96+02	9.89+0
40.420	-1.59+00	7.87+01	3.16+00	9.61+02	5.47-02	6.08+02	6.06+02	9.68+0
41.280	-1.29+00	7.90+01	3.17+00	8.65+02	1.02-01	5.29+02	7.79+02	8.45+0
42.140	-6.50-01	7.95+01	3.19+00	2.69+02	2.06-01	3.10+02	1.01+03	1.91+0
43.000	5.41-01	8.06+01	3.24+00	8.62+00	8.34+00	2.08+01	2.27+03	1.79-0

JES USED IN CALCULATING DERIVATIVES

D2	D3	D4	PE1	PE2	PE3	PE4	PE5	PE6	PI3	PI6
00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62-05	1.91-01	0.00	6.55+01	2.60-05	3.21+01	2.58-10	1.77-07	3.16+00	1.39-11	5.18-04
29-03	7.67+00	0.00	1.24+04	1.92-03	4.13+03	1.45-07	8.23-05	1.05+03	-8.55-11	-3.15-01
26-03	2.12+02	0.00	9.67+04	9.78+00	8.23+04	2.24-04	2.50-03	7.09+03	-8.71-09	-7.89+00
37-03	3.91+02	0.00	9.72+04	6.66+01	8.61+04	9.86-04	6.16-03	7.78+03	-2.97-08	-1.63+00
20-03	5.15+02	0.00	9.95+04	1.44+02	8.71+04	1.85-03	1.13-02	8.67+03	2.08-06	2.39+01
47-03	6.07+02	0.00	9.96+04	2.22+02	8.74+04	2.68-03	1.77-02	9.34+03	1.52-05	6.44+01
79-03	6.76+02	0.00	9.96+04	2.93+02	8.75+04	3.40-03	2.52-02	9.86+03	5.41-05	1.14+02
19-03	7.30+02	0.00	9.96+04	3.54+02	8.75+04	4.01-03	3.35-02	1.03+04	1.33-04	1.69+02
67-03	7.71+02	0.00	9.96+04	4.05+02	8.75+04	4.52-03	4.23-02	1.06+04	2.60-04	2.23+02
22-03	8.03+02	0.00	9.96+04	4.46+02	8.75+04	4.93-03	5.15-02	1.08+04	4.34-04	2.76+02
35-03	8.28+02	0.00	9.96+04	4.79+02	8.75+04	5.25-03	6.07-02	1.10+04	6.46-04	3.25+02
54-03	8.48+02	0.00	9.96+04	5.05+02	8.75+04	5.52-03	6.98-02	1.11+04	8.83-04	3.69+02
27-03	8.63+02	0.00	9.96+04	5.26+02	8.75+04	5.72-03	7.86-02	1.13+04	1.13-03	4.07+02
06-03	8.75+02	0.00	9.96+04	5.42+02	8.74+04	5.88-03	8.70-02	1.13+04	1.38-03	4.40+02
88-03	8.85+02	0.00	9.96+04	5.54+02	8.74+04	6.01-03	9.47-02	1.14+04	1.61-03	4.69+02
73-03	8.92+02	0.00	9.96+04	5.63+02	8.74+04	6.11-03	1.02-01	1.15+04	1.83-03	4.92+02
61-03	8.97+02	0.00	9.96+04	5.70+02	8.74+04	6.18-03	1.08-01	1.15+04	2.02-03	5.12+02
61-03	9.02+02	0.00	9.96+04	5.76+02	8.74+04	6.24-03	1.13-01	1.15+04	2.18-03	5.28+02
44-03	9.05+02	0.00	9.96+04	5.80+02	8.74+04	6.28-03	1.17-01	1.16+04	2.33-03	5.41+02
17-03	9.08+02	0.00	9.96+04	5.83+02	8.74+04	6.32-03	1.21-01	1.16+04	2.45-03	5.52+02
36-03	9.10+02	0.00	9.96+04	5.85+02	8.74+04	6.34-03	1.23-01	1.16+04	2.55-03	5.61+02
35-03	9.11+02	0.00	9.96+04	5.87+02	8.74+04	6.36-03	1.24-01	1.16+04	2.63-03	5.67+02
35-03	9.12+02	5.44+00	9.96+04	5.88+02	8.74+04	6.37-03	1.24-01	1.17+04	2.70-03	5.75+02
36-03	9.11+02	1.70+01	9.96+04	5.86+02	8.74+04	6.36-03	1.23-01	1.17+04	2.75-03	5.81+02
