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A Mathematical Model of Electrostatic Precipitation (Revision 2)

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A Mathematical Model of Electrostatic Precipitation (Revision 2)

by

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ABSTRACT

The objectives of this project were to develop analytic approximations for describing the electrical conditions in a wire-plate precipitator and to reduce the execution time required by the computer program which represents the model of electrostatic precipitation developed under the sponsorship of the Environmental Protection Agency.

In this report, a new semi-empirical, approximate theory for predicting electrical conditions is described. In the approximate theory, analytical expressions are derived for calculating voltage-current characteristics and electric potential, electric field, and space charge density distributions. Comparisons of numerical and approximate solutions over a wide range of possible precipitator geometries and electrical operating points indicate that for practical purposes the approximate theory can be used in lieu of the more rigorous numerical theory. This saves large amounts of computer time and makes possible hand calculator usage. Recent modifications to a previously described theory for numerically determining electrical conditions in wire-plate electrostatic precipitators are also discussed.

The numerical technique for performing the integration over the particle surface in the charging rate equation has been changed in order to decrease the computer time required. A Gaussian quadrature method which replaces a Simpson's rule method is presented. This modification results in a factor of 10 decrease in computer time required to perform the particle charging calculations while preserving essentially the same degree of accuracy.

The new and modified subroutines in the computer program are discussed. Detailed flow charts for each of these subroutines are provided. A listing of the computer code for each of these subroutines as well as for the entire program is given. Examples of various applications of the model are described and demonstrated in detail.

This report was submitted in partial fulfillment of Task 5 of Contract No. 68-02-2193 by Southern Research Institute under the sponsorship of the U.S. Environmental Protection Agency. This report covers a contract period from October 1, 1976 to December 31, 1978 and work was completed as of December 31, 1978.

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NOMENCLATURE

$V_s(x,y)$	The electrostatic potential at a point (x,y) (V)
V_{st}	A constant determined by the amount of charge on a wire (V)
x	Coordinate position measured toward the plate with the corona wire as origin (m)
y	Coordinate position measured parallel to the plate with the corona wire as origin (m)
S_x	Wire-to-plate spacing (m)
S_y	Half wire-to-wire spacing (m)
E_0	The electric field at the surface of the wires (V/m)
a_0	Radius of the discharge wires (m)
V	Potential (V)
J	Current density (A/m^2)
b	Ion mobility (m^2/V-sec)
ε_0	Permittivity of vacuum (A sec/Vm)
R	Distance from the wire at which the solutions are to be matched (m)
V_1	A constant determined by the amount of space charge in a cylinder (V)
V(x,y)	Potential at the point (x,y) (V)
V_0	Constant used for matching the potentials at x=R (V)
ζ	Constant occurring in the potential expression
δ	Constant occurring in the potential expression
γ	Constant occurring in the potential expression

$\rho(x,y)$	Charge density at point (x,y) (C/m^3)
K_1	A constant used to match the charge density profiles at X=R
f_1	Empirical factor used in charge density calculation
f_2	Empirical factor used in charge density calculation
f_3	Empirical factor used in charge density calculation
F	Factor which corrects for overlapping of space charge cylinders
E	Electric field (V/m)
E_x	x-component of the electric field (V/m)
E_y	y-component of the electric field (V/m)
ax	Spacing of integration points along the x-direction (m)
ay	Spacing of integration points along the y-direction (m)
α	Parameter in the equation for charge density (C/m^3)
β	Parameter in the equation for charge density (C^2/m^6)
ΔV	Potential drop across the corona region (V)
VW	Potential at the surface of the wire (V)
ECOR	Average field required to drive the corona (V/m)
RC	Radius of the corona (m)
AC	Radius of the wire (m)
q	Instantaneous charge on a particle (C)
t	Time (sec)
N_0	Free ion density (m^{-3})
e	Electronic charge (C)
q_s	Saturation charge due to field charging (C)
a	Particle radius (m)
$\tilde{v}$	Mean thermal speed of ions (m/sec)

θ_0	Arccos (q/q_s)
r_0	Radial distance along θ at which the radial component of the total electric field is zero (m)
k	Boltzmann's constant (J/°K)
T	Absolute temperature (°K)
K	Dielectric constant of the particle
E_a	Average electric field between the electrodes (V/m)
θ	Azimuthal angle in a spherical coordinate system with origin at the center of the particle (radians)
$f(\theta)$	Function to be integrated
$F(t)$	Function to be integrated
$A_k (k=0,1,\ldots,n)$	Gaussian weights
$t_k (k=0,1,\ldots,n)$	Roots of Legendre polynomials

METRIC CONVERSION FACTORS

To Convert From	To	Multiply by
grams/ft^3	kg/m^3	0.00229
ft	m	0.3048
ft^2	m^2	0.0929
in	m	0.0254
ft^3/min	m^3/sec	0.000472
ft/sec	m/sec	0.3048
°F	°K	$(°F+459) \times \frac{1}{1.8}$

SECTION 1

INTRODUCTION

The EPA/SoRI computer model of electrostatic precipitation was first published in 1975.[1] Revision 1 of the model[2,3] was published in 1978. This computer model has been used by many individuals involved in electrostatic precipitation technology. In general, the various users have found the model useful. However, many users have commented that the time required to run the model was excessive.

This report describes revisions to the model that greatly reduce the computer time required with only a slight loss in accuracy. The revisions described in this report consist of:

1. A new procedure for calculating electric fields and V-I curves using an approximate analytic solution and,

2. A new procedure for calculating particle charge.

The revisions affect the internal workings of the program, but do not affect the model-user interface. The data input requirements and the format for the data are the same in this revised model as the data in the original model.

The revisions may be implemented either by adding the new procedures to an existing version of the model or by obtaining a tape copy of the complete revised model from NTIS*.

This report does not replace the previous model reports but is intended to supplement them. The user is urged to obtain and read references 2 and 3 before using Revision 2 of the model. This report provides a complete description of the new procedures including their effect on execution time and accuracy.

A second, new procedure for calculating electric fields and V-I curves is also described in this report. This procedure has not been incorporated into the working version of the model because the slight increase in accuracy gained by its use does

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*National Technical Information Service, Springfield, Virginia 22161.

not justify the long computing time required to use it.

The report contains sample problems showing how to use the new procedures. Complete FORTRAN listings for all new procedures and the revised model are included in appendices of this report. This revised model is described as Revision II Aug. 1979.

Please note that this computer program is distributed on an "As Is" basis without warranty by either the United States Environmental Protection agency or Southern Research Institute. We are, however, interested in your comments--especially those that will allow us to improve the model. If you have comments or suggestions, please contact either the authors or the EPA project officer.

SECTION 2

CONCLUSIONS

The version of the mathematical model of electrostatic precipitation presented in this report offers an option which requires significantly less time to perform a calculation than does the previous version because of two factors. First, the time required to perform the charge calculation has been decreased through the use of Gaussian quadratures instead of the Simpson's rule integration. There is little loss in accuracy (on the order of 2% maximum) due to the faster charge calculation. Second, the time required to run the program has been further decreased by the use of analytic approximations to the solutions of the electrical equations. For practical ranges of operating parameters, the inaccuracies introduced by these approximations are within acceptable limits. The combination of these two modifications to the program decreases the computation time by about a factor of 10 from that required by the previous version of the model.

The numerical method used to compute the electrical solutions in the previous version of the model has been modified to accept variable step sizes in the discretization scheme. This new numerical method gives rise to improved accuracy in some cases, but requires more execution time than is justified by its use. Consequently, this new numerical scheme has not been incorporated into the computer program.

For current users of the model, this new version can be used in exactly the same manner and with the same input data as before with the only difference being that the particle charging will be done using the Gaussian quadratures rather than the Simpson's rule integration. In order to convert a working version of the program to the new revised form, it is necessary to replace subprograms CMAN and RATE by the new versions listed in Appendices B and E, respectively. The new subprogram EFLD3 listed in Appendix A must also be added. In addition to these subprograms, a few statements must be added to the main program. These modifications may be seen in the listing of the program in Appendix F. The data block subprogram used to initialize certain variable arrays may not be necessary with some computers. A tape copy of the complete program is available from NTIS (see footnote in the Introduction). Detailed instructions for using the model must still be obtained from Revision 1 of the model report.

SECTION 3

RECOMMENDATIONS

Although the mathematical model of electrostatic precipitation presented in this report represents a significant improvement over the previous version, more work still needs to be performed in order to improve the fundamental basis and user oriented aspects of the model.

With respect to the fundamental basis of the model, it is recommended that the following research be pursued:

1. Theoretical and experimental studies of the effects of particles on the electrical conditions should be continued in order to better describe the effect on the electric field distribution.

2. Theoretical and experimental studies of electrical breakdown mechanisms in the collected particulate layer should be given greater emphasis in an attempt to acquire the capability of theoretical prediction of when electrical breakdown will ensue for a given value of dust resistivity.

3. Since the model underpredicts field-measured collection efficiencies for fine particles without the use of empirical correction factors, theoretical and experimental studies should be continued in order to remove the empiricism or to explain the discrepancy. These studies should include a reevaluation of the theories presently used in the model and an examination of those effects which are presently neglected such as particle charging near corona wires and phenomena due to the gas flow field. There is evidence[4] that free electrons may play a role in particle charging in negative coronas for temperatures of 150°C to 350°C. A charging theory which accounts for this effect is needed.

4. The mathematical model should be restructured to take into account time-dependent effects. The effects due to the growth of the particulate layer and the rapping schedule should be included as a function of time. Although the empirical procedure employed in the present version of the model represents a useful interim technique for estimating the effects due to rapping reentrainment in precipitators, it does not describe the temporal and dynamic aspects of the rapping process. The inclusion of time-dependent effects is necessary in order to optimize the electrical operating conditions and the rapping schedule and intensity.

The above research is needed in order to make the model independent of empiricism and of the experience and judgment of the user.

With respect to the user oriented aspects of the model, it is recommended that the following work be performed:

1. Alternative numerical techniques need to be investigated and implemented in order to make the computer program run significantly faster.

2. Although the charging calculation has been speeded up considerably by the Gaussian quadratures, the speed could be increased even more. As can be seen from Figure 2 of Reference 4, the particle charge distribution could be represented to a considerable degree of accuracy by two simple power laws in the two regions separated by a particle radius of about one micrometer. To determine the two power relationships it would only be necessary to compute the charge for three particle sizes. The charge on the remaining particles would be computed from the appropriate relationship. For a calculation with 15 particle sizes, this approximation should decrease the time for computing the charge on the particles by about a factor of 5.

3. Procedures which edit the input data should be implemented.

4. Documentation of the computer program needs to be included in abbreviated form in the computer card deck.

The above work is needed in order to continue the transition in which the model is transformed from a research tool to one which is more practical to use.

SECTION 4

APPROXIMATE SOLUTION FOR SPACE CHARGE LIMITED CURRENTS IN WIRE-DUCT PRECIPITATORS

BACKGROUND

In order to model the behavior of an electrostatic precipitator, it is necessary to compute the electric field and potential in the interelectrode space. In the mathematical model of precipitation developed by Southern Research Institute under the direction of the Environmental Protection Agency's Particulate Technology Branch of the Industrial Research Laboratory at Research Triangle Park, a relaxation method is used to solve Poisson's equation coupled with the charge transport equation. This numerical procedure requires a great deal of computer time. The computer time required could be greatly reduced if an analytic solution to this system of equations were available. Since an exact solution does not seem probable, an approximate solution is appropriate. An analytic solution is further desirable because it would significantly simplify some of the difficulties of incorporating the space-charge effects of particles into the mathematical model.

DEVELOPMENT OF EQUATIONS

Using a conformal mapping technique, Cooperman[5] demonstrated that the electrostatic potential $V_s(x,y)$ in the interelectrode space of a wire-duct precipitator with 2N+1 corona wires can be written as

$$V_s(x,y) = V_{st} \sum_{m=-N}^{N} \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)} \right] \quad (1)$$

with

$$V_{st} = - \frac{s_x \quad E_0}{\pi \ \mathrm{Sin}(\pi a_0/2s_x)} \left\{ \sum_{m=-N}^{N} \frac{\cosh\ (m\pi s_y/s_x)}{\cosh^2(m\pi s_y/s_x) - \cos^2(\pi a_0/2s_x)} \right\}^{-1} \quad (2)$$

where

E_0 = the electric field at the surface of the wires (V/m),

a_0 = radius of the wires (m),

s_x = wire-to-plate spacing (m),

s_y = half wire-to-wire spacing (m),

x = the displacement from a wire toward the plate (m),

y = the displacement from a wire in the direction parallel to the plate (m),

$2N+1$ = the number of corona wires.

Figure 1 shows the region of the precipitator that is of interest. The origin is taken at the wire, while x is measured toward the plate and y is measured toward an adjacent wire. When a current flows in the presence of space charge, equation (1) does not apply. Equation 1 can be used to advantage, however, in obtaining an approximate solution for the dynamic case in which the current is space charge limited. Suppose a steady current flows under the action of an applied potential for the case illustrated in Figure 1. The electrical configuration will be simplified by using the principle of superposition. Each of the contributions to the potential will be separated and described below.

First consider just the electrodes. For a negative corona, the wire will be charged negatively while the plate will be charged positively. The charge on the plate will exceed the magnitude of the charge on the wire by an amount equal to the quantity of negative space charge in the interelectrode space. The negative charge on the wires coupled with an equal amount of positive charge on the two plates constitutes a situation similar to the static case of Cooperman. Mathematically, the solution for this case is identical in form to the electrostatic case, but the amount of charge on the wires is not necessarily the same as when the current is zero. Suppose that a small increase in the electric field at the surface of the wire gives rise to a large increase in the number of electrons emitted from the wire during the corona discharge. The field at the surface of the wire when a current flows, then would be nearly the same as Peek's value of the field required for corona start. In this case, the charge on the wire will be computed in terms of Peek's condition[6] on the field at the wire. The static-like solution would then be completely determined. It remains to specify the contributions to the potential from the negative space charge coupled with an equal amount of positive charge on the plates and from the corona discharge process itself. These last contributions must be approximated since closed-form solutions are not available.

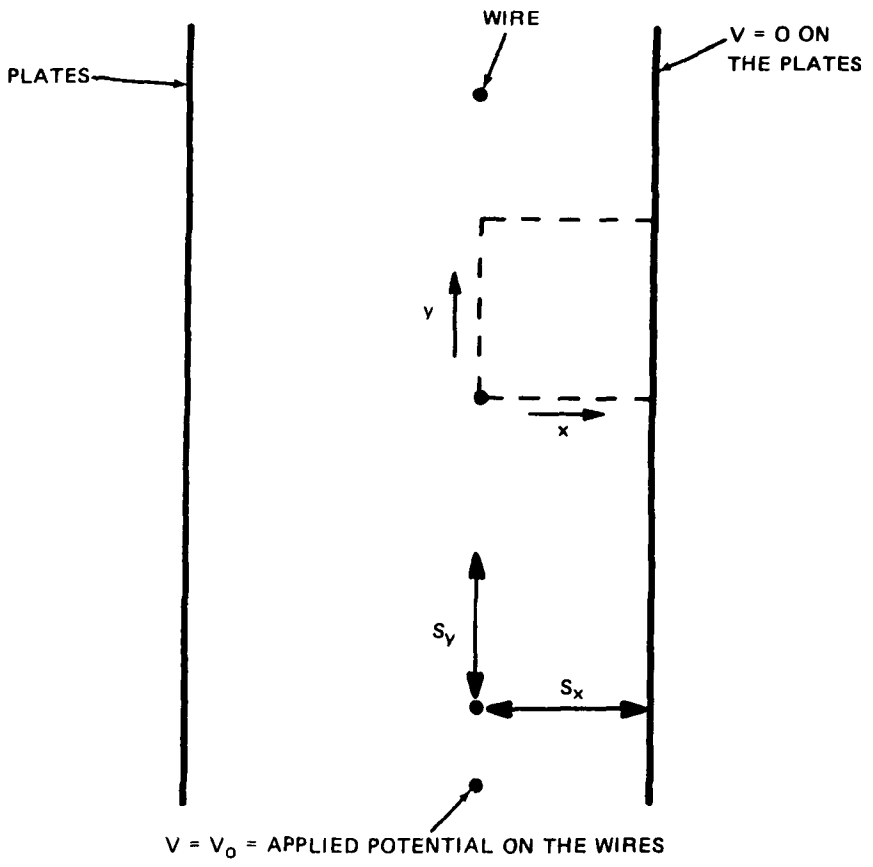

Figure 1. Schematic showing across section of the wires and plates in an electrostatic precipitator.

The primary considerations to be used in obtaining approximate solutions will be the apparent symmetry of the arrangement. For example, the equipotential lines near the discharge wires look very much like those for a wire-cylinder geometry,[5] while the equipotential lines near the plates look very much like those for a parallel plate geometry.[7,8] Using these observations, it will be assumed that the space charge near the wire is distributed in the same manner as that in a wire cylinder geometry, and that the space charge near the plate is distributed in the same manner as that in a parallel plate geometry. These two space charge distributions along with their associated surface charges are illustrated in Figures 2 and 3, respectively. Potentials computed from these two geometries will be matched at some point (x=R, where R is the radius of the cylinder of charge) in the interelectrode space to yield continuity of potential. The electric field is also required to be continuous at the matching point.

The contributions to the potential by the corona region will be assumed to be small. According to Loeb,[9] the potential drop across the ionization region of a corona is essentially independent of the current. The effect of the corona on the field at the surface of the wire at corona start is included in the measurement of Peek's field since the measurement is made with a minimum steady current. Based on the above considerations, it is assumed that the only role which the corona plays is to supply ions to carry the current in the interelectrode space.

Negative charge distributed uniformly in planes parallel to the plate which has an equal amount of positive charge, as shown in Figure 3, will yield a potential V given by

$$V = -\frac{2}{3}\left(\frac{2J}{b\varepsilon_0}\right)^{\frac{1}{2}}\left[(s_x - R)^{3/2} - (x - R)^{3/2}\right], \qquad (3)$$

where

J = current density (A/m^2),

b = ion mobility ($m^2/V\text{-sec}$),

ε_0 = permittivity of gas (approximately 8.85×10^{-12} A sec/Vm), and

R = point at which the solutions are to be matched.

In this same region, near the plate, the potential produced by the cylinder of negative charge coupled to an equal amount of positive charge on the plates must be taken into account. For points which lie outside the cylinder of charge shown in Figure 2, the solution will be the same as for a line of charge at the center with the same quantity of charge as contained in the cylinder. This problem has a solution similar to the electrostatic

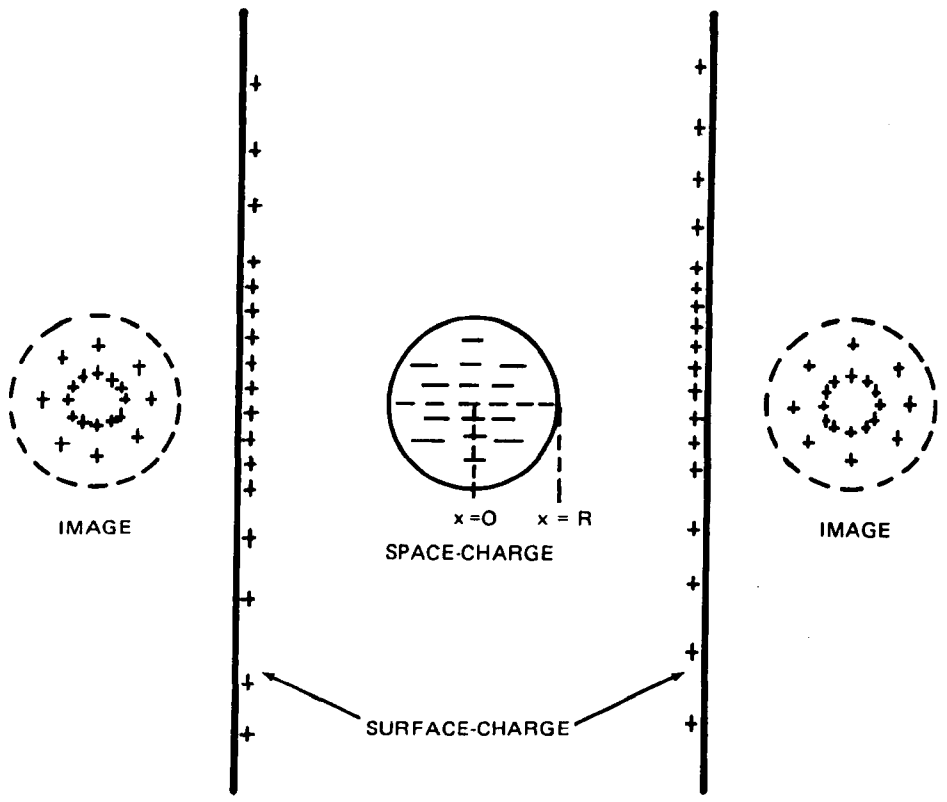

Figure 2. Schematic representing a cylindrical distribution of space charge and its associated images.

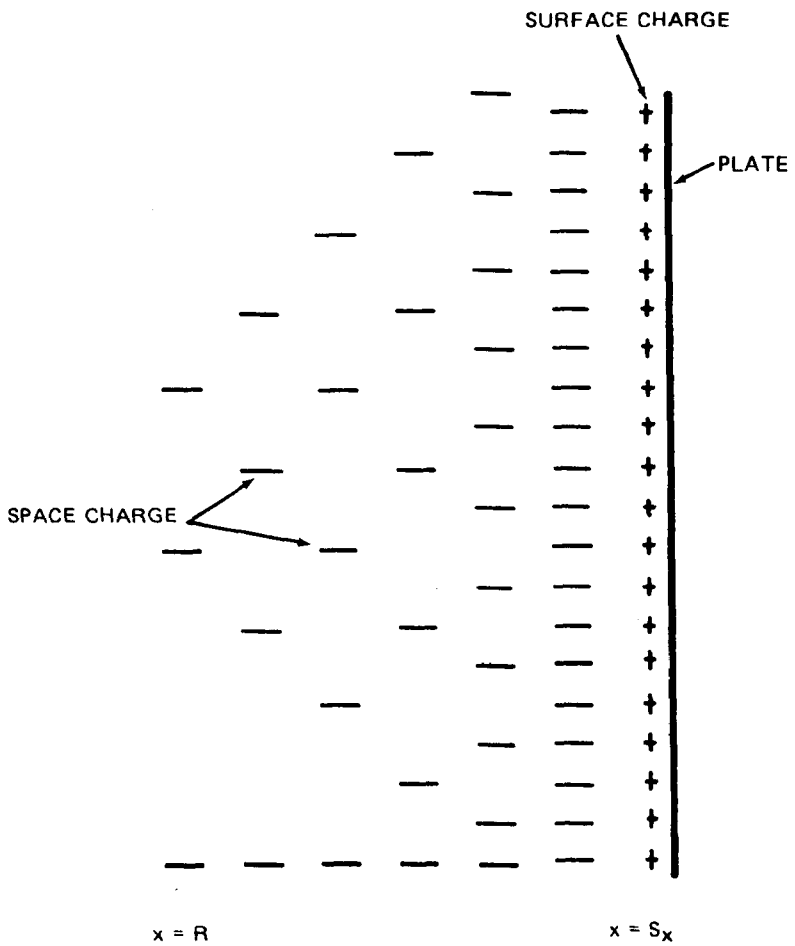

Figure 3. Schematic illustrating a planar distribution of space charge and its associated surface charge.

case mentioned before. When all 2N+1 wires are considered, the contribution to the potential for x greater than R will be

$$V = V_1 \sum_{m=-N}^{N} \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)} \right] , \qquad (4)$$

where V_1 depends on the amount of charge in the cylinder.

At points inside the cylinder of charge, the potential due to the other wires is given by

$$V = V_1 \sum_{m=1}^{N} \left\{ \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)} \right] + \ln \left[\frac{\cosh\pi(y+2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y+2ms_y)/2s_x + \cos(\pi x/2s_x)} \right] \right\} . \qquad (5)$$

To this we must add the potential due to the charge inside the cylinder as well as that due to the two images shown in Figure 2. To obtain the potential due to the negative space charge in the cylindrical distribution, we subtract the electrostatic solution for a wire and cylinder with no space charge from the solution of the same wire and cylinder with space charge.[10] The two images are used to account for the coupling of the space charge in the cylinder with the associated charge on the plates. The potential at a point inside the cylinder due to space charge and the two images is given by

$$V(x,y) = V_0 - a_0E_0 \left\{ \left(\frac{\zeta-1}{2}\right) \ln \left(\frac{x^2+y^2}{R^2}\right) + (1+\delta(x^2+y^2-a_0^2))^{\frac{1}{2}} - \gamma + \zeta \ln \left[\frac{\zeta + \gamma}{\zeta + (1 + \delta(x^2 + y^2-a_0^2))^{\frac{1}{2}}} \right] - \left(\frac{\gamma-1}{4}\right) \left[\ln \left(\frac{x^2 + y^2 + 4s_x(s_x - x)}{R^2 + 4s_x(s_x - R)} \right) + \ln \left(\frac{x^2 + y^2 + 4s_x(s_x + x)}{R^2 + 4s_x(s_x + R)} \right) \right] \right\} , \qquad (6)$$

where

$$\delta = 2Js_y/\pi\varepsilon_0 ba_0^2E_0^2,$$

$$\zeta = (1 - \delta a_0^2)^{\frac{1}{2}},$$

$$\gamma = (1 + \delta(R^2-a_0^2))^{\frac{1}{2}},$$

E_0 = electric field at the wire,

a_0 = radius of the wire.

The constant V_0 is to be chosen to match the solutions at the point x=R.