39-03	9.08+02	2.85+01	9.96+04	5.81+02	8.74+04	6.31-03	1.21-01	1.18+04	2.77-03	5.86+02
42-03	9.04+02	3.97+01	9.96+04	5.74+02	8.74+04	6.25-03	1.18-01	1.18+04	2.77-03	5.87+02
48-03	8.98+02	5.09+01	9.76+04	5.66+02	8.74+04	6.17-03	1.13-01	1.18+04	2.74-03	5.87+02
54-03	8.92+02	6.19+01	9.96+04	5.56+02	8.74+04	6.07-03	1.08-01	1.19+04	2.68-03	5.84+02
63-03	8.85+02	7.30+01	9.96+04	5.46+02	8.74+04	5.97-03	1.03-01	1.19+04	2.61-03	5.79+02
75-03	8.78+02	8.43+01	9.96+04	5.35+02	8.74+04	5.87-03	9.65-02	1.19+04	2.52-03	5.72+02
69-03	8.70+02	9.57+01	9.96+04	5.24+02	8.74+04	5.76-03	8.98-02	1.19+04	2.41-03	5.65+02
06-03	8.62+02	1.07+02	9.96+04	5.12+02	8.74+04	5.64-03	8.28-02	1.20+04	2.30-03	5.56+02
27-03	8.53+02	1.20+02	9.96+04	5.[illegible]0+02	8.74+04	5.52-03	7.56-02	1.20+04	2.18-03	5.46+02
63-03	8.44+02	1.32+02	9.76+04	4.88+02	8.74+04	5.40-03	6.83-02	1.20+04	2.06-03	5.36+02
95-03	8.35+02	1.46+02	9.96+04	4.75+02	8.74+04	5.27-03	6.10-02	1.20+04	1.93-03	5.25+02
24-03	8.25+02	1.60+02	9.96+04	4.62+02	8.74+04	5.14-03	5.38-02	1.20+04	1.81-03	5.14+02
74-03	8.15+02	1.76+02	9.97+04	4.48+02	8.75+04	5.01-03	4.68-02	1.21+04	1.68-03	5.02+02
36-03	8.04+02	1.93+02	9.97+04	4.34+02	8.75+04	4.87-03	4.01-02	1.21+04	1.56-03	4.90+02
15-03	7.93+02	2.12+02	9.97+04	4.19+02	8.75+04	4.72-03	3.37-02	1.22+04	1.43-03	4.77+02
18-03	7.80+02	2.33+02	9.97+04	4.03+02	8.75+04	4.55-03	2.78-02	1.22+04	1.31-03	4.64+[illegible]2
56-03	7.66+02	2.58+02	9.97+04	3.85+02	8.75+04	4.38-03	2.23-02	1.23+04	1.19-03	4.51+02
04-02	7.50+02	2.86+02	9.97+04	3.66+02	8.74+04	4.19-03	1.74-02	1.24+04	1.06-03	4.36+02
11-02	7.32+02	3.21+02	9.97+04	3.45+02	8.74+04	3.97-03	1.31-02	1.25+04	9.38-04	4.21+02
71-02	7.11+02	3.64+02	9.96+04	3.21+02	8.73+04	3.73-03	9.44-03	1.27+04	8.12-04	4.05+02
33-02	6.86+02	4.20+02	9.94+04	2.93+02	8.71+04	3.45-03	6.36-03	1.30+04	6.85-04	3.88+02
40-02	6.53+02	4.96+02	9.89+04	2.60+02	8.66+04	3.10-03	3.90-03	1.33+04	5.57-04	3.70+02
47-02	6.08+02	6.06+02	9.68+04	2.19+02	8.49+04	2.66-03	2.06-03	1.38+04	4.28-04	3.50+02
02-01	5.29+02	7.79+02	8.45+04	1.64+02	7.60+04	2.00-03	8.01-04	1.41+04	3.07-04	3.30+02
06-01	3.10+02	1.01+03	1.91+04	8.04+01	2.66+04	7.75-04	1.05-04	9.71+03	2.40-04	3.10+02
34+00	2.08+01	2.27+03	1.79-03	4.74-01	9.76+02	3.66-06	6.19-09	1.10+04	2.31-04	1.09+03

MULTIPOLE SIMULATION

DENSITY-10**9/CM**3 SAT CUR-MA/CM**2
TEMPERATURE-EV POWER-WATTS
MAG FIELD-KGAUSS