In the event that the cylindrical symmetry extends all the way to the plate, the condition that the potential be zero on the plate will be met rigorously only for y=0. This limitation can be removed in an empirical manner by adding y^2 to a few terms. This would have little effect near the wire, but allows the boundary conditions to be met by a slight modification to the cylindrical solution. The potential at a point inside the cylinder (x<R) due to space charge and the two images then becomes

$$V(x,y) = V_0 - a_0E_0 \left\{ \left(\frac{\zeta-1}{2}\right) \ln \left(\frac{x^2+y^2}{R^2+y^2}\right) + (1 + \delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}} - (1 + \delta(R^2+y^2-a_0{}^2))^{\frac{1}{2}} + \zeta \ln \left[\frac{\zeta + (1+\delta(R^2+y^2-a_0{}^2))^{\frac{1}{2}}}{\zeta + (1+\delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}}}\right] - \left(\frac{\gamma-1}{4}\right) \left[\ln \left(\frac{x^2+ y^2+4s_x(s_x-x)}{R^2+ y^2+4s_x(s_x-R)}\right) + \ln \left(\frac{x^2+y^2+4s_x(s_x+x)}{R^2+y^2+4s_x(s_x+R)}\right)\right]\right\} \tag{7}$$

This solution not only yields a constant potential on the plane x=R, but also leads to x and y components of electric field which satisfy the necessary boundary conditions imposed on the solution by symmetry. Specifically, the x-component of electric field must vanish in the plane of the wires, while the y-component must vanish at the plates and at the two planes represented by dashed lines connecting the plane of the wires with the plates in Figure 1. The x and y components of the electric field are computed by differentiating the potential expressions. The constant V_0 is chosen to match the potentials at x=R, and V_1 is chosen to match the x-component of the electric field at x=R, y=0. After the matching is carried out for both the potential and electric field we obtain

$$V(x,y) = -\frac{2}{3}\left(\frac{2J}{b\varepsilon_0}\right)^{\frac{1}{2}} (s_x-R)^{3/2} + V_1 \ln \left[\frac{1 - \cos(\pi R/2s_x)}{1 + \cos(\pi R/2s_x)}\right] - a_0E_0 \left\{ \left(\frac{\zeta-1}{2}\right) \ln \left(\frac{x^2+y^2}{R^2+y^2}\right) + (1 + \delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}} - (1+\delta(R^2+y^2-a_0{}^2))^{\frac{1}{2}} + \zeta \ln \left[\frac{\zeta+(1+\delta(R^2+y^2-a_0{}^2))^{\frac{1}{2}}}{\zeta+(1+\delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}}}\right]\right.$$

$$- \left(\frac{\gamma-1}{4}\right) \left[\ln \left(\frac{x^2+y^2+4s_x(s_x-x)}{R^2+y^2+4s_x(s_x-R)}\right) + \ln \left(\frac{x^2+y^2+4s_x(s_x+x)}{R^2+y^2+4s_x(s_x+R)}\right)\right]\Bigg\}$$

$$+ V_1 \sum_{m=1}^{N} \Bigg\{ \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)}\right]$$

$$+ \ln \left[\frac{\cosh\pi(y+2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y+2ms_y)/2s_x + \cos(\pi x/2s_x)}\right]\Bigg\}$$

$$+ V_{st} \sum_{m=-N}^{N} \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)}\right] \tag{8}$$

$$E_x(x,y) = a_0E_0 \Bigg\{ \frac{x}{x^2+y^2} \left[(1+\delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}} - 1\right]$$

$$- \left(\frac{\gamma-1}{2}\right) \left[\frac{x-2s_x}{x^2+y^2+4s_x(s_x-x)} + \frac{x+2s_x}{x^2+y^2+4s_x(s_x+x)}\right]\Bigg\}$$

$$- \frac{V_1\pi}{s_x} \operatorname{Sin}(\pi x/2s_x) \sum_{m=1}^{N} \Bigg\{ \frac{\cosh\pi(y-2ms_y)/2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)}$$

$$+ \frac{\cosh\pi(y+2ms_y)/2s_x}{\cosh^2\pi(y+2ms_y)/2s_x - \cos^2(\pi x/2s_x)}\Bigg\}$$

$$- \frac{V_{st}\pi}{s_x} \operatorname{Sin}(\pi x/2s_x) \sum_{m=-N}^{N} \Bigg\{ \frac{\cosh\pi(y-2ms_y)/2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)}\Bigg\} \tag{9}$$

$$E_y(x,y) = a_0E_0 \Bigg\{ \left(\frac{y}{x^2+y^2}\right) \left[(1+\delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}} - 1\right]$$

$$- \left(\frac{y}{R^2+y^2}\right) \left[(1+\delta(R^2+y^2-a_0{}^2))^{\frac{1}{2}} - 1\right]$$

$$- \left(\frac{\gamma-1}{2}\right) \left[\frac{y}{x^2+y^2+4s_x(s_x-x)} + \frac{y}{x^2+y^2+4s_x(s_x+x)} - \frac{y}{R^2+y^2+4s_x(s_x-R)} - \frac{y}{R^2+y^2+4s_x(s_x+R)} \right] \Bigg\}$$

$$- \frac{V_1\pi}{s_x} \cos(\pi x/2s_x) \sum_{m=1}^{N} \left\{ \frac{\mathrm{Sinh}\,\pi(y-2ms_y)/2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)} + \frac{\mathrm{Sinh}\,\pi(y+2ms_y)/2s_x}{\cosh^2\pi(y+2ms_y)/2s_x - \cos^2(\pi x/2s_x)} \right\}$$

$$- \frac{V_{st}\pi}{s_x} \cos(\pi x/2s_x) \sum_{m=-N}^{N} \left\{ \frac{\mathrm{Sinh}\,\pi(y-2ms_y)/2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)} \right\} \quad (10)$$

for $x < R$, and

$$V(x,y) = -\frac{2}{3}\left(\frac{2J}{b\varepsilon_0}\right)^{1/2} \left[(s_x-R)^{3/2} - (x-R)^{3/2} \right] + (V_{st}+V_1) \sum_{m=-N}^{N} \ln \left[\frac{\cosh\pi(y-2ms_y)/2s_x - \cos(\pi x/2s_x)}{\cosh\pi(y-2ms_y)/2s_x + \cos(\pi x/2s_x)} \right] \quad (11)$$

$$E_x(x,y) = -\left(\frac{2J}{b\varepsilon_0}\right)^{1/2} (x-R)^{1/2} - (V_{st}+V_1)\pi/s_x \,\mathrm{Sin}(\pi x/2s_x) \sum_{m=-N}^{N} \left[\frac{\cosh\pi(y-2ms_y)\,2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)} \right] \quad (12)$$

$$E_y(x,y) = -(V_{st}+V_1)\pi/s_x \cos(\pi x/2s_x) \sum_{m=-N}^{N} \left[\frac{\mathrm{Sinh}\,\pi(y-2ms_y)/2s_x}{\cosh^2\pi(y-2ms_y)/2s_x - \cos^2(\pi x/2s_x)} \right] \quad (13)$$

for $x > R$, where

$$V_1 = \frac{a_0 E_0 (\gamma-1) s_x}{\pi R} \operatorname{Sin}(\pi R/2s_x) \left\{ 1 - \frac{R}{2} \left[\frac{R-2s_x}{R^2+4s_x(s_x-R)} + \frac{R+2s_x}{R^2+4s_x(s_x+R)} \right] \right\} \tag{14}$$

The charge density profiles corresponding to the above functions can be computed from the two separate symmetries used in this model. For cylindrical symmetry the charge density is given by

$$\rho(x,y) = - (2J/ba_0E_0) \ (1+\delta(x^2+y^2- a_0{}^2))^{-\frac{1}{2}} \tag{15}$$

while, for rectangular symmetry the charge density is

$$\rho(x,y) = - (\varepsilon_0 J/2b)^{\frac{1}{2}} \ (x-R+K_1)^{-\frac{1}{2}} \ , \tag{16}$$

where K is a constant which is added to avoid a singularity in the charge density at x=R. The constant K_1 is to be chosen to match the two charge density profiles at x=R, y=0. Because the charge distributions are distorted considerably by the charge on the plates, it is necessary to use empirical correction factors to improve the agreement of these charge profiles with the numerically integrated solutions. One such correction term can be generated by differentiating the image terms in equation (8) and then replacing R^2 by x^2. With correction factors we obtain

$$\rho(x,y) = - (2J/ba_0E_0) \ (1+\delta(x^2+y^2-a_0{}^2))^{-\frac{1}{2}} \ f_1 + f_2 \tag{17}$$

for $x < R$ and

$$\rho(x,y) = - (\varepsilon_0 J/2b)^{\frac{1}{2}} \ (x-R+K_1)^{-\frac{1}{2}} \ f_3 \tag{18}$$

for $x > R$ where

$$f_1 = \{[1+0.16 \ y/s_y] \ [1+2.2 \ (y/s_y)^9]\}^{-1} \ , \tag{19}$$

$$f_2 = 0.45 \ \varepsilon_0 a_0 E_0 \ [(1+\delta(x^2+y^2-a_0{}^2))^{\frac{1}{2}} - 1]$$

$$\left[\frac{R^2-y^2+4s_x(s_x-R)}{(R^2+y^2+4s_x(s_x-R))^2} + \frac{R^2-y^2+4s_x(s_x+R)}{(R^2+y^2+4s_x(s_x+R))^2} \right] \ , \tag{20}$$

and

$$f_3 = \{[1+0.75 \ y/s_y] \ [1+2.2 \ (y/s_y)^9]\}^{-1} \ . \tag{21}$$

Equations (8) through (21) completely characterize the approximate model. Although the charge profiles have not been optimized from an empirical standpoint, they are adequate for most purposes. It

should be pointed out that the charge density profiles are the least important of all the functions described in this model. The electrical behavior of precipitators is characterized primarily by the potential and the electric field. As will be shown in the next section, the potential and electric field expressions of this approximate model predict the operating conditions of wire-duct precipitators quite well.

COMPARISONS OF APPROXIMATE MODEL WITH NUMERICALLY INTEGRATED SOLUTIONS AND EXPERIMENTAL OBSERVATIONS

In general, the agreement of the approximate model with the numerically integrated solution is found to be quite good. In all the cases described here, the approximate model was compared with the results of the numerical integration scheme described in Section 5 of this report. Table 1 summarizes the comparison between the approximate model and the numerical solution for a wide range of geometrical parameters and current densities. Columns 1, 2, and 3 list the corona wire radius, the wire-to-plate spacing, and the half wire-to-wire spacing, respectively. While more combinations of geometrical parameters in this table are typical of industrial electrostatic precipitators, examples of both close and wide wire spacing are shown. Both large and small corona wires are represented and a considerable range of plate spacings is given. Column 4 lists the current densities that were used. The values of current density were chosen to represent both moderate and relatively high space charge situations. Column 5 gives the percent difference in applied voltage for the approximate and numerically integrated solutions. Column 6 gives the percent difference in the average electric field at the plate. Column 7 gives the maximum percent difference in the potential profiles. Columns 8 and 9 give the maximum percent differences in the x-component and the y-component respectively of the electric field profiles. Column 10 gives the maximum percent difference in the charge density profiles. For a comparison with average errors, consider the parameters shown in row 3 of Table 1. For these parameters, which are typical of electrostatic precipitators in the United States, the average difference in the approximate and integrated potential profiles is 1 percent. The average difference in the x-component of the electric fields is 2 percent while the average difference in the y-components is 24 percent. The average difference in the charge density profiles is 8 percent. It can be observed that the average differences in the approximate and integrated solutions are appreciably smaller than the corresponding maximum values listed in Table 1. The average errors stated for this particular set of parameters are representative of those occurring throughout the table.

In the approximate model, one is free to choose the position (x=R) at which to match the functions derived from the two different symmetries. For the calculations shown in Table 1, R was chosen to be $0.975s_x$. This corresponds to using only a few

Table 1. COMPARISON OF APPROXIMATION AND NUMERICALLY INTEGRATED SOLUTION

Wire Radius (10^{-3} m)	Wire Plate Distance (m)	Half Wire-to-wire Distance (m)	Current Density (nA/cm^2)	Percent Difference In Applied Voltage	Percent Difference In Field At The Plate	Max. % Difference In Potential Profiles	Max. % Difference In x-component of field[1]	Max. % Difference In y-component of field[2]	Max. % Difference In Charge Density Profiles[3]
1.1906	0.127	0.03175	10	1	6	2	12	400	23
1.1906	0.127	0.03175	100	3	12	5	12	400	32
1.1906	0.127	0.0635	10	0	8	3	12	100	18
1.1906	0.127	0.0635	100	2	9	8	11	320	12
1.1906	0.127	0.127	10	3	1	8	12	53	8
1.1906	0.127	0.127	100	1	0.1	11	5	118	10
1.1906	0.127	0.15875	20	2	5	12	10	30	19
1.1906	0.127	0.15875	100	2	6	13	16	40	22
1.1906	0.200	0.0635	20	3	1	7	15	60	24
1.1906	0.200	0.0635	80	4	6	2	7	50	10
3.00	0.127	0.0635	20	2	4	2	7	50	10
3.00	0.127	0.0635	100	2	2	4	9	50	12
0.500	0.127	0.0635	10	3	9	4	15	300	14
1.016	0.1143	0.07348	20	1	3	3	9	40	9
1.016	0.1143	0.07348	200	2	1	6	10	80	15
0.1524	0.1143	0.07348	5	22	6	22	18	300	6
0.1524	0.1143	0.07348	180	9	10	9	16	213	13

[1]Points closer than two diameters to the wire and points near the plane connecting the centers of the wires with the plates have been neglected.

[2]Even though the percent difference in the y-components of the electric field seems quite large in some cases, the absolute error is relatively unimportant because the y-component is much smaller than the total field for nearly all such cases.

[3]Some points very near the plates and some near the centers of the wires have been neglected.

millimeters near the plate in which the space charge is distributed according to the rectangular geometry of a parallel plate arrangement. The reason for using such a small volume with rectangular symmetry is that in general the parallel plate solution predicts too large an effect due to space charge. The fact that rectangular symmetry plays such a small role in the space charge contribution to the profiles does not necessarily contradict the observations made earlier that the equipotential lines near the plate reflect a strong influence of planar geometry. The planar character of the equipotential lines is largely provided by the static-like solution which accounts rigorously for much of the charge on the plates. For cases in which the radius (R) of the cylinder of space charge is larger than the half wire-to-wire spacing, adjacent cylinders of space charge will overlap. In this situation the effects of space charge would be overestimated. To correct for that error in this simple model we reduce the contribution to the potential and electric field components from space charge associated with wires other than the central one by the fraction of the volume of the cylinder that does not extend beyond s_y. This fraction is given by

$$F = \begin{cases} 1 - \frac{2}{\pi}\left[\mathrm{ArcCos}(s_y/R) - \frac{s_y}{R^2}\,(R^2 - s_y{}^2)^{\frac{1}{2}}\right], & s_y < R \\ 1 & , s_y \geq R \,. \end{cases} \qquad (22)$$

This factor would multiply V_1 in the space charge terms arising from wires other than the central one (m=0). Surprisingly, this simplistic correction yields rather good agreement between the approximate model and the numerically integrated solution. In all cases the approximate model agrees well with the numerically integrated solution for zero current. This case, of course, corresponds to the electrostatic solution at conditions for corona start, the limit in which the approximate model becomes exact.

Predictions of the approximate model as well as those of the numerical solution are compared with some experimental results of Penney and Matick[8] in Figures 4, 5, and 6. An effective ion mobility of 1.8×10^{-4} $m^2/V\cdot sec$ in the approximate model yields voltage-current curves which predict the experimental operating conditions to within one percent. These voltage-current curves along with the numerically integrated ones are shown in Figure 4. Figure 5 shows a comparison of the potential profiles along a line connecting the wire with the plate. The approximate model agrees with this measured potential profile to within 3 percent. A comparison of the potential profiles along a line connecting a point midway between two wires with the plate is shown in Figure 6. The approximate potential is as much as 15 percent larger than the measured potential along this line. The approximate potential is 10 percent larger than the numerically integrated

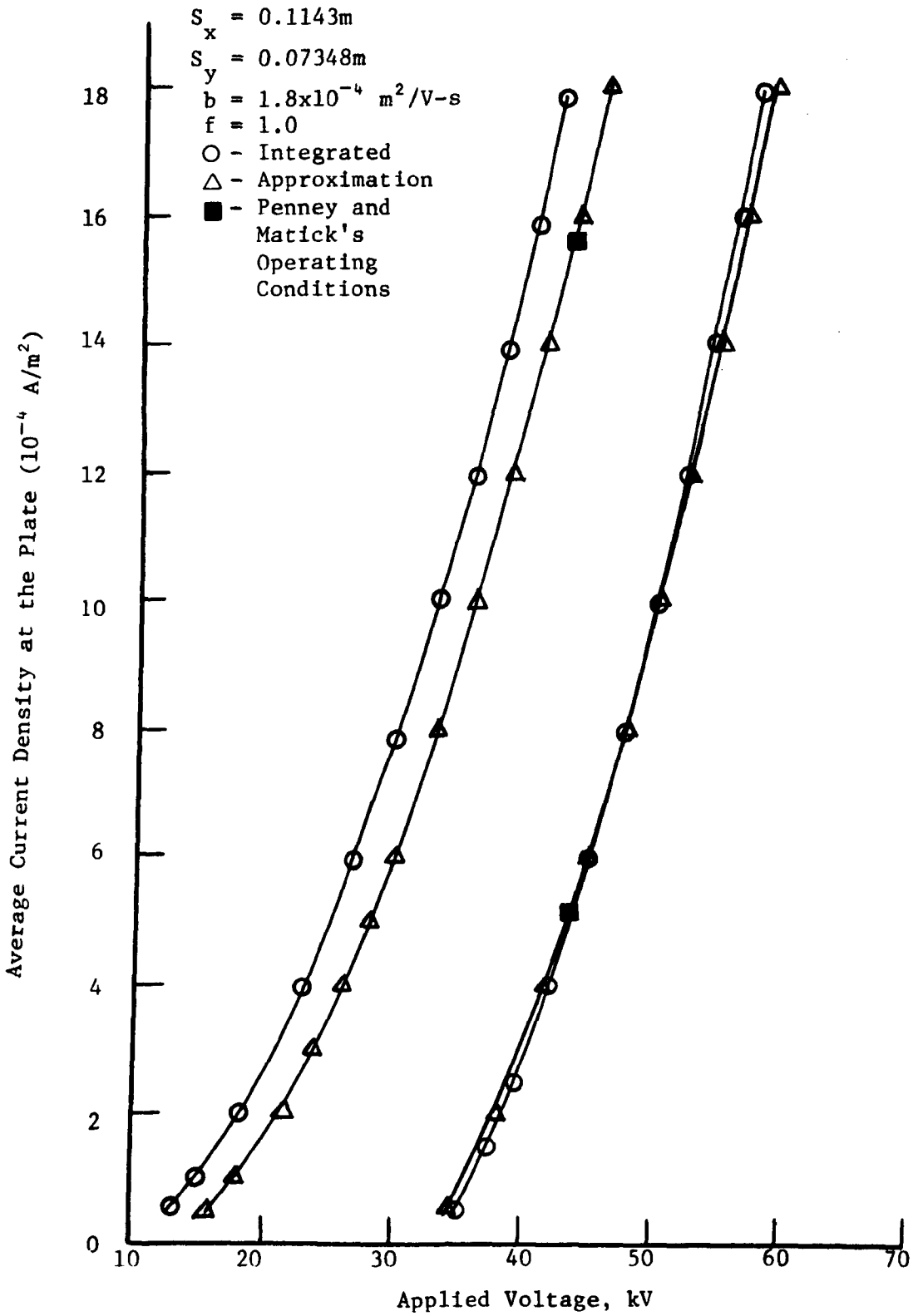

Figure 4. Current-voltage curves showing a comparison of the approximate model with the numerically integrated solution for geometrical parameters corresponding to the experimental conditions of Penney and Matick.

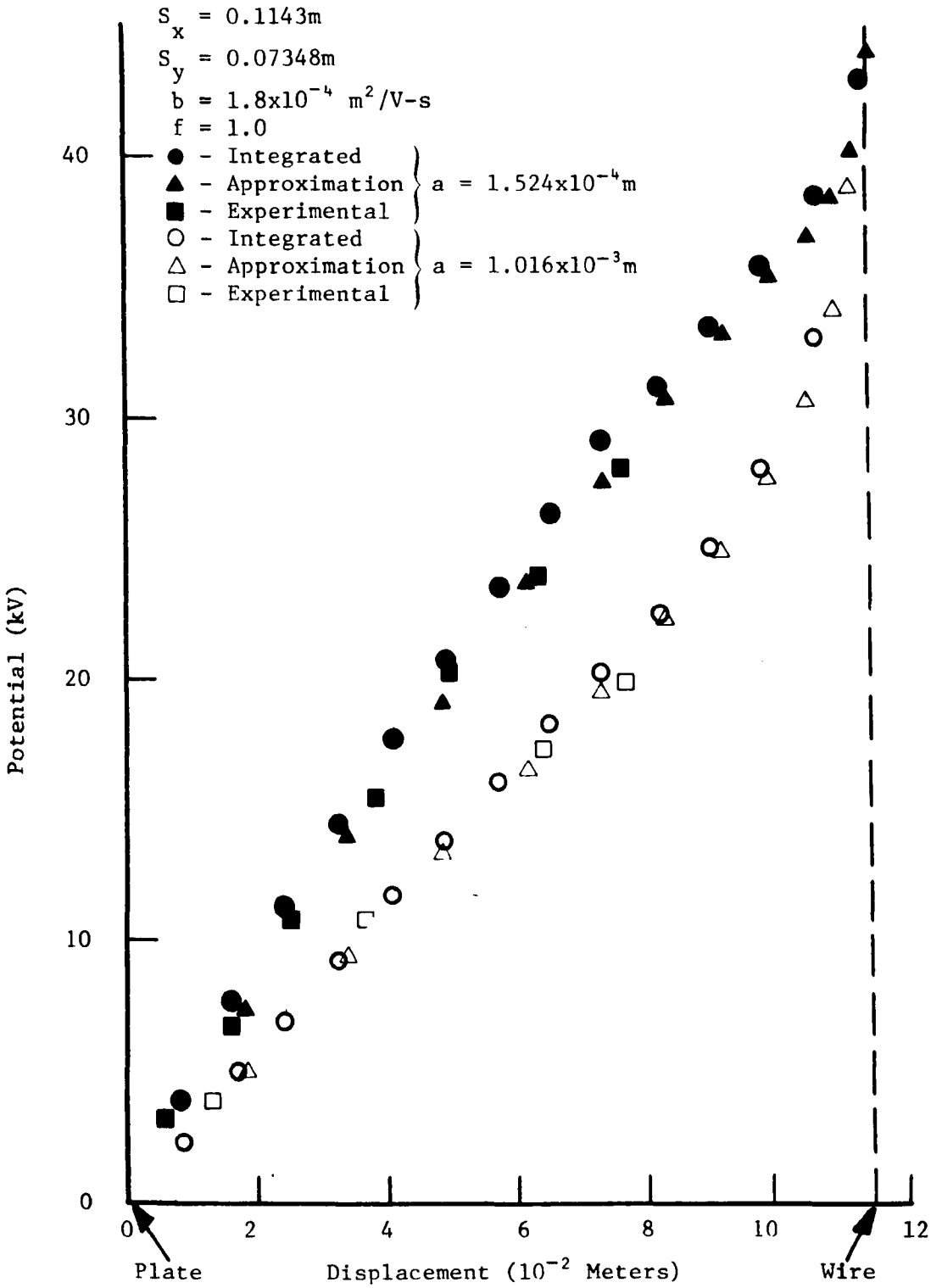

Figure 5. Comparison of theoretical potential profiles between a wire and plate with experiments of Penney and Matick.

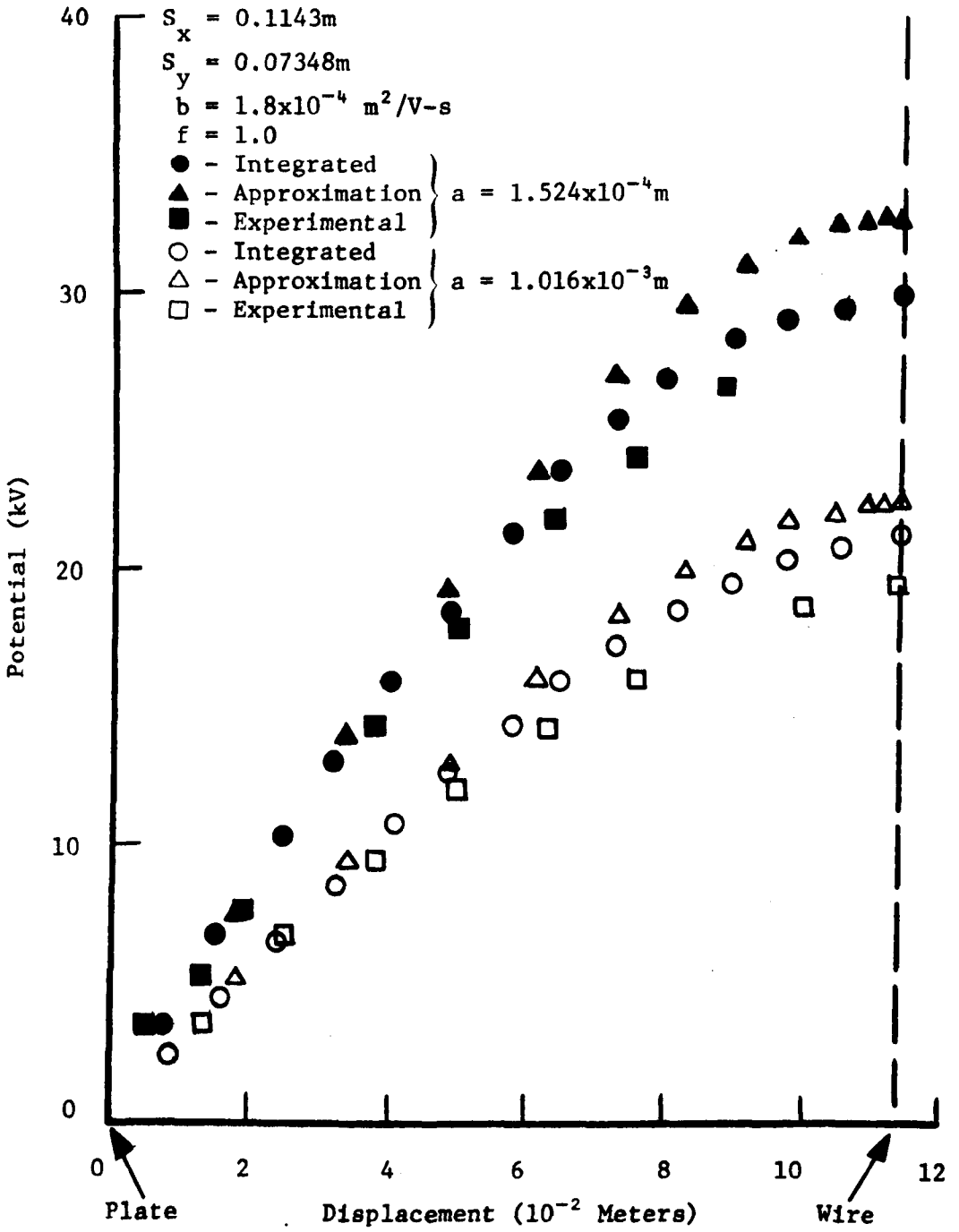

Figure 6. Comparison of theoretical potential profiles midway between wires with experiments of Penney and Matick.

potential along this same line. The apparent reason for this disagreement lies in the large current density used. A large current density corresponds to the large space charge limit where the approximation is expected to be less accurate. Also, the region between the wires is where the approximate model is expected to be least accurate. It should be noted that moderate errors in the potential profile in the regions between the wires have little influence on the predicted electrical operating conditions of the electrostatic precipitator. The value of 1.8×10^{-4} $m^2/V \cdot sec$ used for effective mobility is consistent with measured values of ion mobility in negative corona discharges in ambient air. It may be concluded that the predictions of the approximate model agree quite well both with the numerically integrated solutions and with experimentally measured electrical properties of electrostatic precipitators.

SUBROUTINE EFLD3

This subroutine calculates the electrical conditions in a wire-plate precipitator under conditions corresponding to those in both EFLD1 and EFLD2. The particular calculation to be done is determined by the value of the parameter NVII which in turn is determined by the input parameter NVI. When NVI has the value 3, NVII is set to 1 (NVI is then, also, set to 1) and a calculation analogous to the one in EFLD1 is performed. Under these conditions, either equation (9) or (12) is used to compute the average electric field at the plate. This calculation is based on known or measured values of current and voltage.

When NVI has the value 4, NVII is set to 2 (NVI is set to 2) and a calculation analogous to that in EFLD2 is performed. In this case, the subroutine calculates a voltage-current curve up to a specified value of operating voltage and calculates the average electric field at the plate for the operating applied voltage. The voltage-current curve is generated by (1) specifying a starting value of average current density at the plate, (2) incrementing upward on the average current density, and (3) determining the applied voltage at each value of current density. When a value of current density results in an applied voltage which exceeds the specified operating applied voltage, an interpolation is performed to obtain the operating voltage and current density. At this operating applied voltage, calculations can also be made to give the average current density, average electric field, and average electric field at the plate in subincremental lengths. The potential, electric field, and charge density are computed using equations (8)-(22).

The following is a sequential list of the calling arguments and their descriptions.

UEQ - Effective charge carrier mobility ($m^2/V \cdot sec$).

AC - Radius of discharge electrode (m).

VO - Chosen operating applied voltage (m).

SX - Wire-to-plate spacing (m).

SY - One-half wire-to-wire spacing (m).

NX - Number of grid points in the x-direction.

NY - Number of grid points in the y-direction.

AEPLT - Average electric field at the plate (V/m).

TDK - Temperature of the gas (°K).

P - Pressure of the gas (atm).

RF - Roughness factor for the discharge wire ($0.5 \leq RF \leq 1.0$).

START - Chosen initial current density at which the voltage-current curve calculations starts (A/m^2). Current density increments in units of START until a change is specified.

DSTART - Chosen increment in current density which is used in place of START when specified (A/m^2).

CSTART - Chosen increment in current density which is used in place of DSTART when specified (A/m^2).

IFINAL - Indicator which terminates the loop over average current densities at the plate after IFINAL times.

VSTART - Initial estimate of applied voltage corresponding to the first value of average current density at the plate on the voltage-current curve (V). VSTART is not actually used in EFLD3.

VW - Operating applied voltage corresponding to a given current density (V).

ACDNTY - Average current density at the plate (A/m^2).

NWIRE - Number of wires per gas passage per electrical section.

NEC - Indicator which governs the calculations of average current density, average electric field, and average electric field at the plate in sub-incremental lengths. The calculations are

performed when NEC = 0 and are not performed when NEC = 1.

EBD - Electrical breakdown strength of the gas (V/m).

JI1 - Indicator which governs the change in the increment on average current density at the plate from START to DSTART. The change occurs on the JI1-th value of current density.

JI2 - Indicator which governs the change in the increment on average current density at the plate from DSTART to CSTART. The change occurs on the J12-th value of current density.

The following is a list of the variables which are in common with the main program.

EAVG(M) - Average electric field in a given subincrement of length (V/m).

CHFID(M) - Average ion density in the absence of particles in a given increment of length (#/m^3).

ECOLL(M) - Average electric field at the plate in a given subincrement of length (V/m).

VCOOP(I,J) - The static-like contribution to the potential at a grid point (V).

NPRNT - Indicator which specifies the logical unit number of the printer.

NVII - A parameter which determines whether a voltage-current curve is generated. If NVII is 1 known values of current and voltage are used. If NVII is 2 a voltage-current curve is generated.

The vollowing variables are in common with EFLD4, and CMAN.

ECX(I,J) - The x-component of the static electric field at a grid point (V/m).

ECY(I,J) - The y-component of the static electric field at a grid point (V/m).

AX(I) - The distance between the I-th and I+1-st grid points in the x-direction (m). This is used only with EFLD4.

AY(J) - The distance between the J-th and the J+1-st grid points in the y-direction (m). This is used only with EFLD4.

X1(I) - The x-position of the I-th grid point (m). This is used only with EFLD4.

Y1(J) - The y-position of the J-th grid point (m). This is used only with EFLD4.

LTEST - A logical variable which determines whether a variable or fixed grid spacing is used. When LTEST is .FALSE. a fixed spacing is used. When LTEST is .TRUE. a variable spacing is used. This variable is initialized to .FALSE. by a Block Data subprogram.

Of the above variables, the values of the following must be provided by the main program: UEQ, AC, VO, SX, SY, NX, NY, TDK, P, RF, START, DSTART, CSTART, IFINAL, VSTART, NWIRE, NEC, EBD, JI1, JI2, NVII, and NPRNT. Values of AEPLT, VW, ACDNTY, EAVG, CHFID, ECOLL, VCOOP, ECX, and ECY are determined in the subroutine. This subroutine calls subroutine CMAN to compute the static-like solutions. It also calls subroutine ARCCOS to evaluate equation (22). Since the subroutine ARCCOS has not been changed from the version described in the previous model report, it will not be described here.

There are three conditions which will terminate the calculation of the voltage-current curve in EFLD3. The calculation is terminated if (1) the specified, operating, applied voltage is reached, or (2) the number of points on the curve is equal to the value of IFINAL, or (3) the specified value of the electrical breakdown strength near the collection electrode is exceeded. If the breakdown strength is exceeded, a message to this effect is printed. Figure 7 shows a detailed flow chart of this subroutine. A listing of this subroutine is given in Appendix A.

SUBROUTINE CMAN

This subroutine calculates the static-like solution for potential and the components of electric field at each point in a grid which is established in EFLD1, EFLD2, EFLD3, or EFLD4. The calculation is based on an electrostatic solution for a wire-plate geometry. It uses equations (1), (2), (4), and (14) to compute the potential. The components of the electric field are computed from the derivatives of these equations. These expressions can be recognized in equations (12) and (13). This subroutine differs from CMAN in the previous model report primarily by the addition of the electric field component calculations.

Figure 8 shows a detailed flow chart for this subroutine. Information is transmitted between this subroutine, the main program, and other subroutines through calling arguments and common statements. The following is a sequential list of the calling arguments and their descriptions.

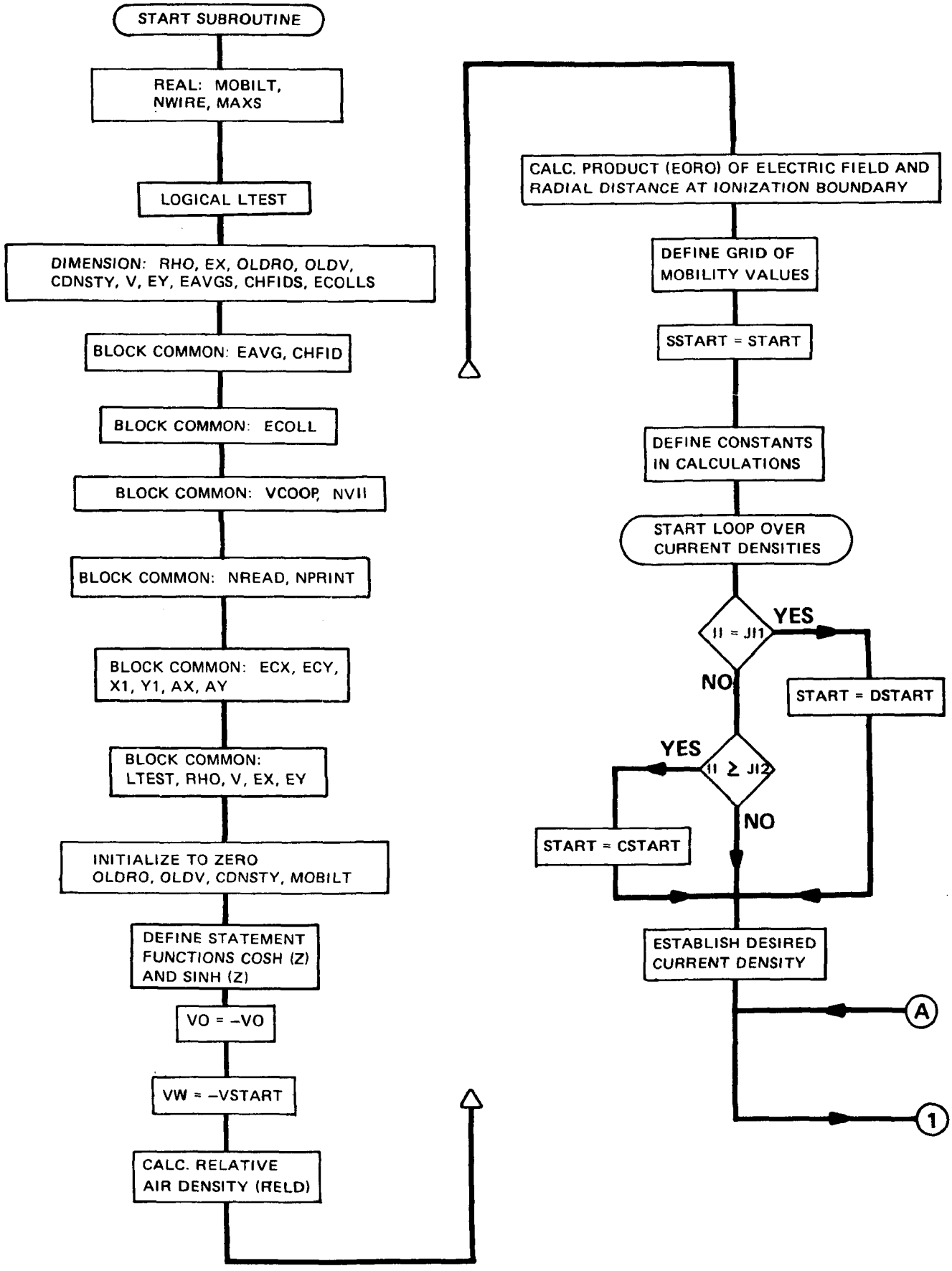

Figure 7. Flow chart for subroutine EFLD3 (sheet 1 of 11).

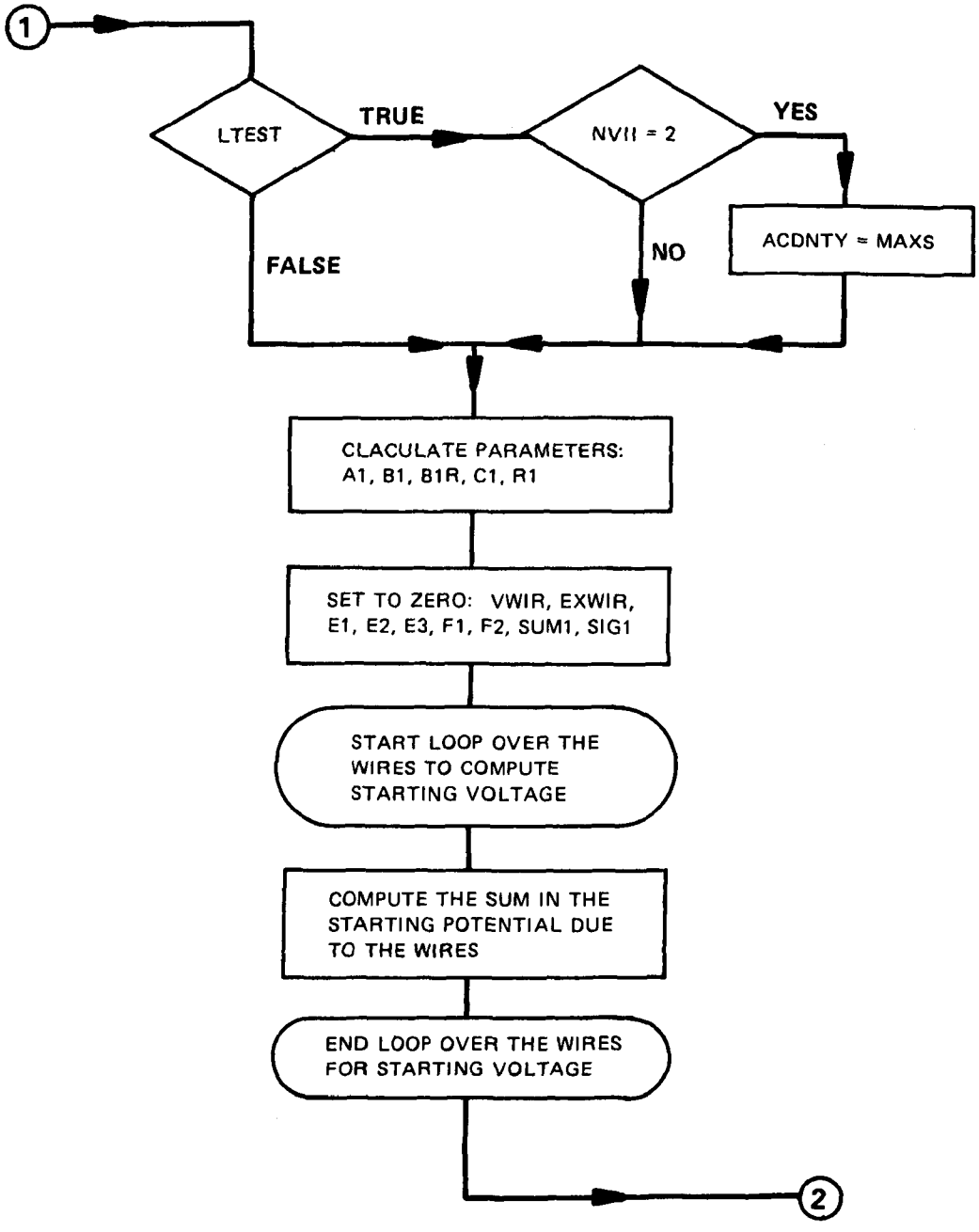

Figure 7. Flow chart for subroutine EFLD3 (sheet 2 of 11).

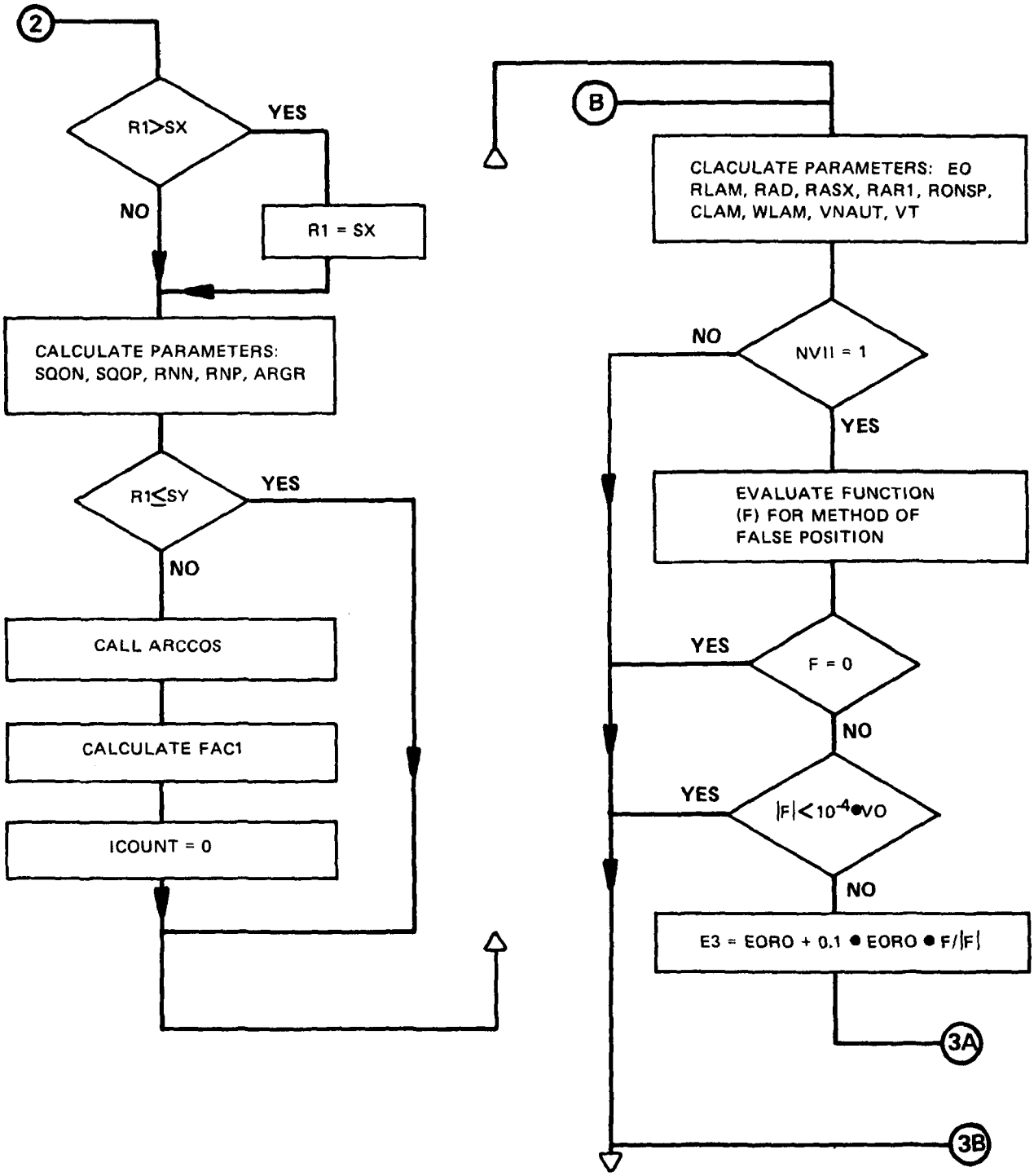

Figure 7. Flow chart for subroutine EFLD3 (sheet 3 of 11).

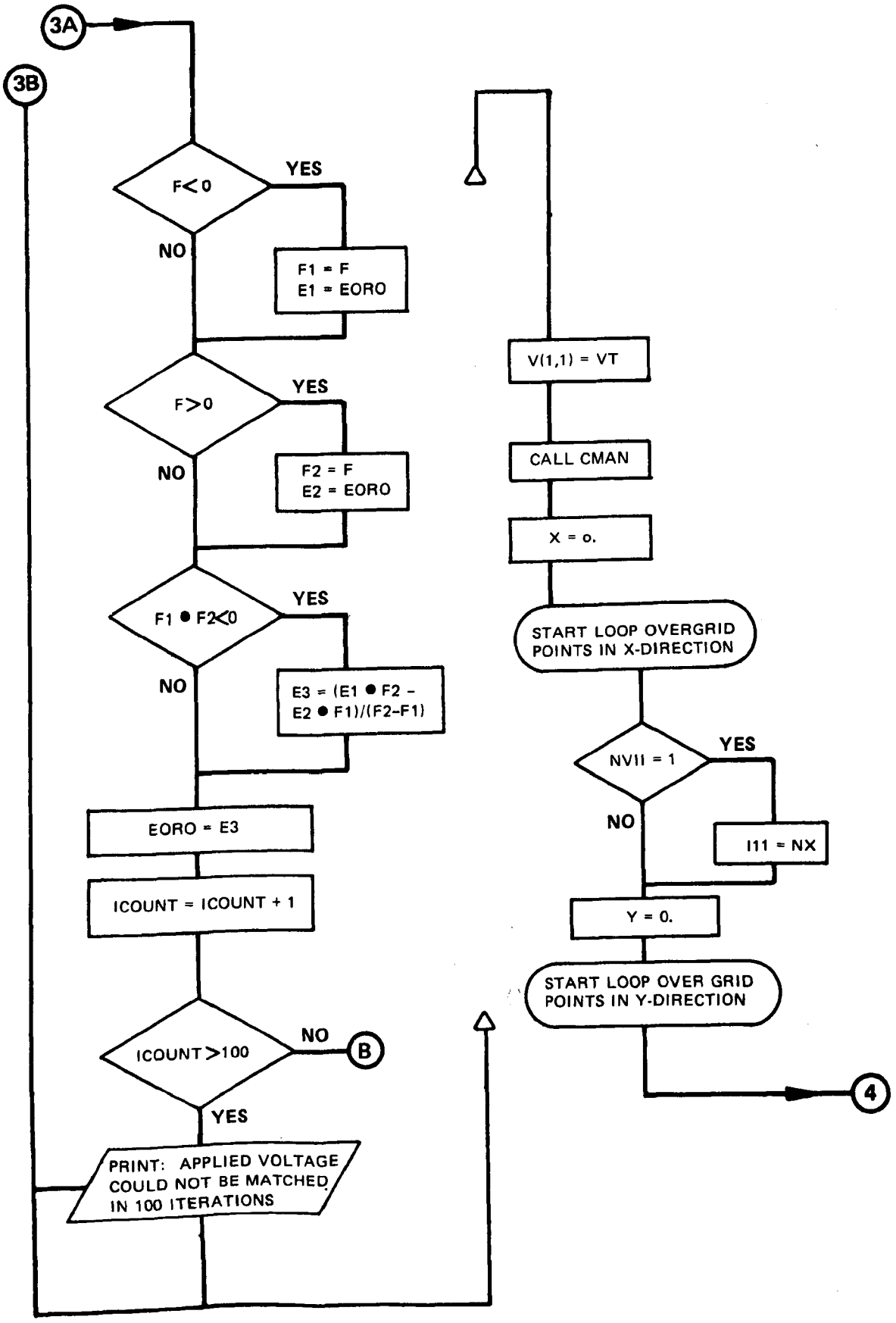

Figure 7. Flow chart for subroutine EFLD3 (sheet 4 of 11).

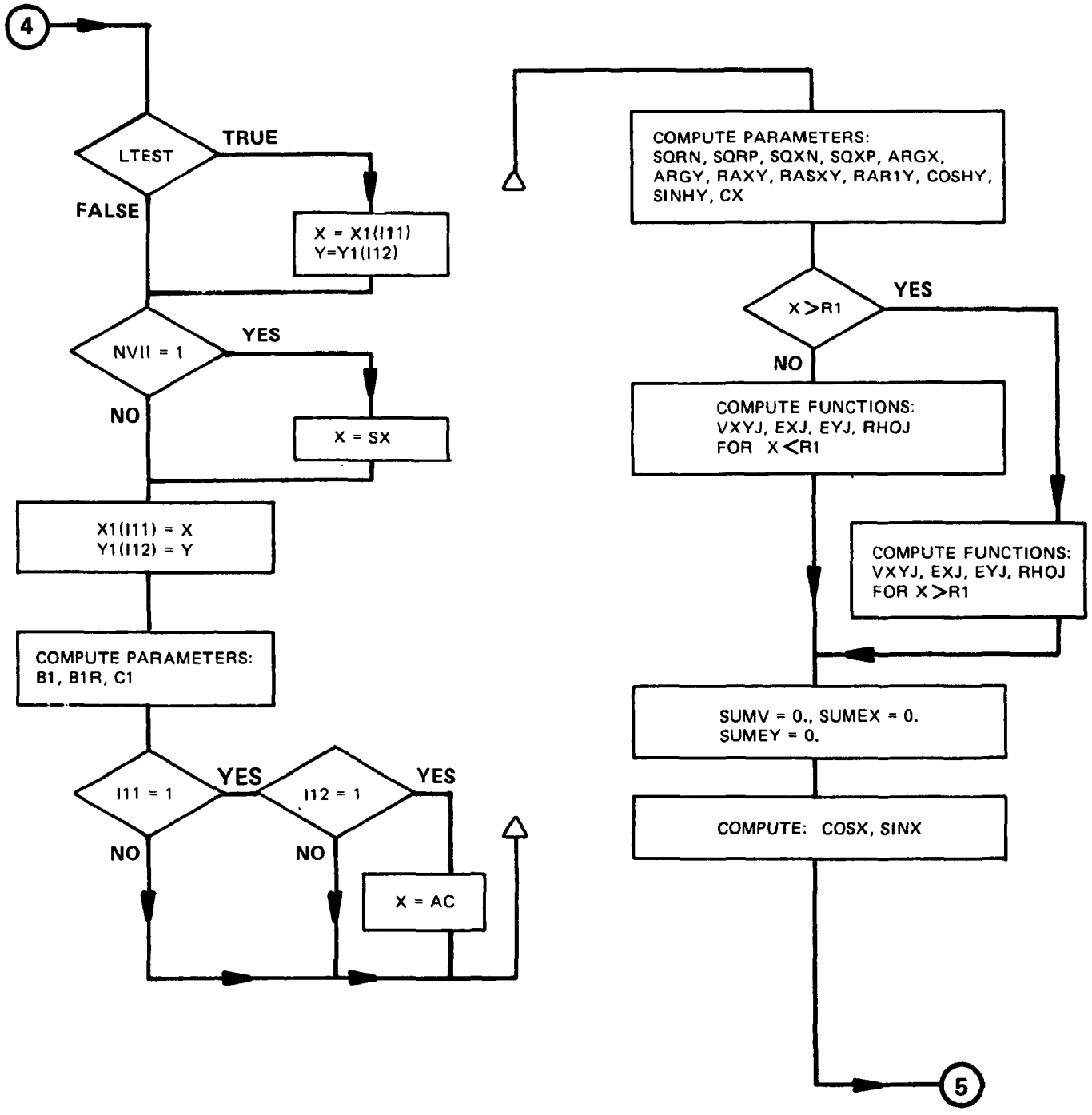

Figure 7. Flow chart for subroutine EFLD3 (sheet 5 of 11).

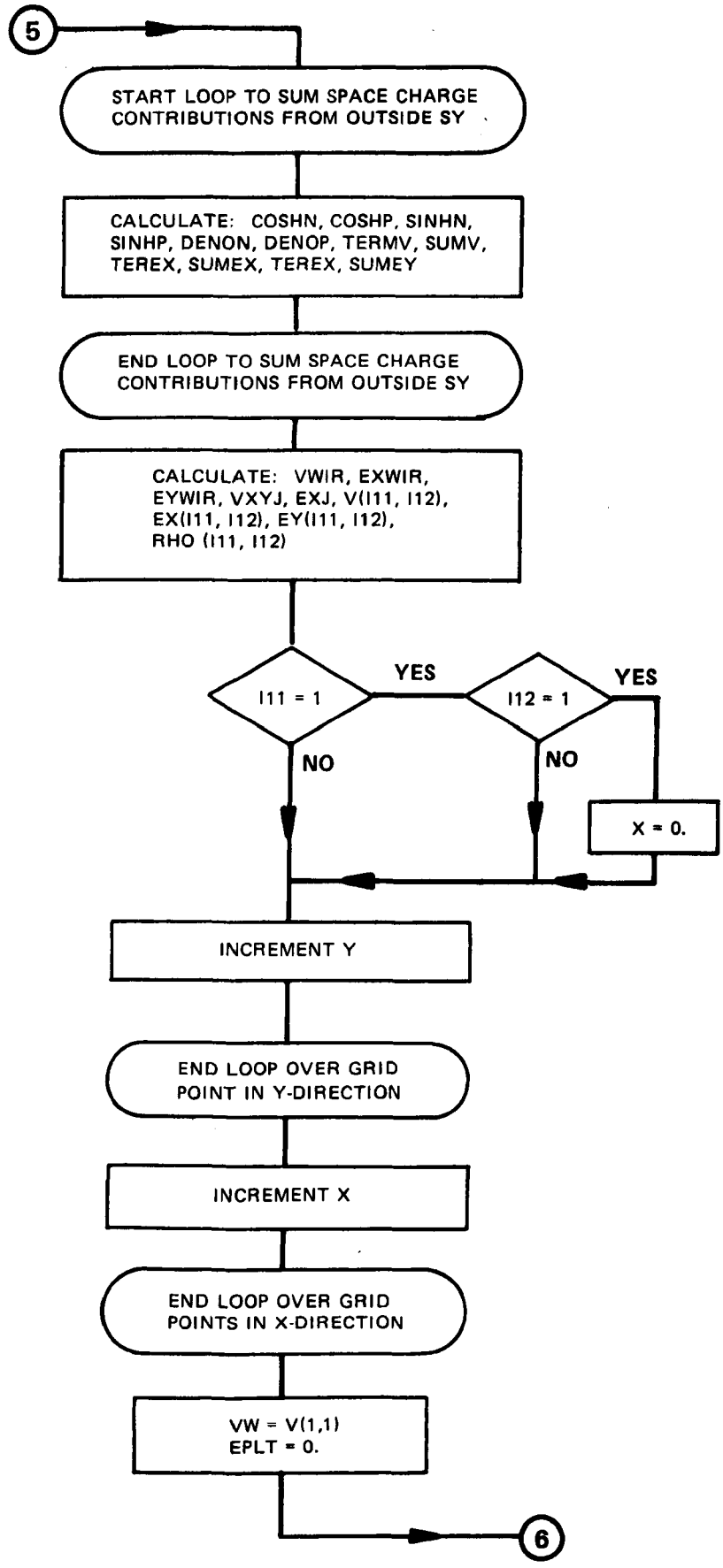

Figure 7. Flow chart for subroutine EFLD3 (sheet 6 of 11).

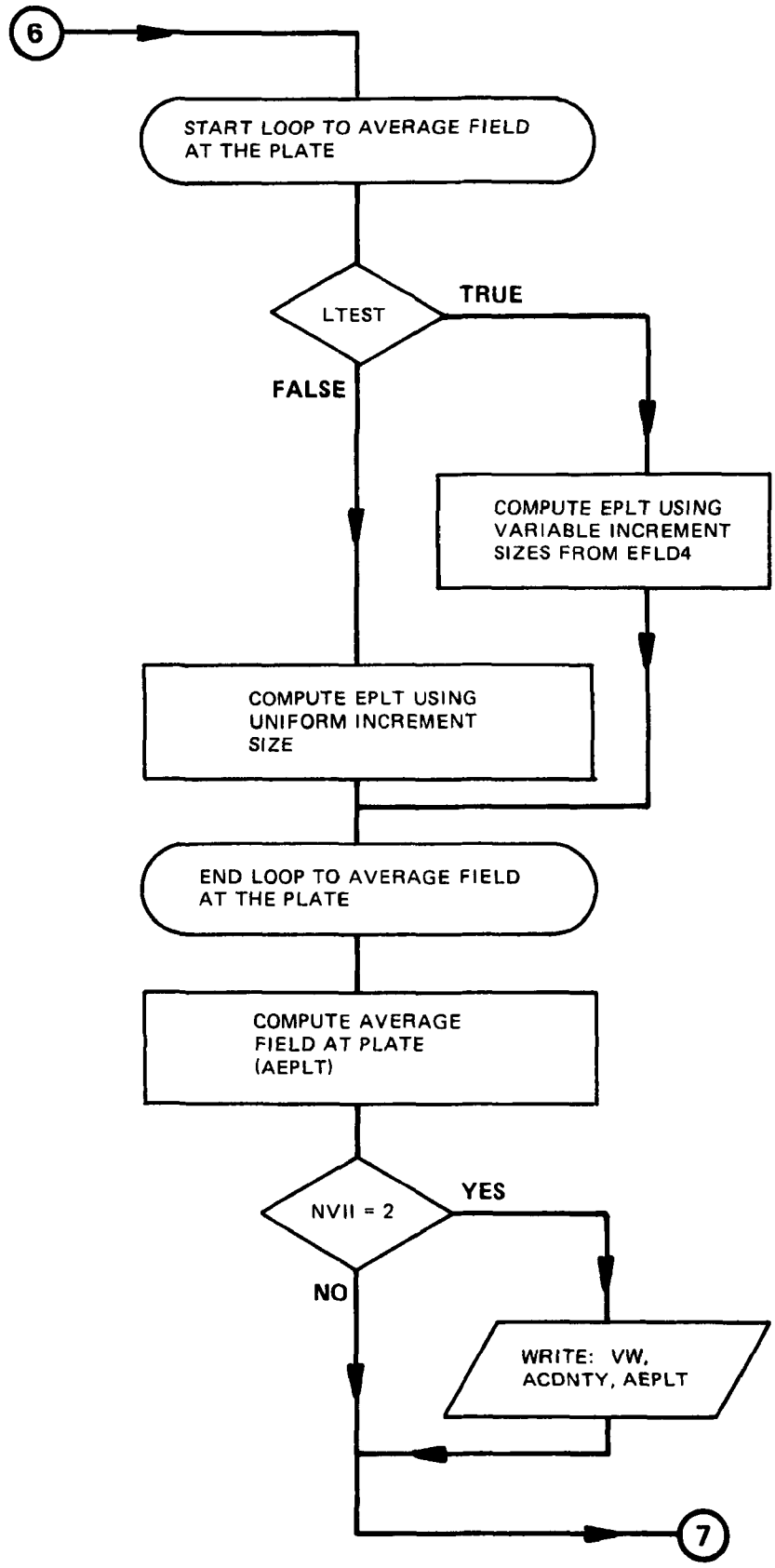

Figure 7. Flow chart for subroutine EFLD3 (sheet 7 of 11).

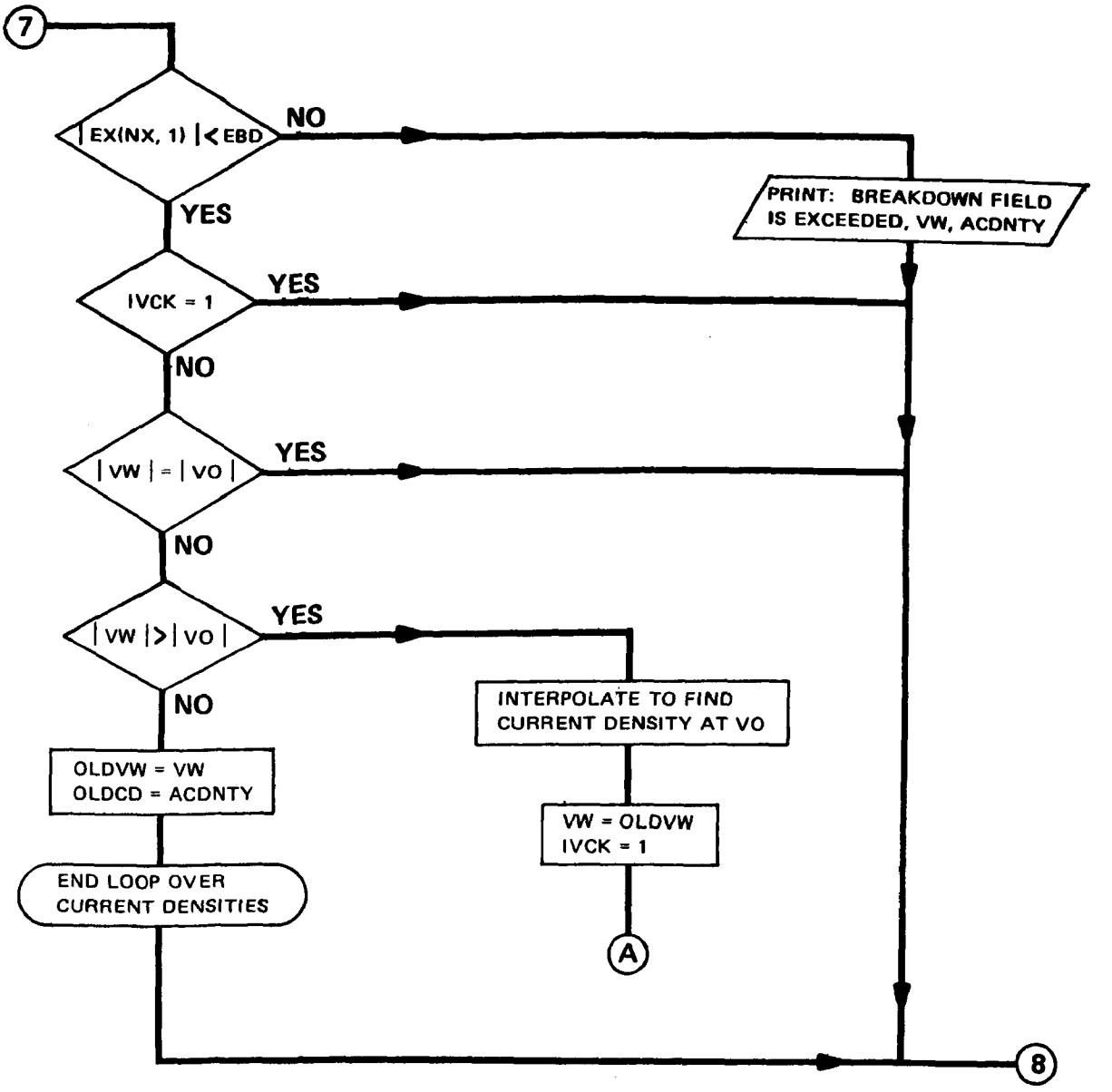

Figure 7. Flow chart for subroutine EFLD3 (sheet 8 of 11).

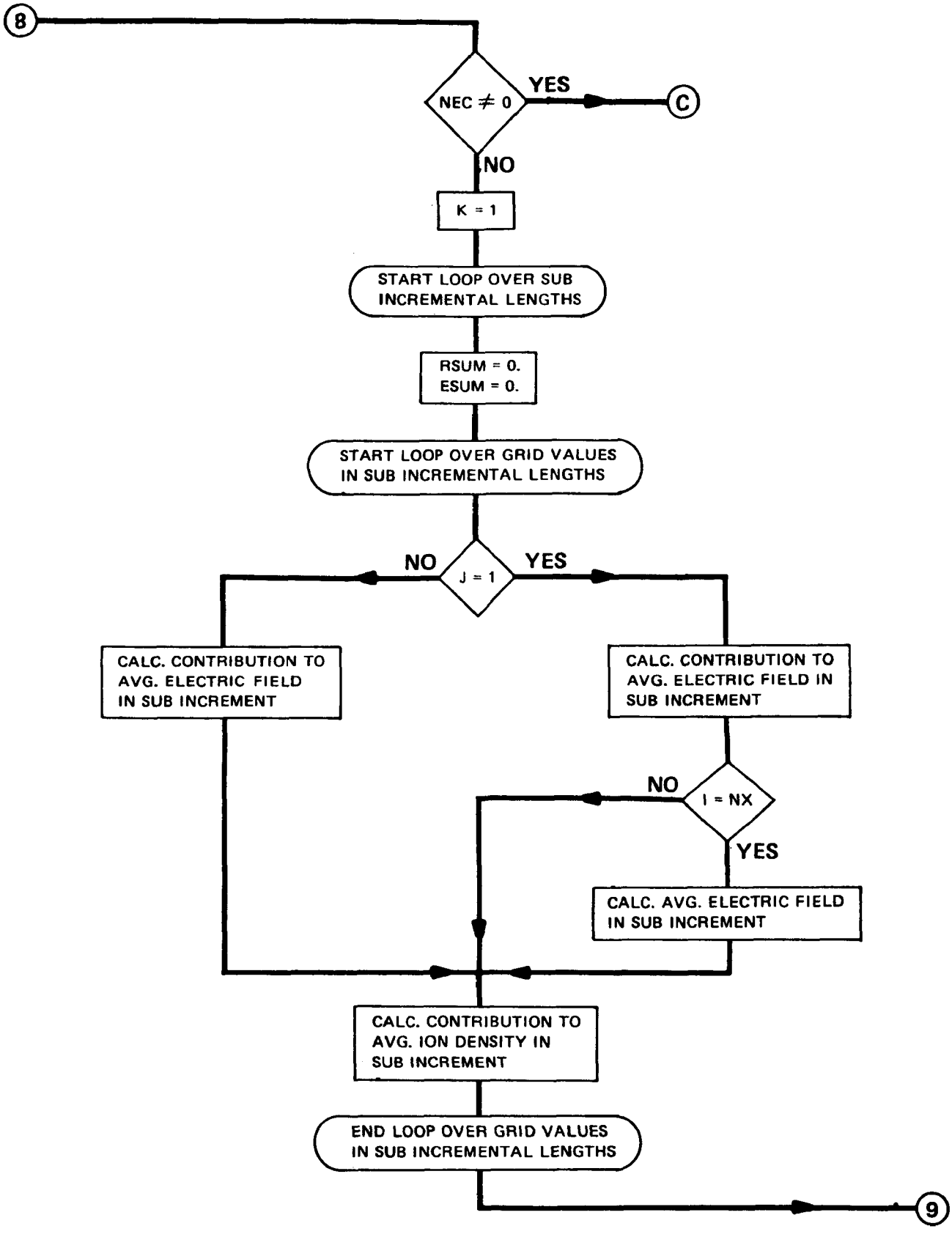

Figure 7. Flow chart for subroutine EFLD3 (sheet 9 of 11).

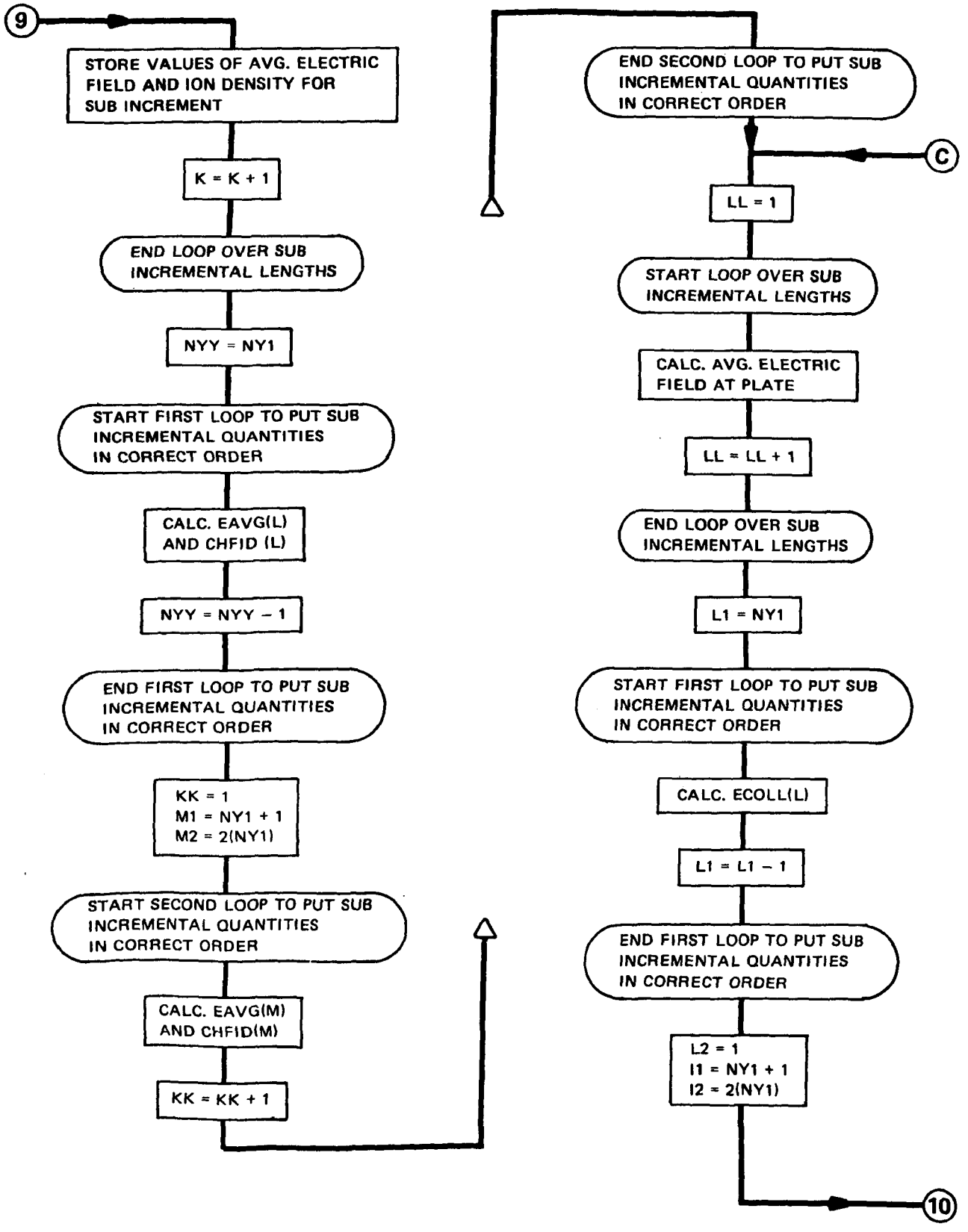

Figure 7. Flow chart for subroutine EFLD3 (sheet 10 of 11).

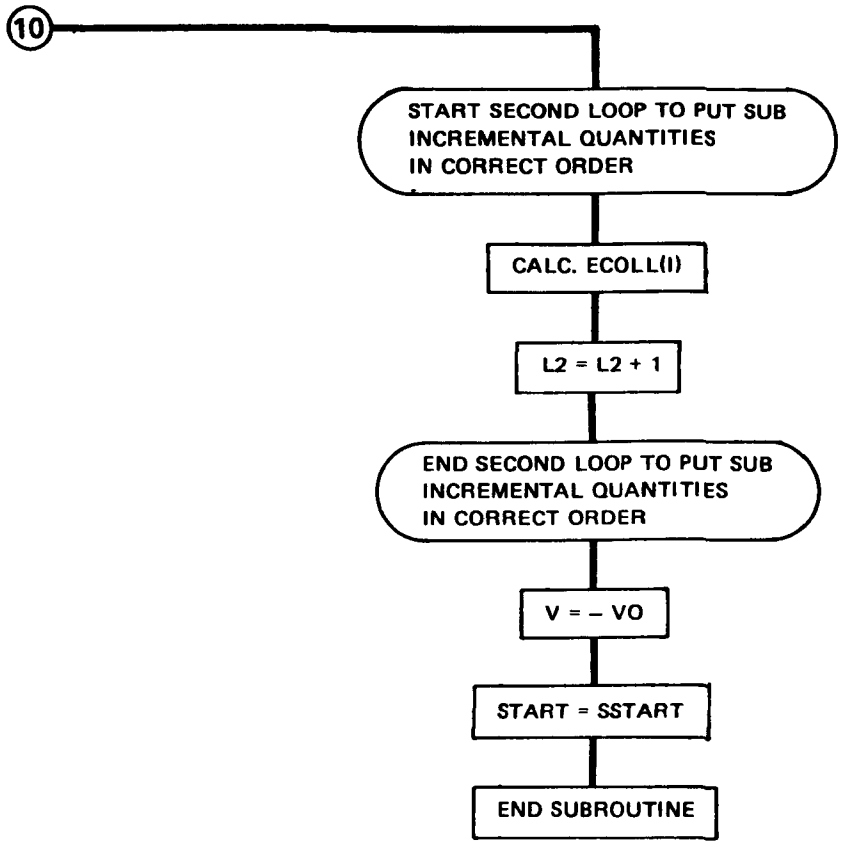

Figure 7. Flow chart for subroutine EFLD3 (sheet 11 of 11).

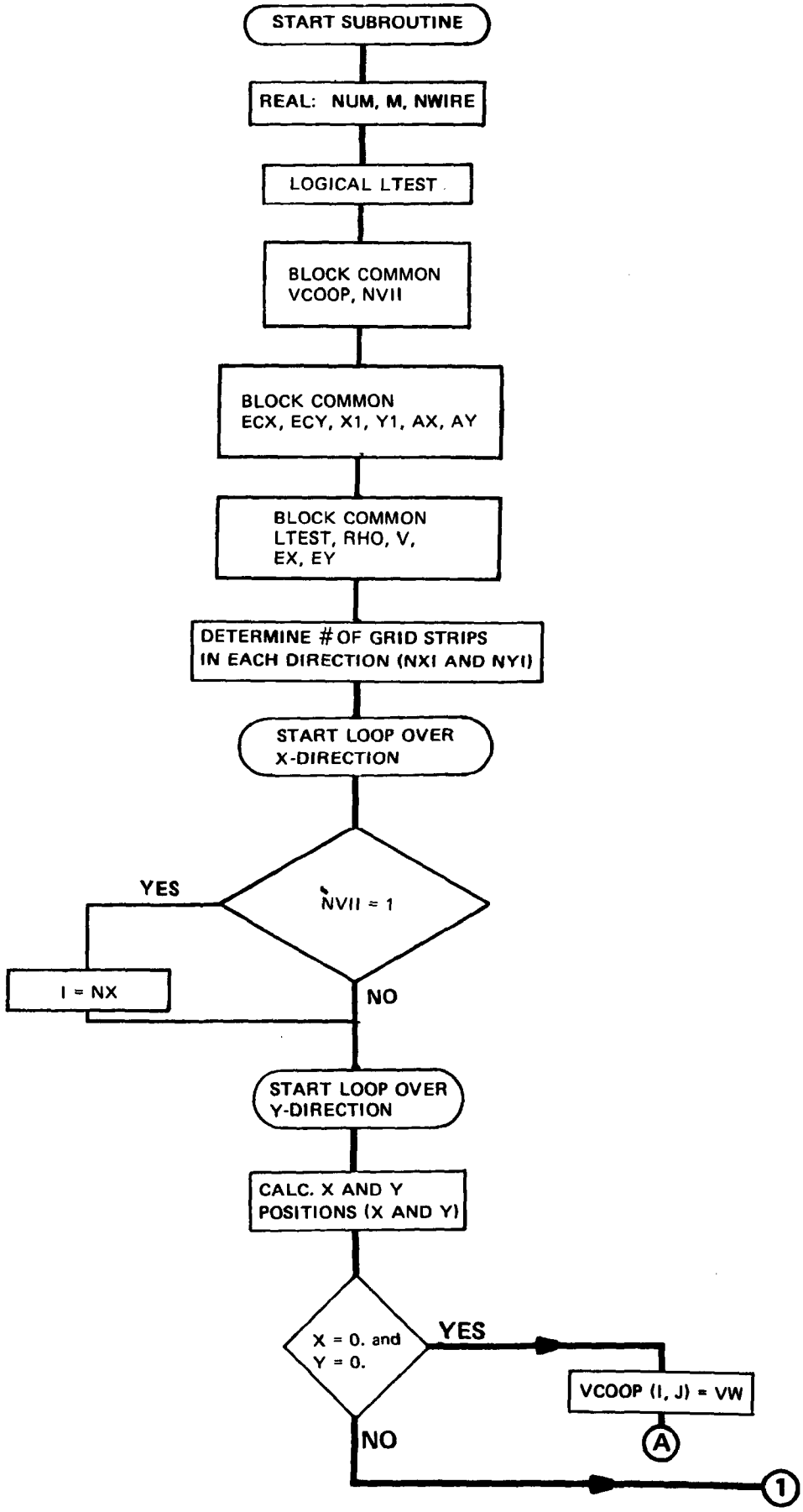

Figure 8. Flow chart for subroutine CMAN (sheet 1 of 3).

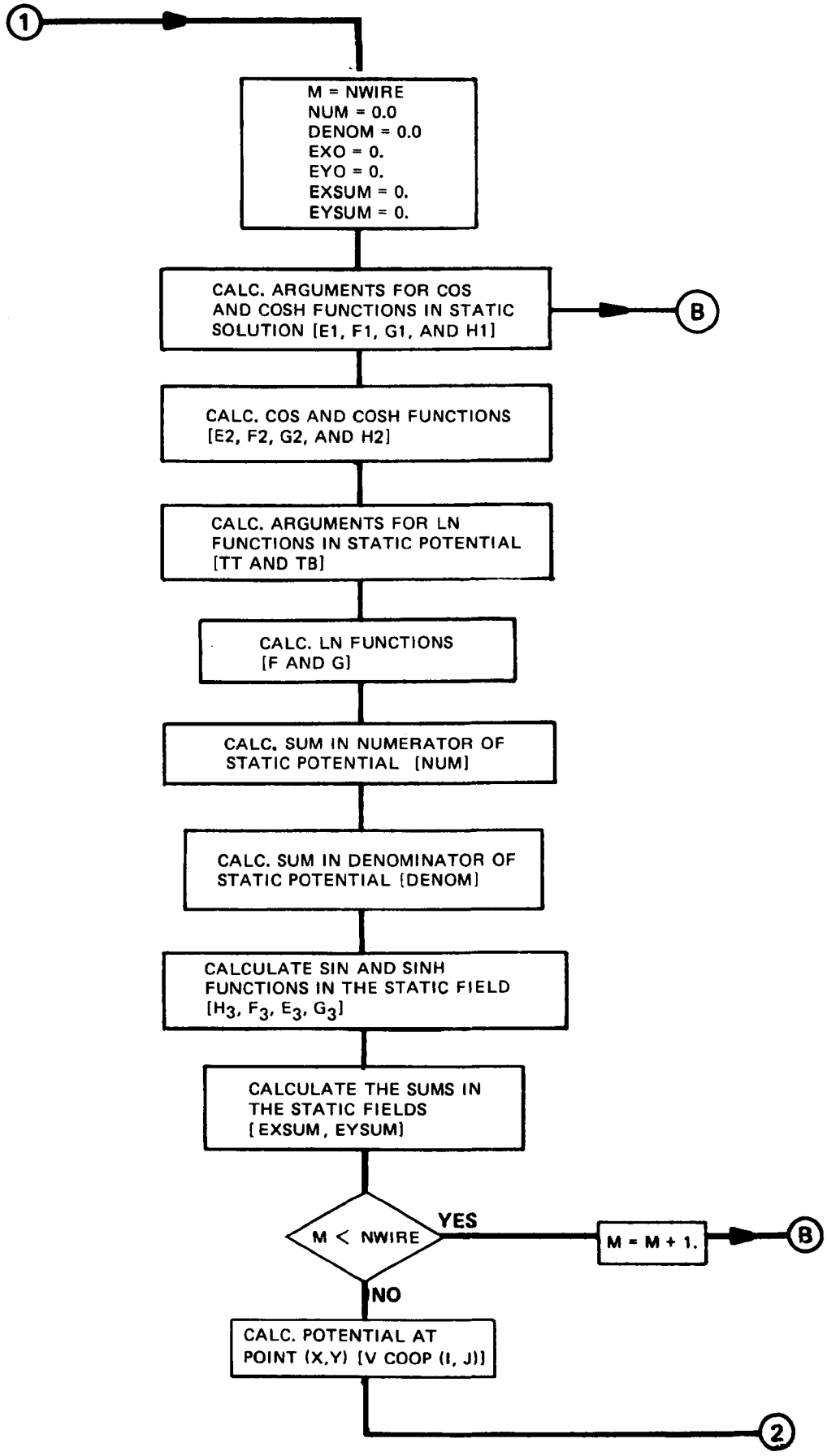

Figure 8. Flow chart for subroutine CMAN (sheet 2 of 3).

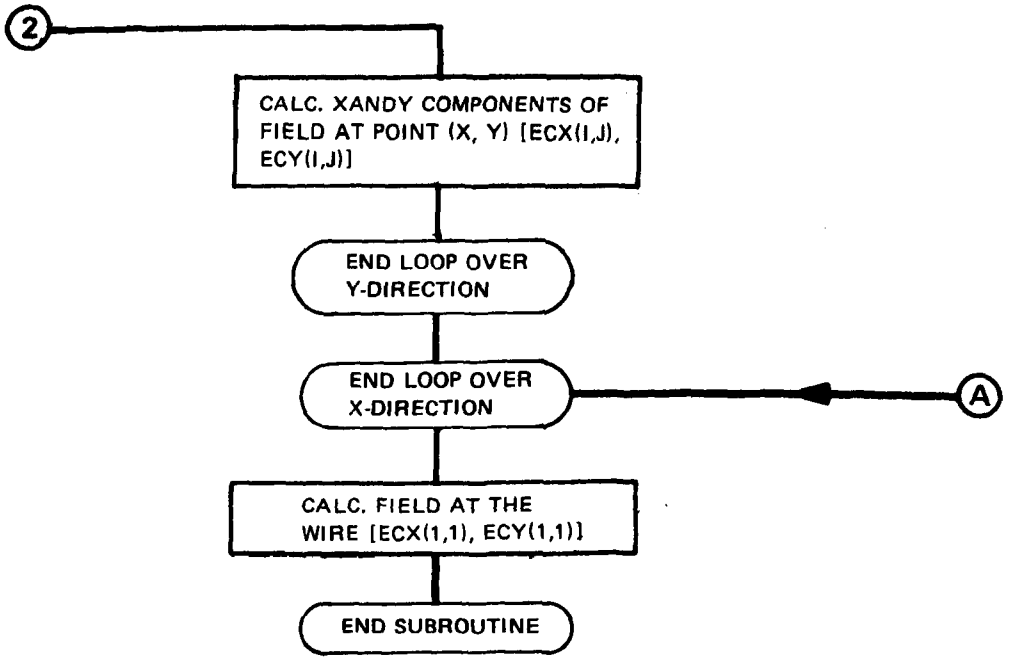

Figure 8. Flow chart for subroutine CMAN (sheet 3 of 3).

VW - Electric potential at the wire (V).

NX - Number of grid points in the x-direction. It cannot exceed a value of 15.

NY - Number of grid points in the y-direction. It cannot exceed a value of 15.

SX - Wire-to-plate spacing (m).

SY - One half wire-to-wire spacing (m).

PI - Value of the constant pi.

AC - Radius of the discharge electrode (m).

NWIRE - Number of wires per gas passage per electrical section.

The following variables are in common with the main program, subroutine EFLD2, subroutine EFLD3, and subroutine EFLD4.

VCOOP(I,J) - The static potential at a point in the grid (V).

NVII - A parameter which determines whether a voltage-current curve is generated. When NVII is 1 known values of current and voltage are used. When NVII is 2 a voltage-current curve is produced.

The following variables are in common with EFLD3 and EFLD4.

ECX(I,J) - The x-component of the static electric field at a grid point (V/m).

ECY(I,J) - The y-component of the static electric field at a grid point (V/m).

AX(I) - The distance between the I-th and the I+1-st grid points in the x-direction (m). This is used only with EFLD4.

AY(J) - The distance between the J-th and the J+1-st grid points in the y-direction (m). This is used only with EFLD4.

X1(I) - The x-position of the I-th grid point (m). It is used only with EFLD4.

Y1(J) - The y-position of the J-th grid point (m). It is used only with ELFD4.

LTEST - A logical variable which distinguishes between fixed and variable grid spacing. When LTEST is TRUE the variable grid spacing of EFLD4 is used.

Of the above variables, the values of the following must be provided by the main program: VW, NX, NY, SX, SY, PI, AC, NVII, and NWIRE. Values of VCOOP, ECX, and ECY are determined in the subroutine.

SECTION 5

A GENERALIZATION OF THE INTEGRATION SCHEME USED IN THE MATHEMATICAL MODEL TO COMPUTE THE ELECTRICAL CONDITIONS IN A WIRE-DUCT PRECIPITATOR

BACKGROUND

A mathematical procedure for calculating electrical conditions in wire-duct electrostatic precipitation devices has been presented by McDonald, et al.[11] This procedure is based on a technique to numerically solve Poisson's equation and the current transport equation simultaneously under appropriate boundary conditions. Values are computed for the electric potential, electric field, and space charge density. The method of solving the transport equations is based on a numerical technique suggested by Leutert and Böhlen.[12] This technique uses equally spaced increments in approximating the derivatives by difference ratios. The use of equal increments can work well when the increments are sufficiently small. In the case of electrostatic precipitation devices, for which a typical wire-to-plate spacing is 12.7 cm (5 in.), a large number of increments are required to obtain the desired accuracy in the numerical calculation. An integration which requires a large number of increments requires both a large computer and a large amount of computing time. In addition, the use of equal increments does not allow one to account for the finite size of the corona wire unless the increments are equal to the radius of the wire. In some cases, treating the wire as if it were infinitesimally small might give rise to significant inaccuracies.

The limitations imposed on the numerical solution by using equal increments can be removed by generalizing the procedure to include variable sized increments. It has been demonstrated[13,14,15,16,17,18] that improved accuracy can be obtained with fewer integration increments if increments are adjusted to the characteristics of the particular solution. For instance, if one chooses small increments in the region where the solution varies rapidly and larger increments where the solution changes more slowly, improved overall accuracy can be obtained for a given number of integration steps. Since the wire-duct geometry represents a case in which the potential and the electric field change more rapidly near the wire than near the plate, a choice of small increments near the wire and larger increments near the plate should yield improved accuracy for a fixed number of integration steps.

DEVELOPMENT OF EQUATIONS

In the steady-state the equations which describe the electrical conditions in an electrostatic precipitator are

$$\nabla \cdot \vec{E} = \rho/\varepsilon_0 \tag{23}$$

$$\nabla \cdot \vec{J} = 0 \tag{24}$$

$$\vec{J} = \rho b \vec{E} \tag{25}$$

$$\vec{E} = -\vec{\nabla} V \tag{26}$$

where

$\vec{E}$ = electric field (V/m),

ρ = space-charge density (A sec/m^2),

ε_0 = permittivity of the gas (A sec/Vm),

J = current density (A/m^2),

V = electric potential (V),

b = mobility of charge carrier (m^2/V·sec),

x = coordinate position measured toward the plate with the corona wire as origin (m),

y = coordinate position measured parallel to the plate with the corona wire as origin (m).

In terms of potential equation (23), Poisson's equation, becomes

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = -\rho/\varepsilon_0 \tag{27}$$

Substitution of (25) and (26) into (24) yields

$$\begin{aligned} \nabla \cdot \vec{J} &= \rho b(\rho/\varepsilon_0) + b(-\nabla V) \cdot (\nabla \rho) \\ &\quad + \rho(-\nabla V) \cdot (\nabla b) \\ &= 0, \end{aligned} \tag{28}$$

or after rearrangement

$$\begin{aligned} (b/\varepsilon_0)\rho^2 &+ \left(\frac{\partial b}{\partial x} E_x + \frac{\partial b}{\partial y} E_y\right)\rho \\ &+ \left(\frac{\partial \rho}{\partial x} E_x + \frac{\partial \rho}{\partial y} E_y\right) b = 0 \end{aligned} \tag{29}$$

Equations (27) and (29) must be solved simultaneously for the potential and charge density. To obtain approximations for the derivatives in (27), first make a Taylor series expansion about the point labeled (2,2) in Figure 9. The potential at a point displaced by a small amount in the x-direction from point (2,2) can be written as

$$V(x,y_2) = V_{2,2} + \left.\frac{\partial V}{\partial x}\right|_{2,2} (x-x_2) + \frac{1}{2!}\left.\frac{\partial^2 V}{\partial x^2}\right|_{2,2} (x-x_2)^2 + \frac{1}{3!}\left.\frac{\partial^3 V}{\partial x^3}\right|_{2,2} (x-x_2)^3 + \ldots \qquad (30)$$

For points displaced in the y-direction, the potential would be

$$V(x_2,y) = V_{2,2} + \left.\frac{\partial V}{\partial y}\right|_{2,2} (y-y_2) + \frac{1}{2!}\left.\frac{\partial^2 V}{\partial y^2}\right|_{2,2} (y-y_2)^2 + \frac{1}{3!}\left.\frac{\partial^3 V}{\partial y^3}\right|_{2,2} (y-y_2)^3 + \ldots \quad . \qquad (31)$$

First consider the x-direction. If terms of greater than second order are neglected, the potential at adjacent grid points can be written as

$$V_{1,2} = V_{2,2} + \left.\frac{\partial V}{\partial x}\right|_{2,2} (-ax_1) + \frac{1}{2}\left.\frac{\partial^2 V}{\partial x^2}\right|_{2,2} (-ax_1)^2 \qquad (32)$$

and

$$V_{3,2} = V_{2,2} + \left.\frac{\partial V}{\partial x}\right|_{2,2} (ax_2) + \frac{1}{2}\left.\frac{\partial^2 V}{\partial x^2}\right|_{2,2} (ax_2)^2 \quad , \qquad (33)$$

where

$$ax_1 = x_2 - x_1$$

$$ax_2 = x_3 - x_2 \quad . \qquad (34)$$

To eliminate the first derivative, multiply (32) by ax_2/ax_1, and add the result to (33). After some rearrangement, the second derivative becomes

$$\left.\frac{\partial^2 V}{\partial x^2}\right|_{2,2} = \frac{2\{ax_1 V_{3,2} + ax_2 V_{1,2} - V_{2,2}(ax_1 + ax_2)\}}{ax_1 ax_2 (ax_1 + ax_2)} \quad . \qquad (35)$$

Similar considerations for the y-direction yield

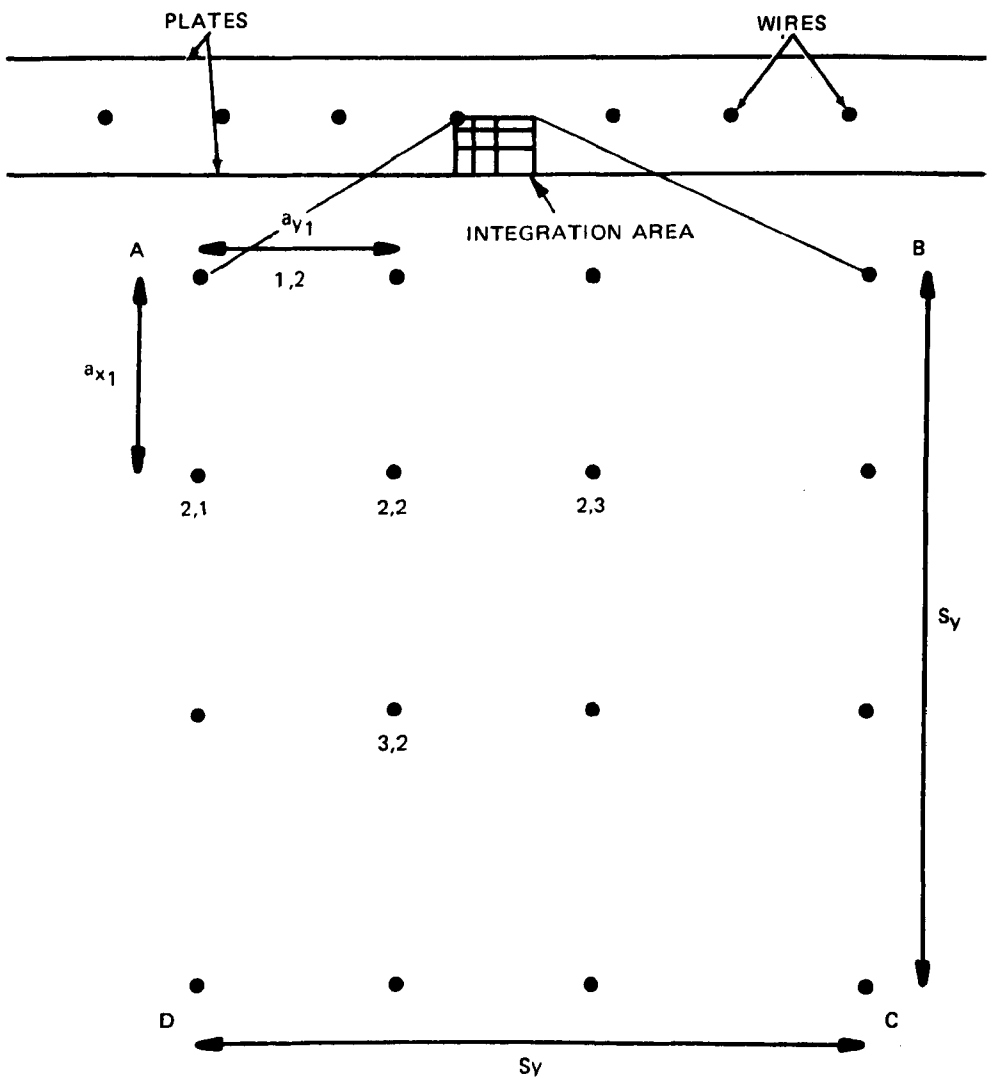

Figure 9. Schematic illustrating positions of integration grid points in the new integration scheme.

$$\left.\frac{\partial^2 V}{\partial y^2}\right|_{2,2} = \frac{2[ay_1 V_{2,3} + ay_2 V_{2,1} - V_{2,2}(ay_1 + ay_2)]}{ay_1 ay_2 (ay_1 + ay_2)} \quad . \tag{36}$$

Equations (35) and (36) can be used in Poisson's equation to compute

$$V_{2,2} = \left(\frac{ax_1 ax_2 ay_1 ay_2}{ax_1 ax_2 + ay_1 ay_2}\right)\left[\frac{ax_1\ V_{3,2} + ax_2\ V_{1,2}}{ax_1 ax_2\ (ax_1 + ax_2)}\right.$$

$$\left. + \frac{ay_1\ V_{2,3} + ay_2\ V_{2,1}}{ay_1 ay_2\ (ay_1 + ay_2)} + \frac{\rho_{2,2}}{2\varepsilon_0}\right] \quad . \tag{37}$$

The components of the electric field can be obtained from the partial derivatives of the potential. If the second derivatives are eliminated from (32) and (33), one obtains

$$E_x = -\left.\frac{\partial V}{\partial x}\right|_{2,2} = -\frac{ax_1^2\ V_{3,2} - ax_2^2\ V_{1,2} - V_{2,2}\ (ax_1^2 - ax_2^2)}{ax_1 ax_2 (ax_1 + ax_2)} \tag{38}$$

and

$$E_y = -\left.\frac{\partial V}{\partial y}\right|_{2,2} = -\frac{ay_1^2\ V_{2,3} - ay_2^2\ V_{2,1} - V_{2,2}\ (ay_1^2 - ay_2^2)}{ay_1 ay_2 (ay_1 + ay_2)} \quad . \tag{39}$$

While equation (37) generalizes the potential calculation to allow for an arbitrary choice of grid spacings, equations (38) and (39) should yield more accurate values of the field components since these equations depend on the potential at three points instead of only two.

The electric field and potential are computed at the boundaries of the integration cells, while the charge density is associated with the centers of the cells. To be consistent with these assumptions, and avoid using two interlacing grids of computational points, we use a different discretization scheme for the charge density and carrier mobility. The derivatives of these two functions are approximated by difference ratios based on the spacing of the cell boundaries.

$$\left.\frac{\partial \rho}{\partial x}\right|_{2,2} = \frac{\rho_{2,2} - \rho_{1,2}}{ax_1}$$

$$\left.\frac{\partial \rho}{\partial y}\right|_{2,2} = \frac{\rho_{2,2} - \rho_{2,1}}{ay_1}$$

$$\left.\frac{\partial b}{\partial x}\right|_{2,2} = \frac{b_{2,2} - b_{1,2}}{ax_1}$$

$$\left.\frac{\partial b}{\partial y}\right|_{2,2} = \frac{b_{2,2} - b_{2,1}}{ay_1} \tag{40}$$

The charge density can then be interpreted as the average value within the cell. Since the charge density varies more slowly than the field and potential, the accuracy of the discretization equation is not critical. Substitution of (40) into (29) leads to

$$\rho_{2,2} = -\alpha \pm (\alpha^2 - \beta)^{\frac{1}{2}} \quad , \tag{41}$$

where

$$\alpha = \frac{\varepsilon_0}{2b_{2,2}} \left[E_x \left(\frac{2b_{2,2} - b_{1,2}}{ax_1}\right) + E_y \left(\frac{2b_{2,2} - b_{2,1}}{ay_1}\right)\right] \tag{42}$$

and

$$\beta = -\varepsilon_0 \left[\frac{E_x \rho_{1,2}}{ax_1} + \frac{E_y \rho_{2,1}}{ay_1}\right] \quad . \tag{43}$$

Both E_x and E_y are evaluated at point (2,2). In effect, the charge density is based on a two point approximation. These equations have the advantage that the charge density in a cell can be updated immediately using the new value of the field at the cell boundary. This iterative scheme has the advantage over the old scheme that new values of all the functions (potential, field, and charge density) are computed each time through the grid of points. In the old scheme, two sweeps through the grid points were required to update all the functions. As implied above, equations (37), (38), (39), and (41) can be solved simultaneously for the potential, field and charge density at point (2,2). Point (2,2) will then be moved successively to all points in the grid producing values of potential, field and charge density at each point.

BOUNDARY CONDITIONS

The solutions for the potential, electric field and charge density must be obtained subject to a certain set of boundary conditions. The current set of boundary conditions is given by

(1) $\rho = \rho_s$, the charge density at the surface of the corona,

(2) $E_x = 0$ along aline AB of Figure 9,

(3) $E_y = 0$ along lines BC, CD, and AD in Figure 9,

(4) $\rho = J/E_x b$ near the plate.

SUBROUTINE EFLD4

This subroutine calculates a voltage-current curve up to a specified value of operating voltage and calculates the average electric field at the plate for the operating applied voltage. The voltage-current curve is generaged by (1) specifying a starting value of average current density at the plate, (2) incrementing upward on the average current density, and (3) determining the applied voltage at each value of current density. When a value of current density results in an applied voltage which exceeds the specified operating applied voltage, an interpolation is performed to obtain the operating voltage and current density. At this operating applied voltage, calculations can also be made to give the average current density, average electric field, and average electric field at the plate in subincremental lengths. As pointed out earlier, this subroutine was used for the comparisons with the approximate solutions shown in Table 1.

The potential, electric field, and charge density are computed by solving equations (37), (38), (39), and (41) simultaneously using a relaxation technique. In solving the equations, the corona region near the wire is treated as a source of ions. It is assumed that the change in potential across the corona region can be described by

$$\Delta V = VW - V(2,1) = ECOR\ (RC - AC), \tag{44}$$

where

VW = potential at the surface of the wire (V),

V(2,1) = V(1,2) = potential at the surface of the corona (V),

ECOR = average field required to drive the corona (V/m),

RC = radius of corona (m),

AC = radius of the wire.

Note that the potential drop across the corona region will be small when the two radii are nearly equal. The case in which RC = AC corresponds to the conditions used in the model previously. It is assumed that the corona is cylindrical.

Numerical Algorithm

(1) Calculate the potential, electric fields, and charge density at the grid points using the approximate solution presented earlier.

(2) Hold the potential at the wire fixed, recalculate the potential, the fields, and the charge density at the grid points using equations (37), (38), (39), and (41) - (43).

(3) Repeat step 2 iteratively until the potential profile changes negligibly in successive interations.

(4) Check to see if the average current density at the plate is the desired value. If the average current density agrees with the specified value, a solution has been obtained. If the average current density at the plate does not agree with the specified value, adjust the potential at the wire and repeat steps 3 and 4.

The primary differences between this subroutine and EFLD2 of the mathematical model are:

(1) EFLD4 uses variable sized integration increments.

(2) EFLD4 can account for the potential drop across the corona.

(3) EFLD4 accounts for the finite size of the corona region by specifying the potential there.

(4) EFLD4 computes the average current density at the plate by integrating over the plate rather than computing the mean value from several points.

(5) EFLD4 also computes the average field at the plate by integrating over the plate.

(6) EFLD4 calls EFLD3 to obtain an approximate starting solution.

(7) EFLD4 uses the method of false position to obtain the correct current density.

(8) EFLD4 does not require a value of VSTART.

(9) EFLD4 uses more stringent conditions for convergence of potential and current density than does EFLD2.

The following is a sequential list of the calling arguments and their descriptions.

UEQ - Effective charge carrier mobility ($m^2/V \cdot sec$).

AC - Radius of discharge electrode (m).

VO - Chosen operating applied voltage (m).

SX - Wire-to-plate spacing (m).

SY - One-half wire-to-wire spacing (m).

NX - Number of grid points in x-direction.

NY - Number of grid points in y-direction.

AEPLT - Average electric field at the plate (V/m).

TDK - Temperature of the gas (°K).

P - Pressure of the gas (atm).

RF - Roughness factor for the discharge wire ($0.5 \leq RF \leq 1.0$).

START - Chosen initial current density at which the voltage current curve calculation starts (A/m^2). Current density increments in units of START until a change is specified.

DSTART - Chosen increment in current density which is used in place of START when specified (A/m^2).

CSTART - Chosen increment in current density which is used in place of DSTART when specified (A/m^2).

IFINAL - Indicator which terminates the loop over average current densities at the plate after IFINAL times.

VSTART - Initial estimate of applied voltage corresponding to the first value of average current density at the plate on the voltage-current curve (V). VSTART is not actually used in EFLD4 to start the integration.

VW - Operating applied voltage corresponding to a given current density (V).

ACDNTY - Average current density at the plate (A/m^2).

NWIRE - Number of wires per gas passage per electrical section.

NEC - Indicator which governs the calculations of average current density, average electric field, and average electric field at the plate in sub-incremental lengths. The calculations are performed when NEC = 0 and are not performed when NEC = 1.

EBD - Electrical breakdown strength of the gas (V/m).

JI1 - Indicator which governs the change in the increment on average current density at the plate from START to DSTART. The change occurs on the JI1-th value of current density.

JI2 - Indicator which governs the change in the increment on average current density at the plate from DSTART to CSTART. The change occurs on the JI2-th value of current density.

The following is a list of the variables which are in common with the main program.

EAVG(M) - Average electric field in a given subincrement of length (V/m).

CHFID(M) - Average ion density in the absence of particles in a given subincrement of length (#/m^3).

ECOLL(M) - Average electric field at the plate in a given subincrement of length (V/m).

NPRNT - Indicator which specifies the logical unit number of the printer.

The following is a list of variables which are in common with subroutines EFLD3 and CMAN.

ECX(I,J) - The x-component of the static electric field at a grid point (V/m).

ECY(I,J) - The y-component of the static electric field at a grid point (V/m).

AX(I) - The distance between the I-th and the I+1-st grid points in the x-direction (m).

AY(J) - The distance between the J-th and the J+1-st grid points in the y-direction (m).

X1(I) - The length of the I-th increment in the x-direction (m). This is used only with EFLD4.

Y1(J) - The length of the J-th increment in the y-direction (m). This is used only with EFLD4.

LTEST - A logical variable which distinguishes between fixed and variable grid spacings. When LTEST is TRUE the variable grid spacing of EFLD4 is used.

VCOOP - The static-like contribution to the potential (V).

NVII - A parameter which determines whether a voltage-current curve is generated.

Of the above variables, the values of the following must be provided by the main program: UEQ, AC, VO, SX, SY, NX, NY, TDK, P, RF, START, DSTART, CSTART, IFINAL, VSTART, NWIRE, NEC, EBD, JI1, JI2, NVII, and NPRNT. Values of AEPLT, VW, ACDNTY, EAVG, CHFID, ECOLL, VCOOP, ECX, ECY, X1, Y1, AX, AY, and LTEST are determined in the subroutine. The subroutine calls subroutine EFLD3 to obtain initial approximations for the potential, electric field, and charge density at the grid points.

If, for a given current density, convergence on the potential grid can not be obtained in 4000 iterations, a message stating that convergence can not be obtained is printed and those values which were calculated in the last iteration are used for that particular point on the voltage-current curve. If convergence on a given average current density at the plate can not be obtained in 25 iterations, a message stating that convergence can not be obtained is printed and those values which were calculated in the last iteration are used for that particular point on the voltage-current curve.

There are three conditions which will terminate the calculation of the voltage-current curve. The calculation is terminated if (1) the specified operating applied voltage is reached, or (2) the number of points on the curve is equal to the value of IFINAL, or (3) the specified value of the electrical breakdown strength near the collection electrode is exceeded. If the breakdown strength is exceeded, a message to this effect is printed. Figure 10 shows a detailed flow chart of this subroutine. A listing of this subroutine is given in Appendix C.

This subroutine calls subroutine EFLD3 which was described earlier. The arrays containing the variable grid spacings are transmitted through a common statement. The logical variable LTEST is used to distinguish the variable spacing of EFLD4 from the fixed spacings used in the previous model. The variable, LTEST, is initialized to FALSE in both CMAN and EFLD3 by a data block subprogram.

SUBROUTINE OUTPUT

This subroutine prints the arrays computed in EFLD4. It prints all rows corresponding to the NX grid points in the x-direction. If NY is greater than 18, only selected columns corresponding to certain values of Y are printed. The first 9 columns are printed, then 9 columns chosen by a multiple which spans the remaining columns are printed. The values of Y are printed above the columns, and the values of X are printed beside the rows. For each point in the array which is printed, the potential is printed under the charge density, the x-component

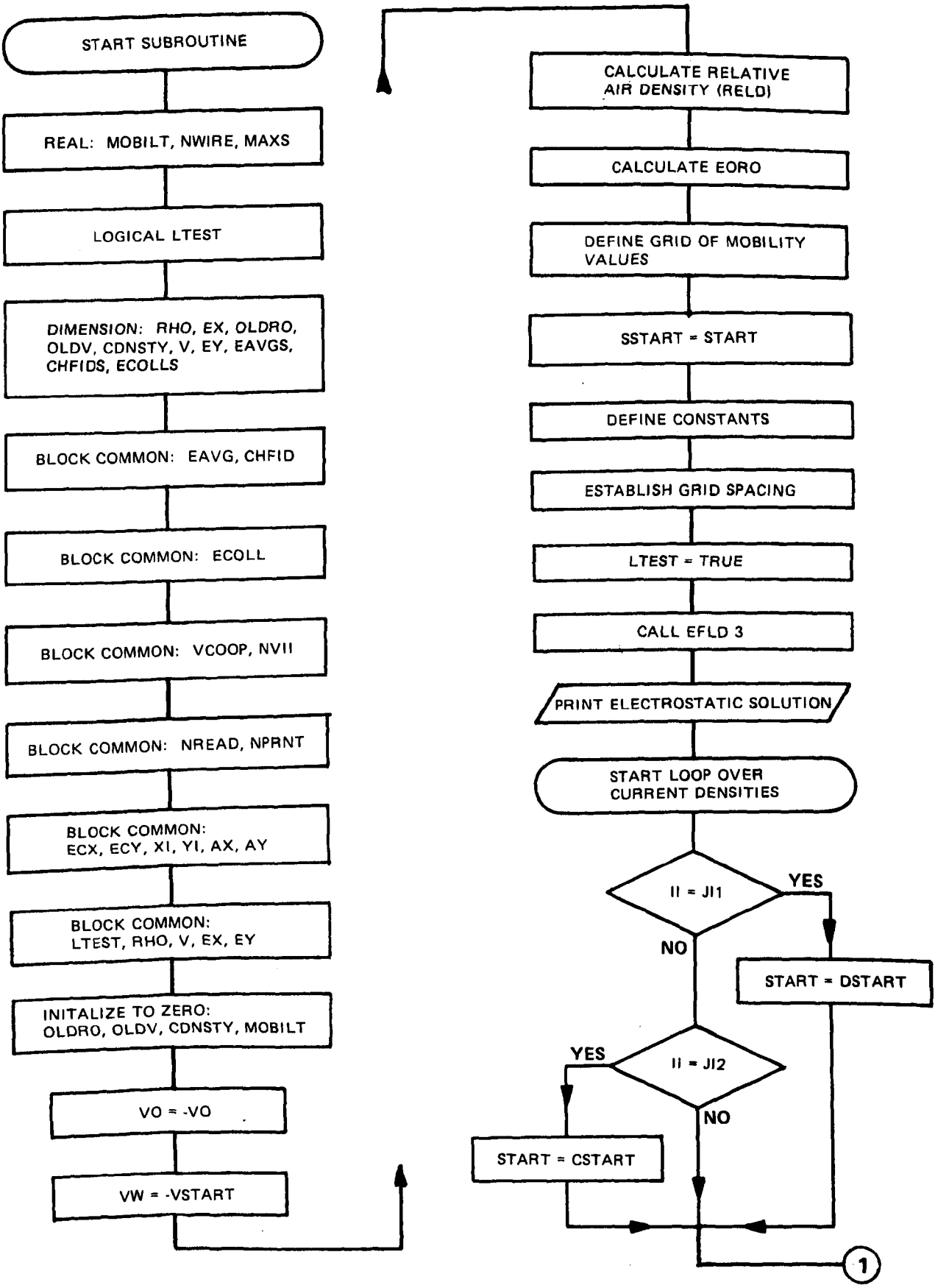

Figure 10. Flow chart for subroutine EFLD4 (sheet 1 of 8).

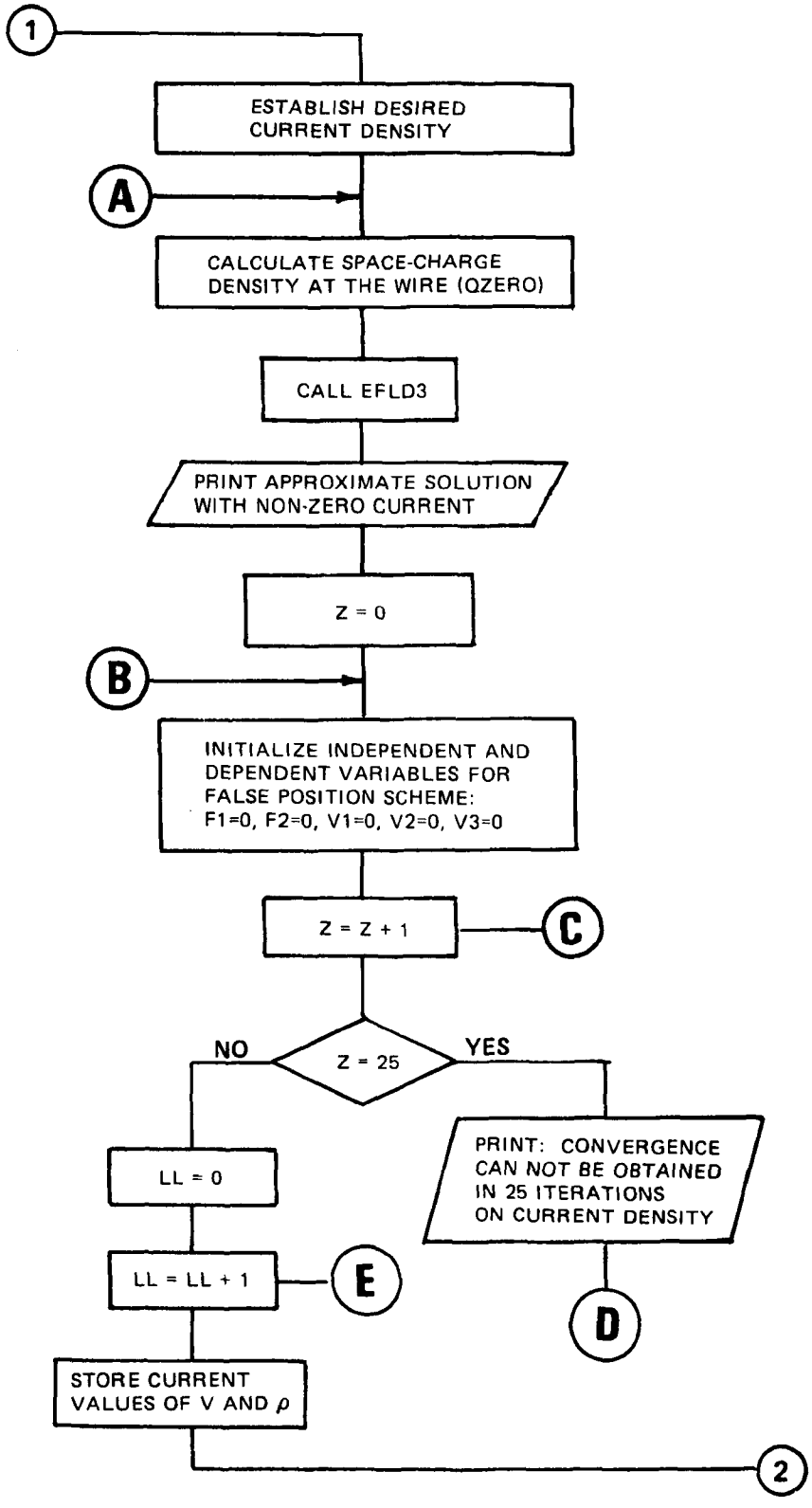

Figure 10. Flow chart for subroutine EFLD4 (sheet 2 of 8).

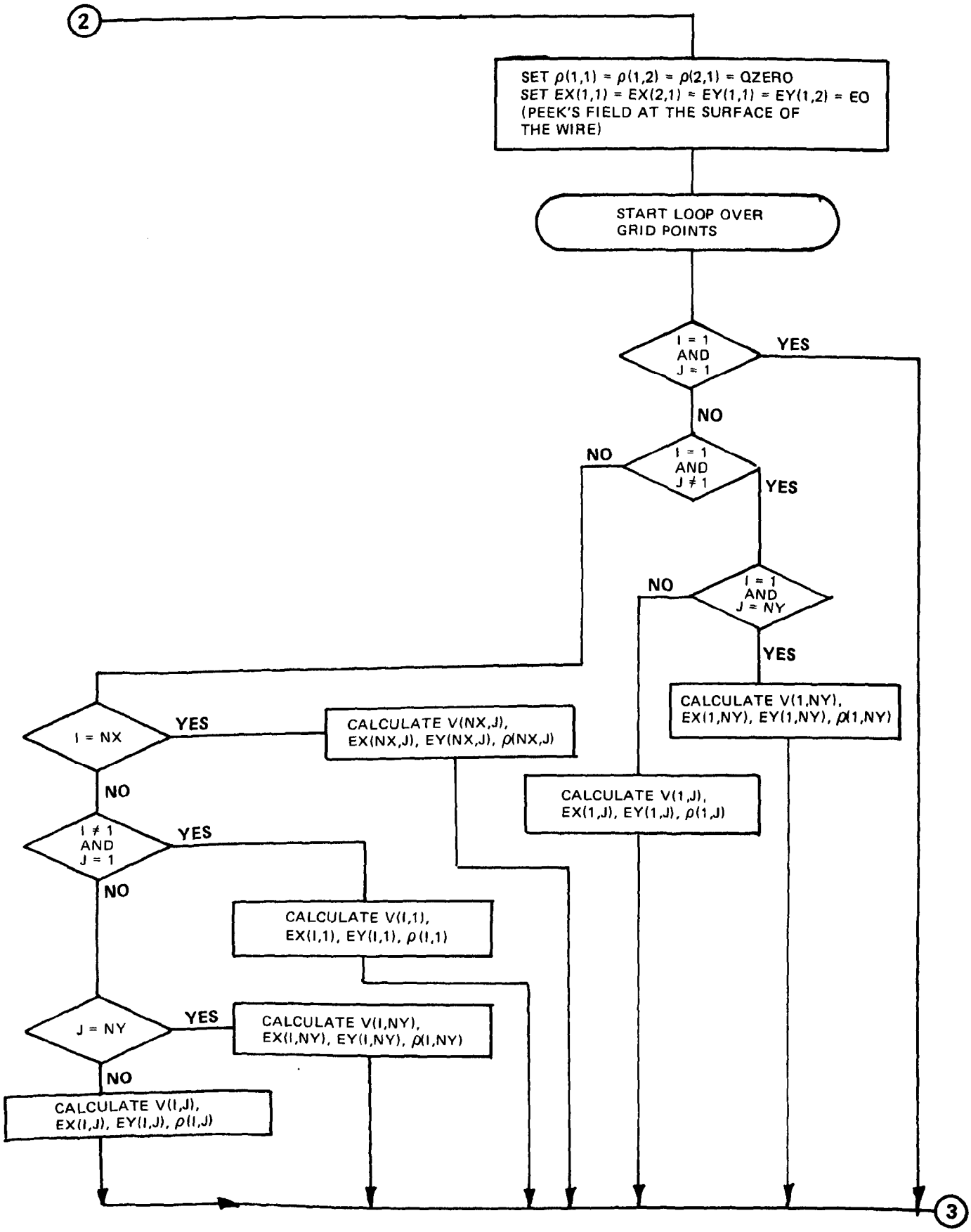

Figure 10. Flow chart for subroutine EFLD4 (sheet 3 of 8).

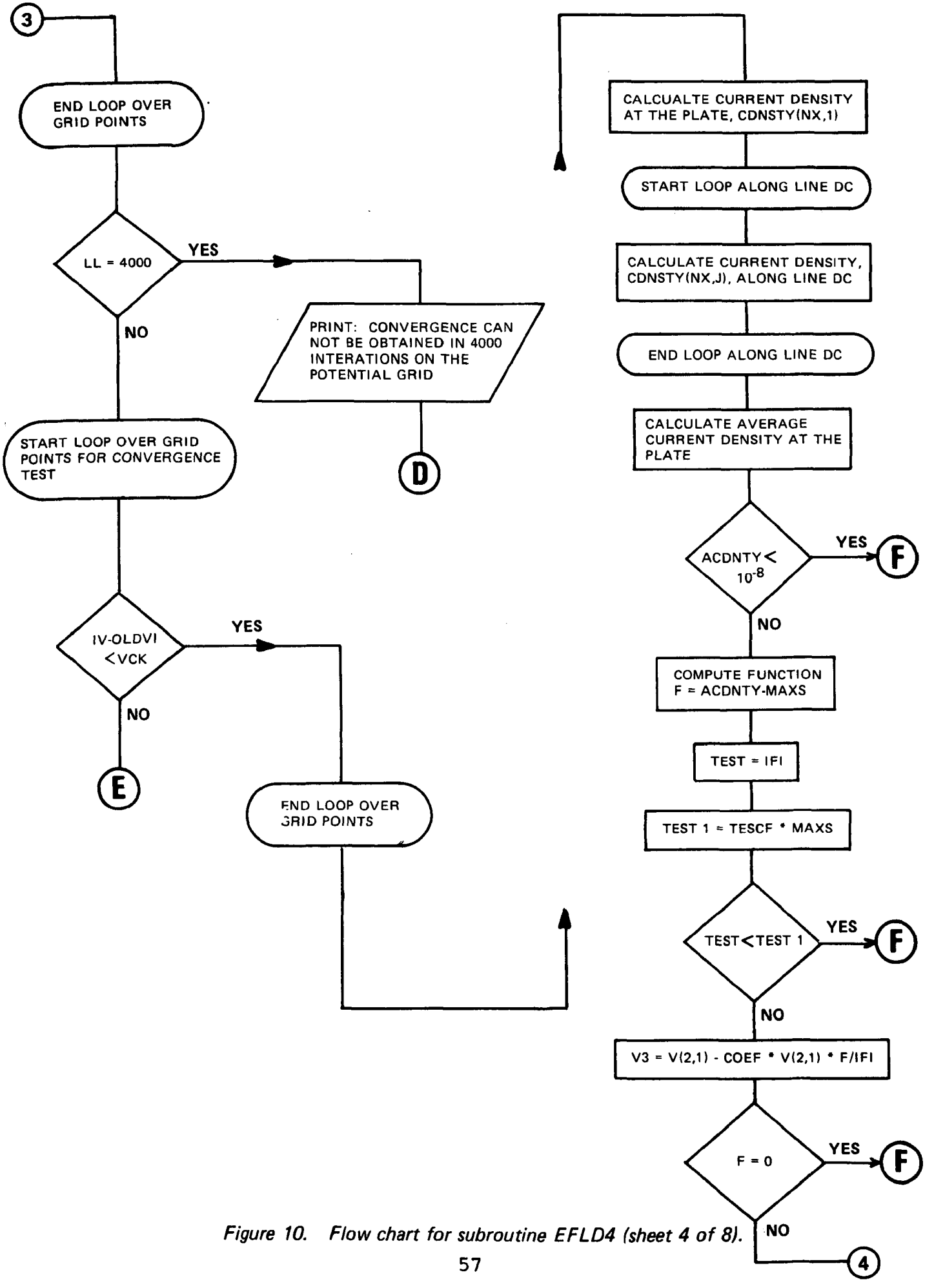

Figure 10. Flow chart for subroutine EFLD4 (sheet 4 of 8).

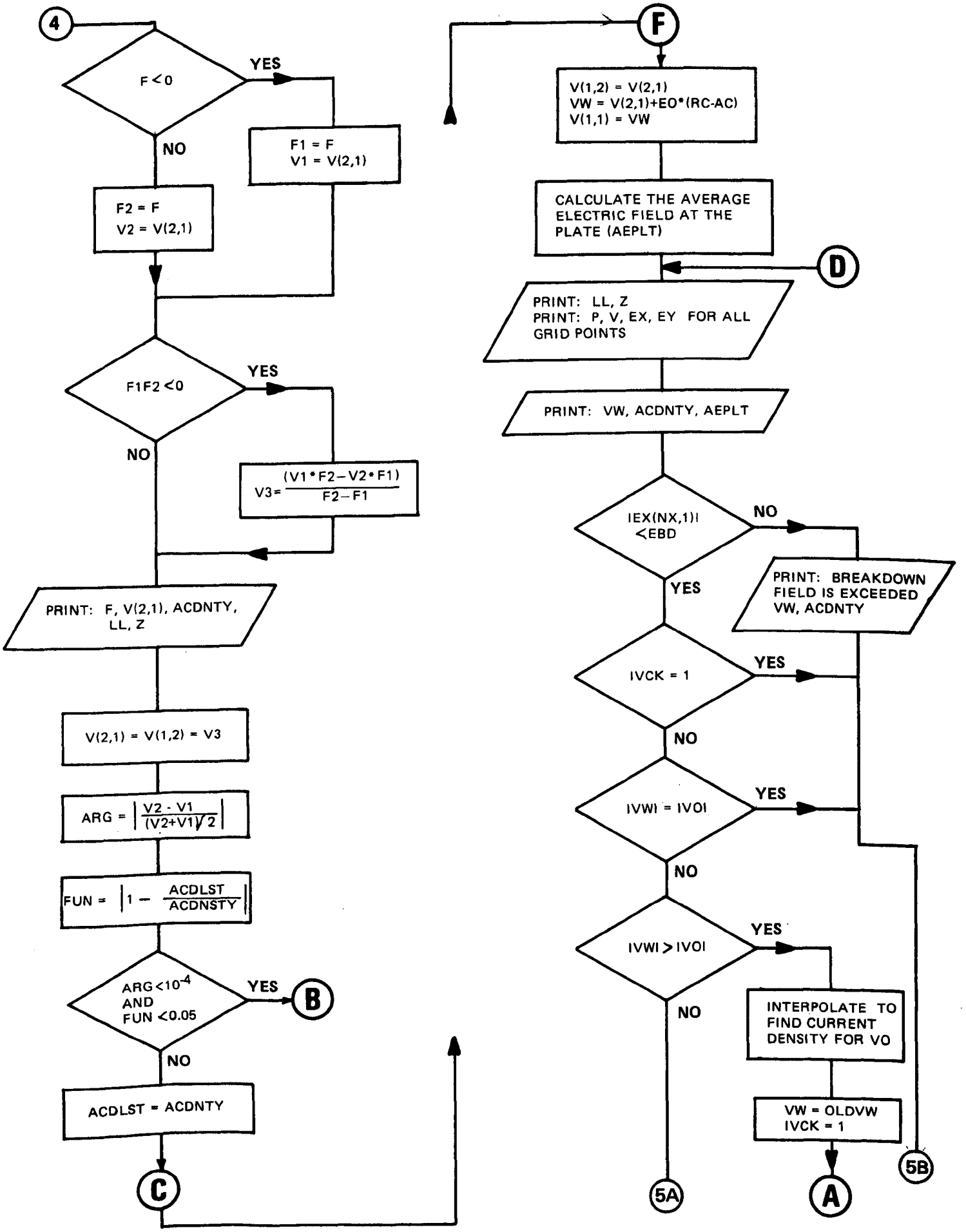

Figure 10. Flow chart for subroutine EFLD4 (sheet 5 of 8).

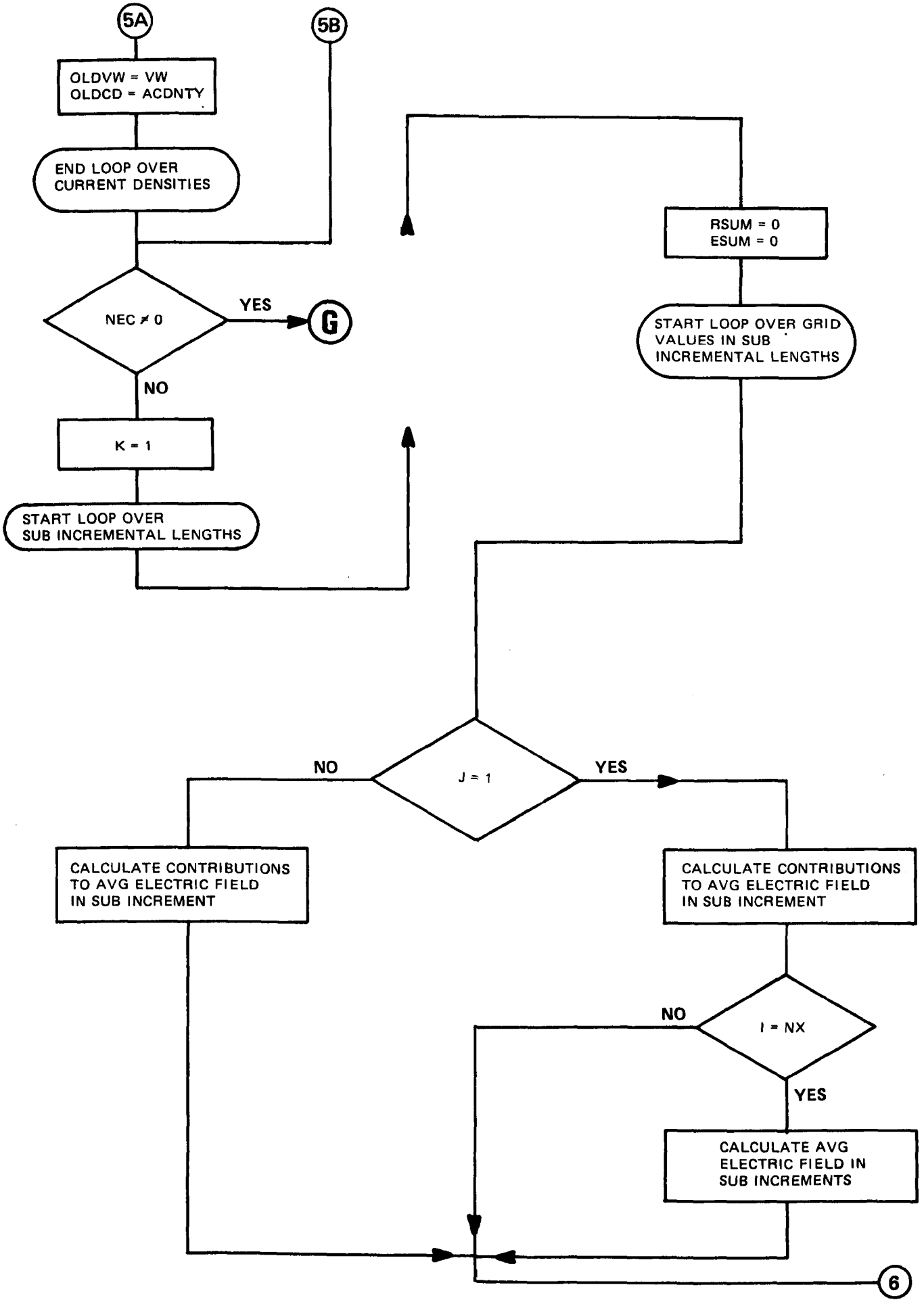

Figure 10. Flow chart for subroutine EFLD4 (sheet 6 of 8).

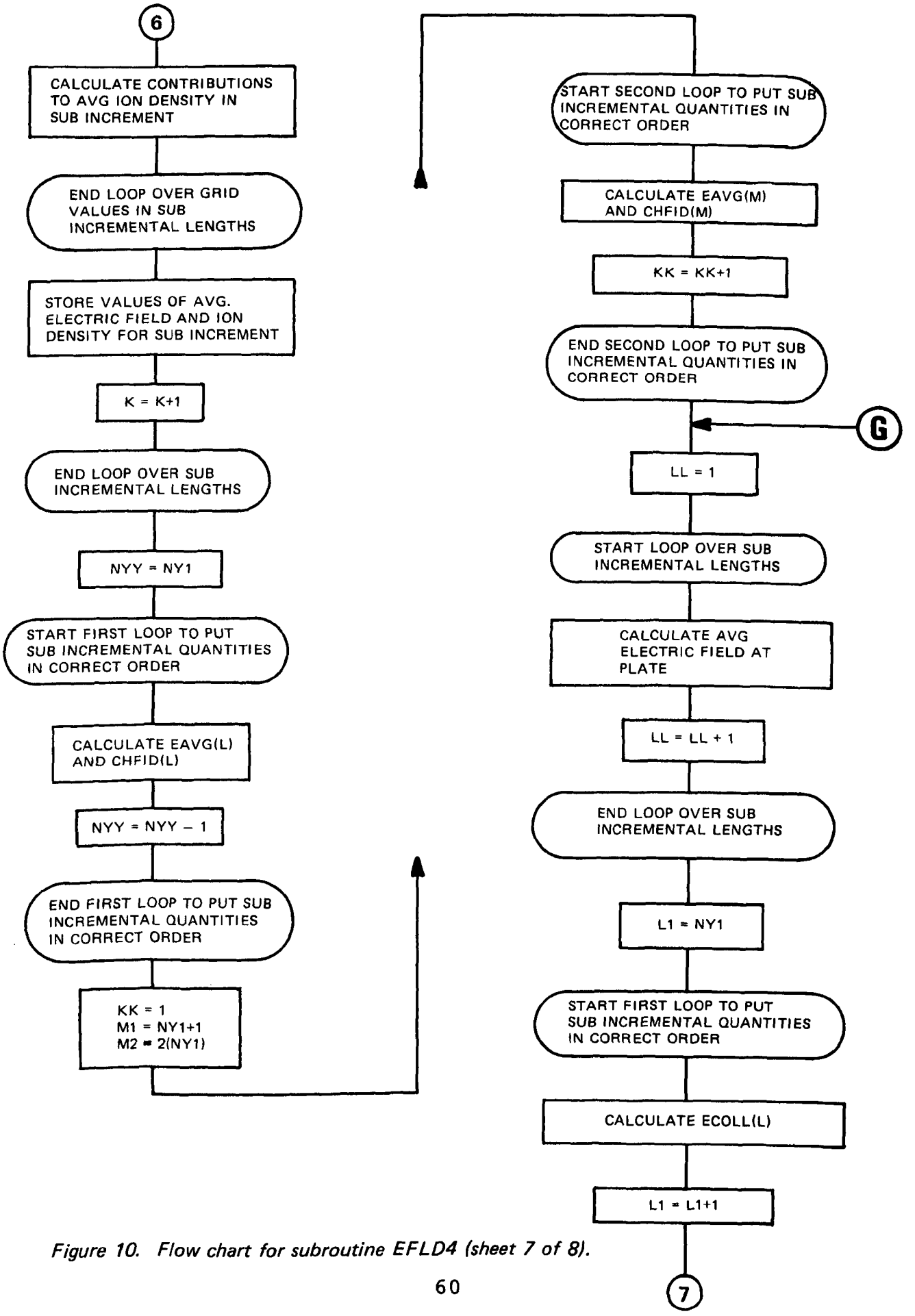

Figure 10. Flow chart for subroutine EFLD4 (sheet 7 of 8).

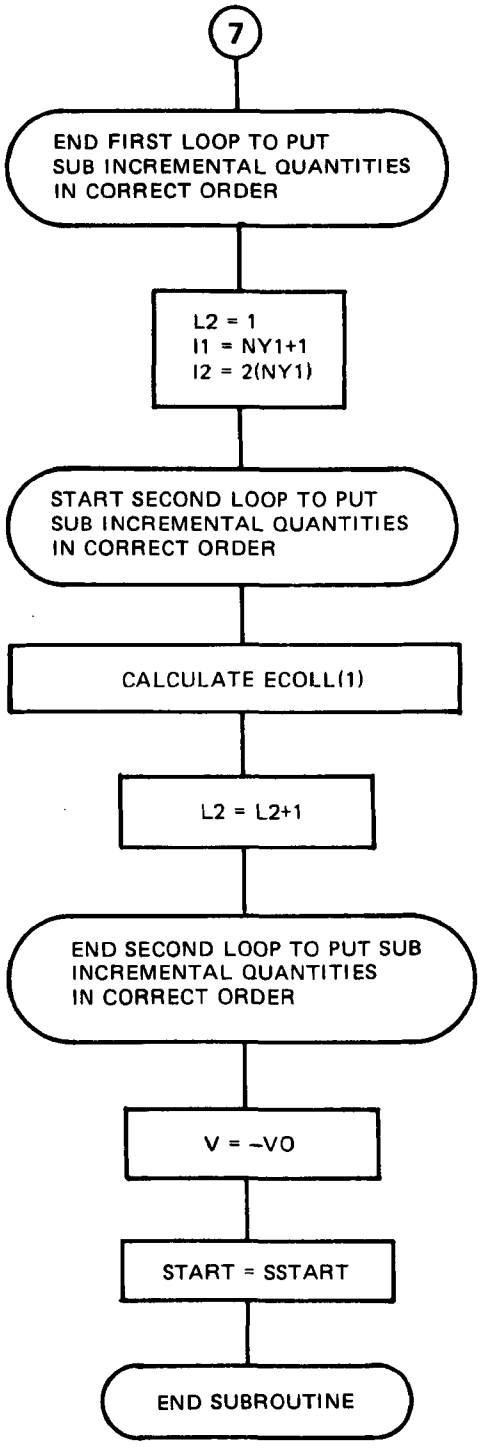

Figure 10. Flow chart for subroutine EFLD4 (sheet 8 of 8).

of electric field is printed under the potential, and the y-component of the electric field is printed under the x-component. The only exception to this order is for the static (zero current) case in which the charge density is not printed. For the static case, this subroutine is called by ENTER2 which is a different entry point. When the subroutine is entered at ENTRY ENTER2 it behaves as described above except that the charge density is not printed.

The following is a sequential list of the calling arguments and their description.

NX - Number of grid points in the x-direction.

NY - Number of grid points in the y-direction.

The following is a list of the variables which are in common with EFLD4.

RHO(I,J) - Charge density at a grid point (c/m^3).

V(I,J) - Potential at a grid point (V).

EX(I,J) - x-component of the electric field at a grid point (V/m).

EY(I,J) - y-component of the electric field at a grid point (V/m).

CDNSTY(NX,J) - Current density at a point on the plate (A/m^2).

X1(I) - x-position of a grid point (m).

Y1(J) - y-position of a grid point (m).

NPRINT - Indicator which specifies the logical unit number of the printer.

EAVG(M) - Average electric field in a given subincrement of length (V/m).

CHFID(M) - Average ion density in the absence of particles in a given subincrement of length ($\#/m^3$).

ECOLL(M) - Average electric field at the plate in a given subincrement of length (V/m).

VCOOP(I,J) - The static-like contribution to the potential at a grid point (V).

ECX(I,J) - The x-component of the static electric field at a grid point (V/m).

ECY(I,J) - The y-component of the static electric field at a grid point (V/m).

AX(I) - The distance between the I-th and I+1-st grid points in the x-direction (m). This is used only with EFLD4.

AY(J) - The distance between the J-th and the J+1-st grid points in the y-direction (m). This is used only with EFLD4.

Figure 11 shows a detailed flow chart of this subroutine. A listing of this subroutine is given in Appendix D.

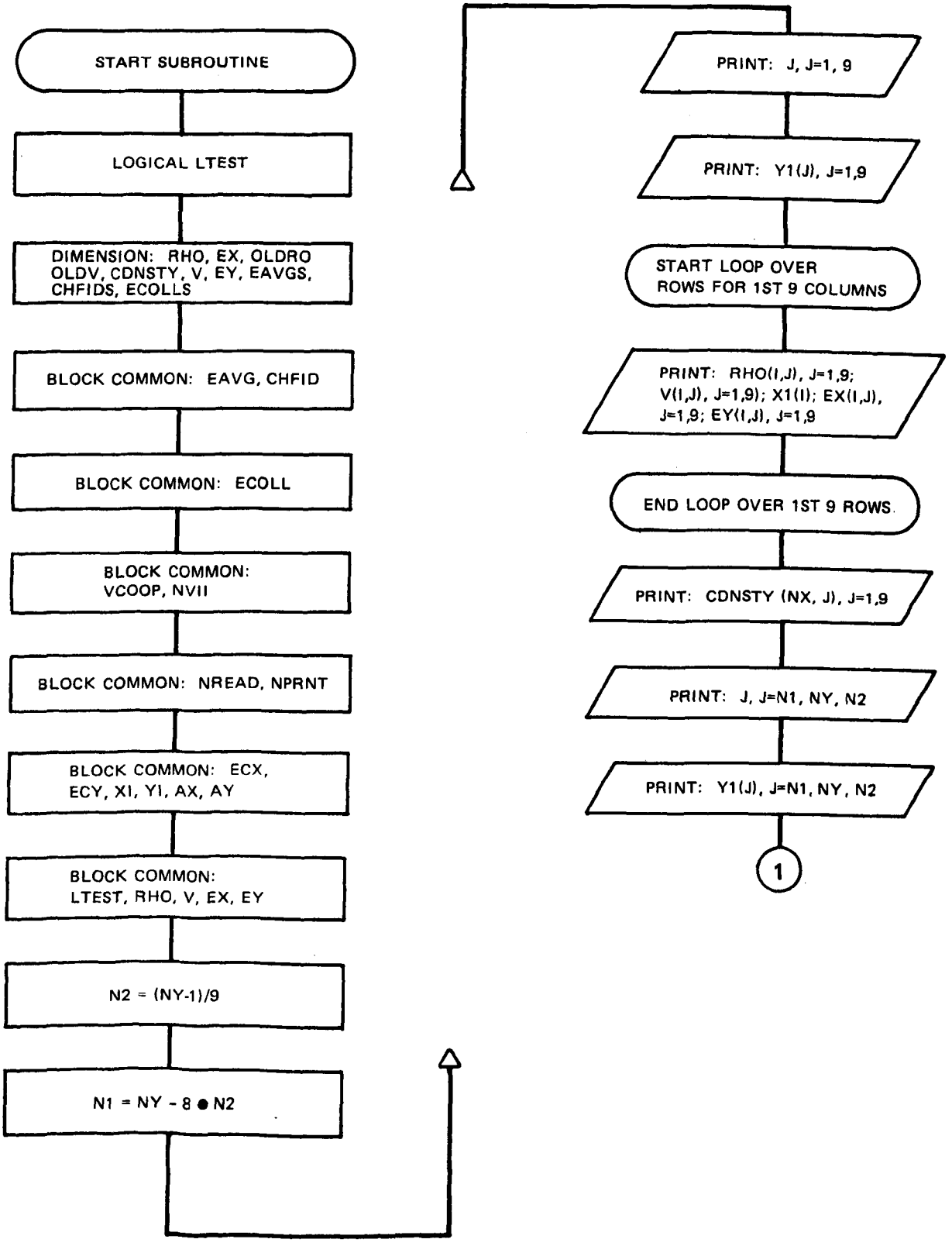

Figure 11. Flow chart for subroutine OUTPUT (sheet 1 of 3).

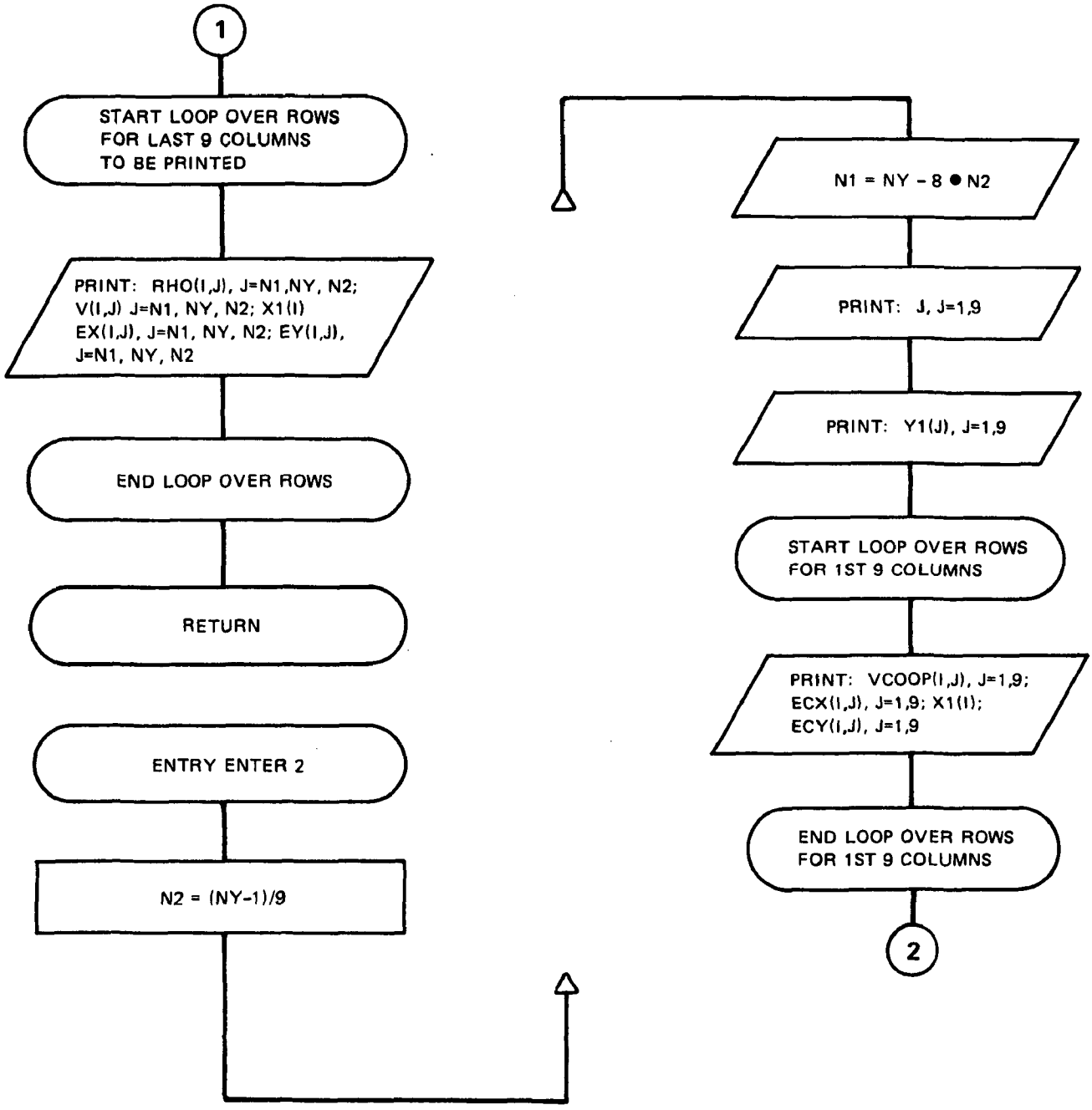

Figure 11. Flow chart for subroutine OUTPUT (sheet 2 of 3).

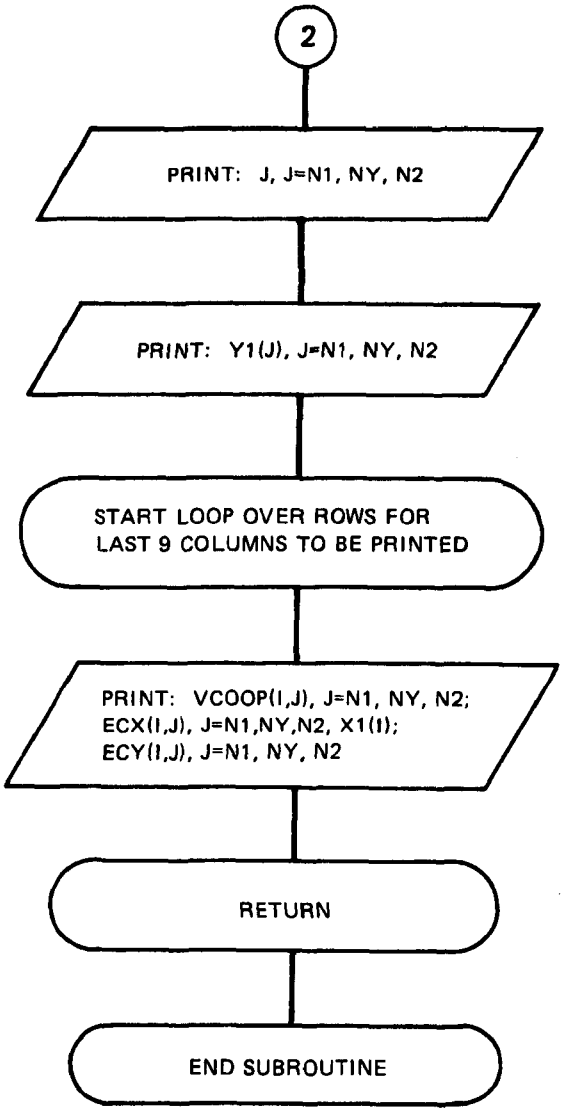

Figure 11. Flow chart for subroutine OUTPUT (sheet 3 of 3).

SECTION 6

GAUSSIAN QUADRATURE INTEGRATION FOR COMPUTING PARTICLE CHARGING RATES

Previously, the RATE function subprogram has used Simpson's rule to perform the numerical integration over the angle θ. RATE has been rewritten using the Gaussian quadrature method to perform this integration since the same accuracy can be obtained using fewer increments than would be required by Simpson's rule. This reduction in the number of integration increments results in a significant saving of computer time. Also, by reducing the number of increments used in the Runga-Kutta integration which is used to integrate the charging rate over time a further reduction in the amount of time required to compute particle charge is accomplished.

Previously, 10 increments in the Runga-Kutta integration and 20 increments in Simpson's rule were recommended in order to obtain sufficient accuracy in the model projections. Comparable accuracy can be obtained using five increments in the Runga-Kutta integration and three increments in the new Gaussian integration. A detailed comparison of the two integration schemes using different numbers of integration increments is shown in Table 2. The charges computed by the different schemes are given for several particle diameters as well as for several positions within the precipitator. The difference in the charge computed by the two methods for various particle diameters is negligible for smaller particle diameters (.1 - 5 micrometers) and increases to the order of 2% for larger particle diameters (20 - 30 micrometers). These differences in accumulated charge have a negligible effect on such quantities as efficiency, effluent MMD, and particle standard deviation since the major differences occur at particle diameters which are easily collected by the precipitation process. In the next section a description of the new RATE function is given.

FUNCTION SUBPROGRAM RATE

This function subprogram calculates the right hand side of

$$\frac{dq}{dt} = \frac{N_o ebq_s}{4\varepsilon_0} \left(1 - \frac{q}{q_s}\right)^2$$

TABLE 2. CHARGE ON PARTICLES COMPUTED BY DIFFERENT INTEGRATION METHODS

Particle Radius (10^{-6}m)	Length Increment of Precipitator	Particle Charge (10^{-16} Coul) 10 Inc. Runga-Kutta 20 Inc. Simpson's Time/Loop ≈ 5.5 sec	20 Inc. Runga-Kutta 40 Inc. Simpson's Time/Loop ≈ 22 sec	10 Inc. Runga-Kutta 5 Pt. Gaussian Time/Loop ≈ 1.4 sec	5 Inc. Runga-Kutta 5 Pt. Gaussian Time/Loop ≈ 0.7 sec	5 Inc. Runga-Kutta 3 Pt. Gaussian Time/Loop ≈ 0.4 sec
0.2	1	0.017469	0.017447	0.017428	0.017452	0.017459
	10	0.035541	0.035536	0.035531	0.035533	0.035534
	20	0.041324	0.041322	0.041320	0.041321	0.041309
	27	0.043734	0.043733	0.043732	0.043733	0.043715
0.7	1	0.14605	0.14574	0.14563	0.14633	0.14636
	10	0.26117	0.26112	0.26107	0.26109	0.25923
	20	0.28877	0.28876	0.28873	0.28874	0.28661
	27	0.29881	0.29880	0.29878	0.29879	0.29658
1.6	1	0.69225	0.69001	0.68934	0.69215	0.69278
	10	1.0918	1.0912	1.0911	1.0912	1.0838
	20	1.1742	1.1740	1.1745	1.1745	1.1682
	27	1.1857	1.1856	1.1862	1.1862	1.1801
3.5	1	3.1898	3.1756	3.1701	3.1822	3.1816
	10	4.5682	4.5534	4.5282	4.5284	4.5578
	20	4.7153	4.7266	4.7183	4.7184	4.7528
	27	4.7153	4.7266	4.7183	4.7184	4.7528
8.5	1	18.618	18.518	18.474	18.548	18.547
	10	26.097	25.920	25.363	25.364	25.358
	20	26.506	26.399	25.832	25.832	25.827
	27	26.506	26.399	25.832	25.832	25.827
20.	1	102.97	102.40	102.15	102.56	102.59
	10	144.39	143.36	140.25	140.26	140.26
	20	146.65	146.04	142.84	142.84	142.84
	27	146.65	146.04	142.84	142.84	142.84

$$+ \frac{\pi a^2 \tilde{v} N_o e}{2} \int_{\theta_o}^{\pi/2} \exp\left[\left(\frac{qe(r_o - a)}{4\pi\varepsilon_o kTar_o}\right.\right.$$

$$\left.\left. + \frac{[3ar_o^2 - r_o^3(K + 2) + a^3(K - 1)]eE_a\cos\theta}{kTr_o^2\ (K + 2)}\right)\right]\sin\theta d\theta$$

$$+ \frac{\pi a^2 \tilde{v} N_o e}{2} \exp\ (-qe/4\pi\varepsilon_o akT)\ , \tag{45}$$

where $q_s = 4\pi\varepsilon_o E_a a^2\ (1 + 2\ \frac{K-1}{K+2})$, (46)

$\theta_o = \arccos\ (q/q_s)$, (47)

and q = instantaneous charge on the particle (C),

q_s = saturation charge due to field charging (C),

θ = azimuthal angle in a spherical coordinate system with origin at the center of the particle (radians),

θ_o = maximum azimuthal angle for which electric field lines enter the particle (radians),

N_o = free ion density (m^{-3}),

e = electronic charge (C),

ε_o = permittivity of free space ($C^2/N\text{-}m^2$),

E_a = average electric field between the electrodes (V/m),

b = ion mobility (m^2/V-sec),

$\tilde{v}$ = mean thermal speed of ions (m/sec),

a = particle radius (m),

k = Boltzmann's constant (J/°K),

T = absolute temperature (°K),

t = time (sec),

K = dielectric constant of the particle, and

r_o = radial distance along θ at which the radial component of the total electric field is zero (m).

The above equation is used in subroutine CHARGN. In order to use this function subprogram, subroutines ARCCOS and ZERO must be supplied.

The first and third terms on the right hand side of equation (45) are calculated in a straight forward manner. However, the third term involves an integration over the angle θ which must be performed numerically. The integration is performed by using the Gaussian guadrature[19] which is given by

$$\int_{\theta_o}^{\pi/2} f(\theta)d\theta = \frac{\pi/2 - \theta_o}{2} \int_{-1}^{1} F(t)dt \quad , \tag{48}$$

where

$$\theta = \tfrac{1}{2}(\pi/2 - \theta_o)t + \tfrac{1}{2}(\theta_o + \pi/2) \quad , \tag{49}$$

and the integral

$$\int_{-1}^{1} F(t)dt = A_oF(t_o) + A_1F(t_1) + \cdots\cdots A_nF(t_n) \tag{50}$$

is evaluated using tabulated values of $A_k (k = 0,1 \cdots\cdots n)$ and $t_k (k = 0,1 \cdots\cdots n)$. The subprogram performs the operations indicated in equations (48) and (50) for a fixed number of points, $n = 3$.

If the charge on the particle is equal to or greater than the saturation charge, the first term on the right hand side of equation (45) is set equal to zero. Once the three terms on the right hand side of equation (45) are calculated, then they are added to give the total charging rate.

Figure 12 shows a detailed flow chart for this subprogram. All information which is transmitted between subroutine CHARGN and this function subprogram is transferred through calling arguments. The following is a sequential list of the calling arguments and their descriptions.

ECHARG - Value of an electronic charge unit (C).

SCHARG - Value of saturation charge number from the field charging equation (see equation 46).

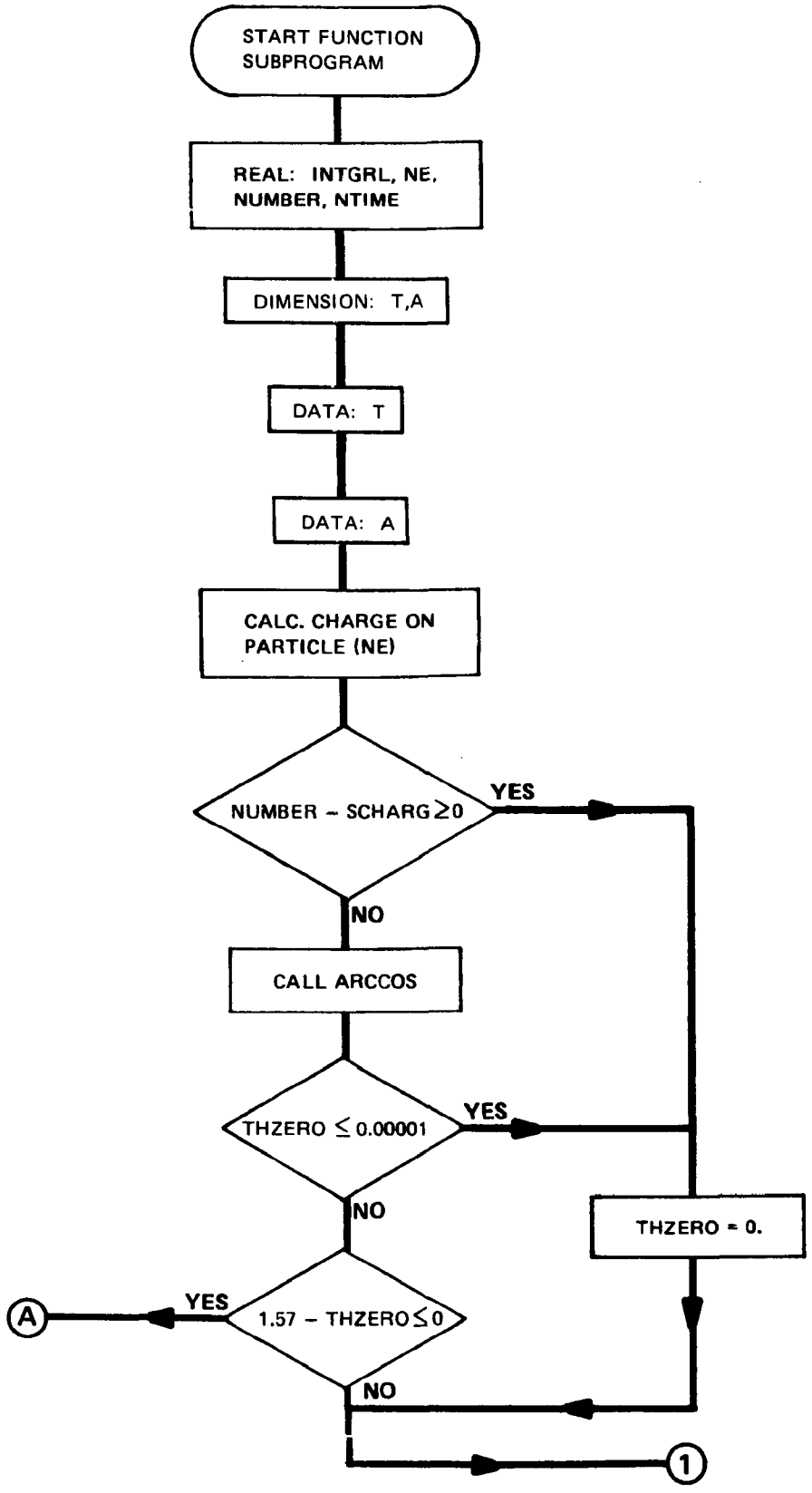

Figure 12. Flow chart for function subprogram RATE (sheet 1 of 3).

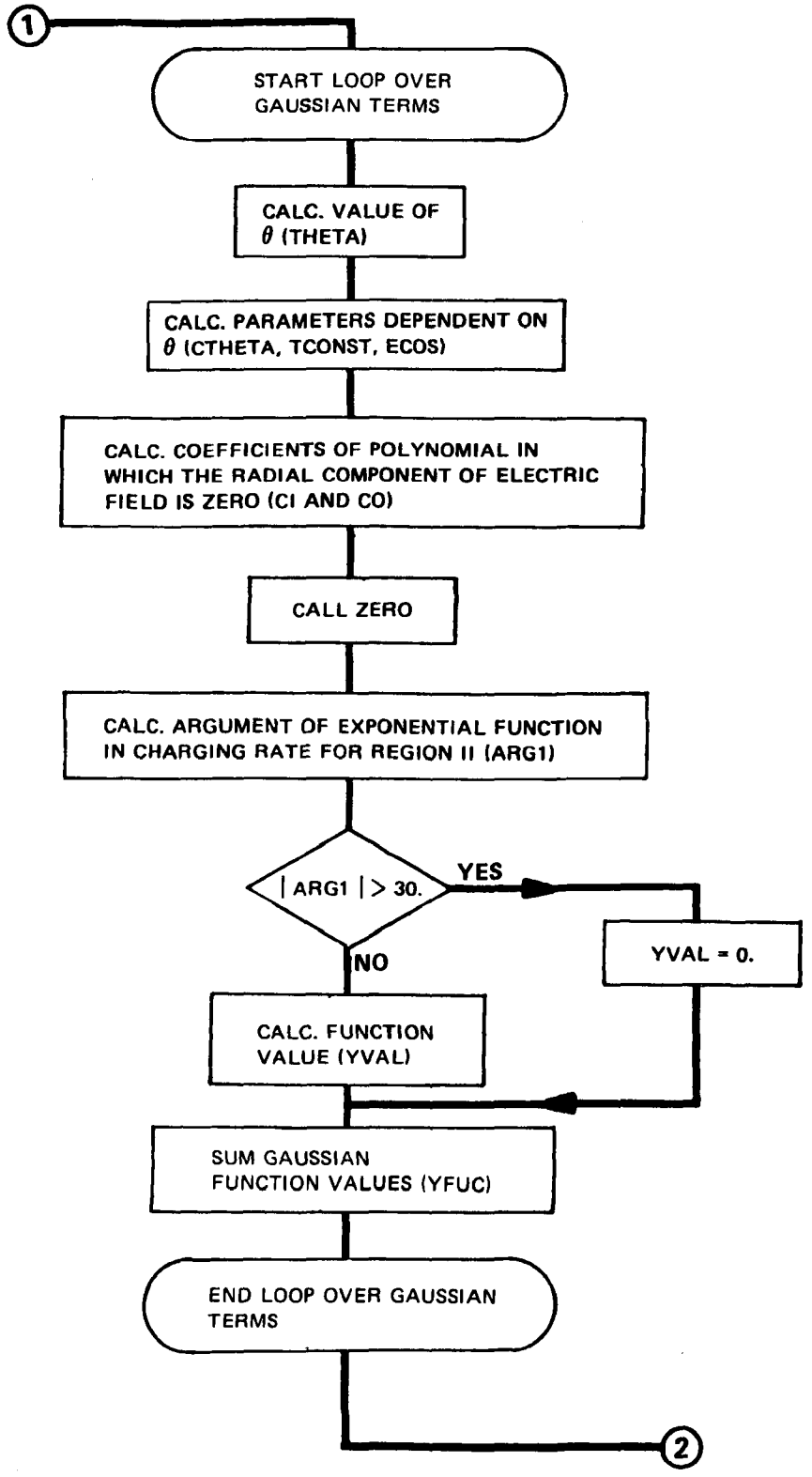

Figure 12. Flow chart for function subprogram RATE (sheet 2 of 3).

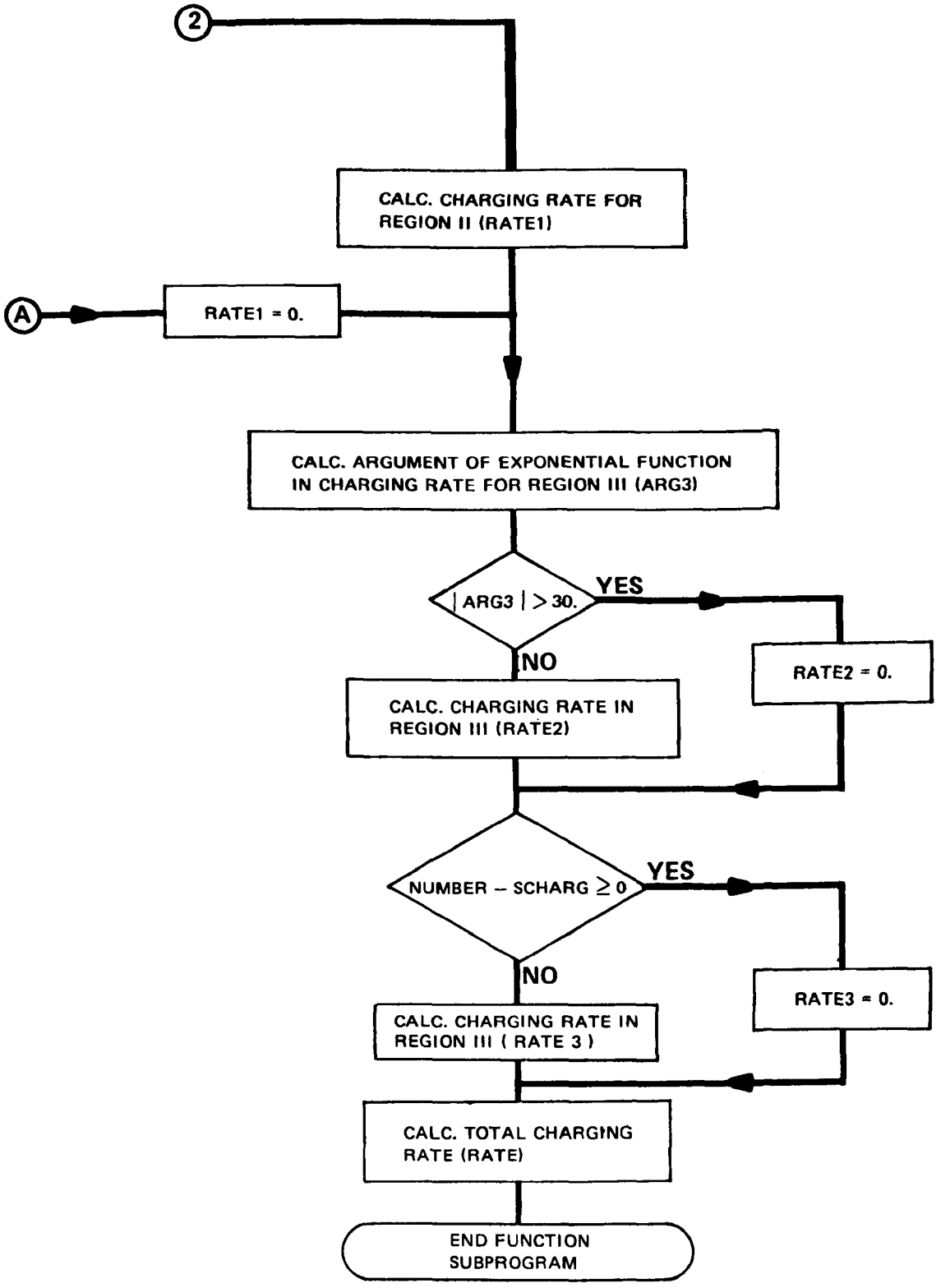

Figure 12. Flow chart for function subprogram RATE (sheet 3 of 3).

CONST - Value of the quantity $[2 \frac{(K-1)}{(K+2)} a^3 E_0]$ found in equation (46) $[V\text{-}m^2]$.

EZERO - Applied electric field strength for particle charging (V/m).

V - Value of the quantity $[\frac{e^2}{4\pi\varepsilon_0 akT}]$ found in equation (45).

RSIZE - Radius of the particle (m).

ECONST - Value of the quantity $[\frac{3eE_0 a}{kT(K+2)}]$ found in equation (45).

CMKS - Value of the quantity $[4\pi\varepsilon_0]$ found in equation (45) $(C^2/nt\text{-}m^2)$.

RR - Value of the quantity $[\frac{eE_0}{kT}]$ found in equation (45) $[m^{-1}]$.

FCONST - Value of the quantity $[\frac{(K-1)eE_0 a^3}{(K+2)kT}]$ found in equation (45) $[m^2]$.

FACTOR - Value of the quantity $[\frac{\pi \tilde{v} a^2}{2}]$ found in equation (45) $[m^3/sec]$.

COEFF - Value of the quantity $[\frac{bq_s}{4E_0}]$ found in equation (45) $[m^3/sec]$.

AFID - Free ion density for particle charging $(\#/m^3)$.

NTIME - Residence time for particle charging (sec).

NUMBER - Particle charge number.

Of the above variables, the values of the following must be provided by subroutine CHARGN: ECHARG, SCHARG, CONST, EZERO, V, RSIZE, ECONST, RR, FCONST, FACTOR, COEFF, AFID, NTIME, and NUMBER. The total charging rate given on the right hand side of equation (45) is RATE and is determined in the function subprogram.

SECTION 7

EFFECTS OF THE NEW MODIFICATIONS ON THE PREDICTIONS OF THE MODEL

DISCUSSIONS

Two of the modifications described earlier in this report have been incorporated into the working version of the computer program which represents the mathematical model of electrostatic precipitation. The analytic approximations to the electrical solutions in a wire-plate geometry have been incorporated into a subroutine called EFLD3. This subprogram has been included in the program with several options. When EFLD3 is used, the calculation performed is completely analogous to that in either EFLD1 or EFLD2, except that the analytic approximations are used to replace the numerical solutions. The subroutine CMAN along with the modifications described earlier was substituted for its original version. The Gaussian Quadratures integration scheme for computing the charge on particles has also been included in the program. This integration method has the effect of speeding up the charge calculations but should not give rise to any noticeable change in the results of the model predictions.

Although a new numerical integration scheme was described in Section 5 and has been listed in Appendix C, it has not been included in the computer program for modeling electrostatic precipitators. This new numerical solution was used primarily to test the previous numerical solution and the approximate solution. The subprogram listed in Appendix C could be substituted for EFLD2 in the computer program if one so desired. Such a step is not considered practical, since the program would then require even more time than before to execute. The new numerical method may prove valuable, however, in developing further extensions to the mathematical model.

A complete listing of the new version of the computer program for modeling wire-plate electrostatic precipitators is given in Appendix F. A list giving the definitions of variables used in the program is given in Appendix O. This program differs from the one listed in the previous model report mainly in that it contains the new subroutine EFLD3 and has new versions of the subroutine CMAN and the function subprogram RATE. A simplified flow chart for the entire program is shown in Figure 13.

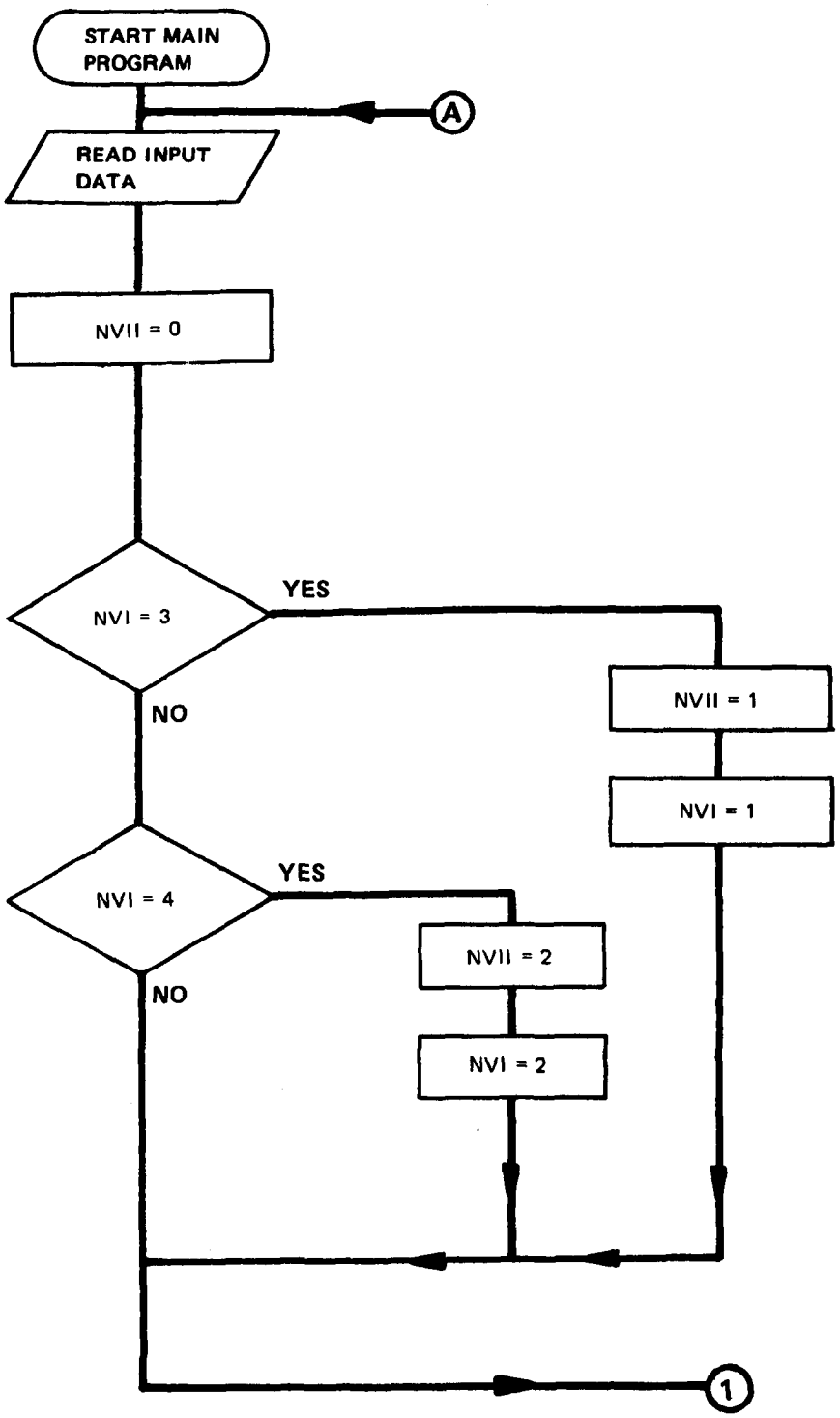

Figure 13. Simplified flow chart for logic of the entire program (sheet 1 of 7).

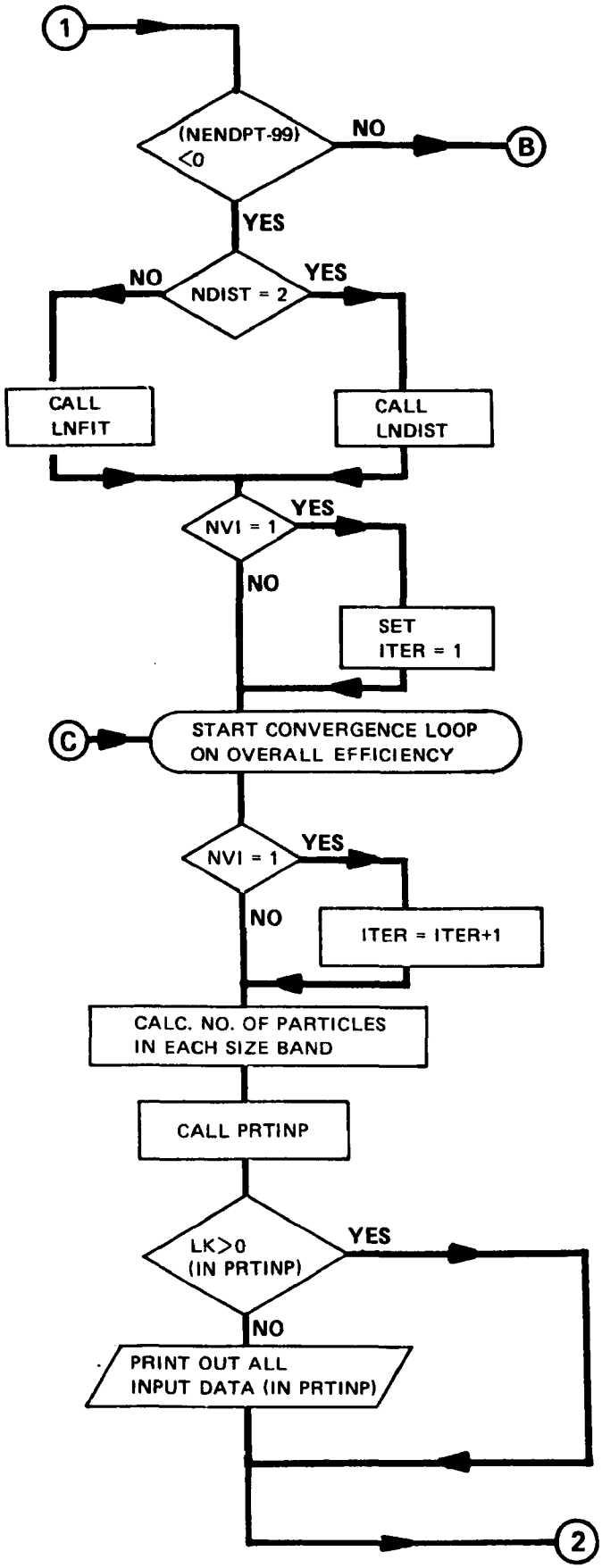

Figure 13. Simplified flow chart for logic of the entire program (sheet 2 of 7).

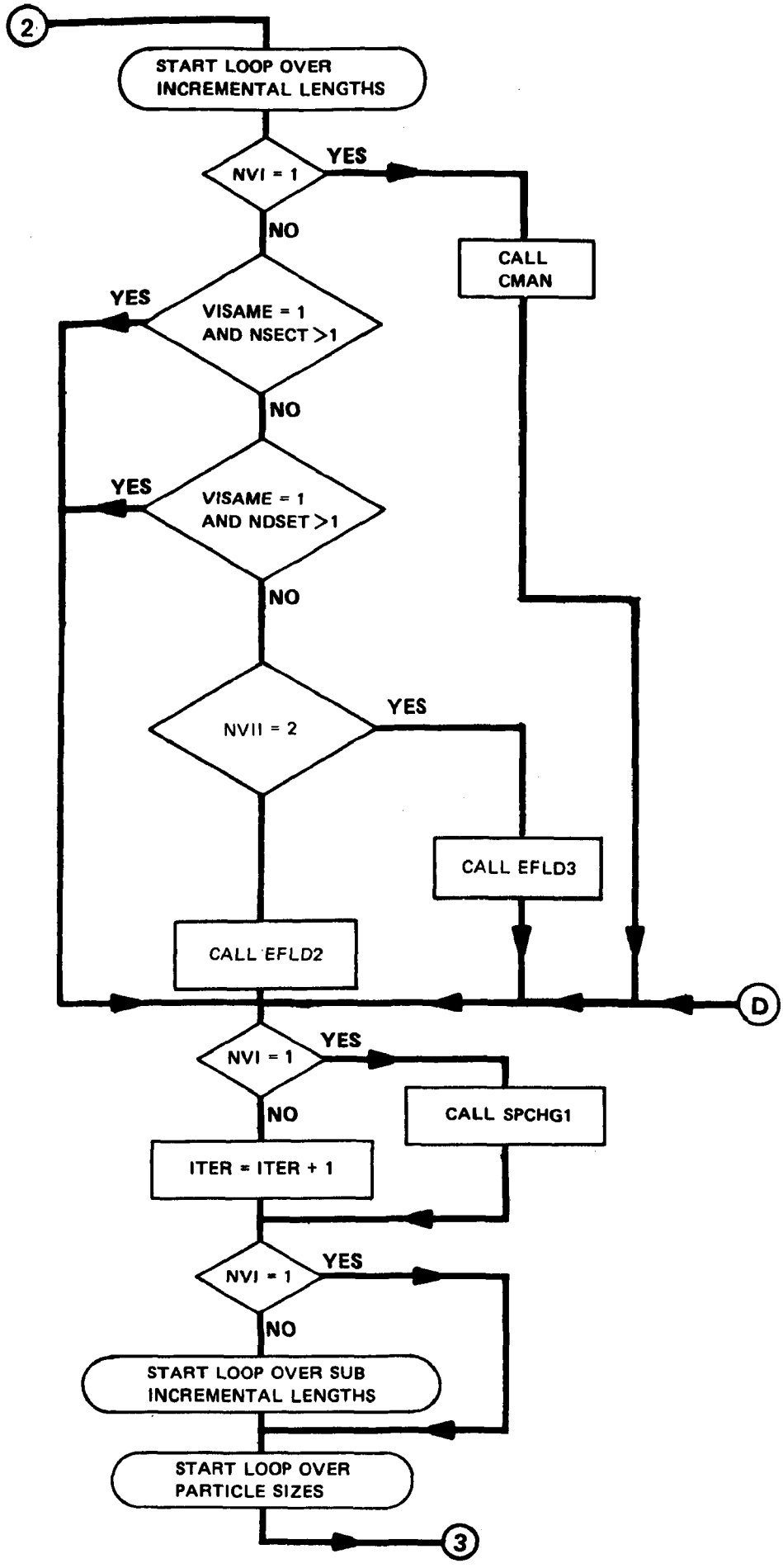

Figure 13. Simplified flow chart for logic of the entire program (sheet 3 of 7).

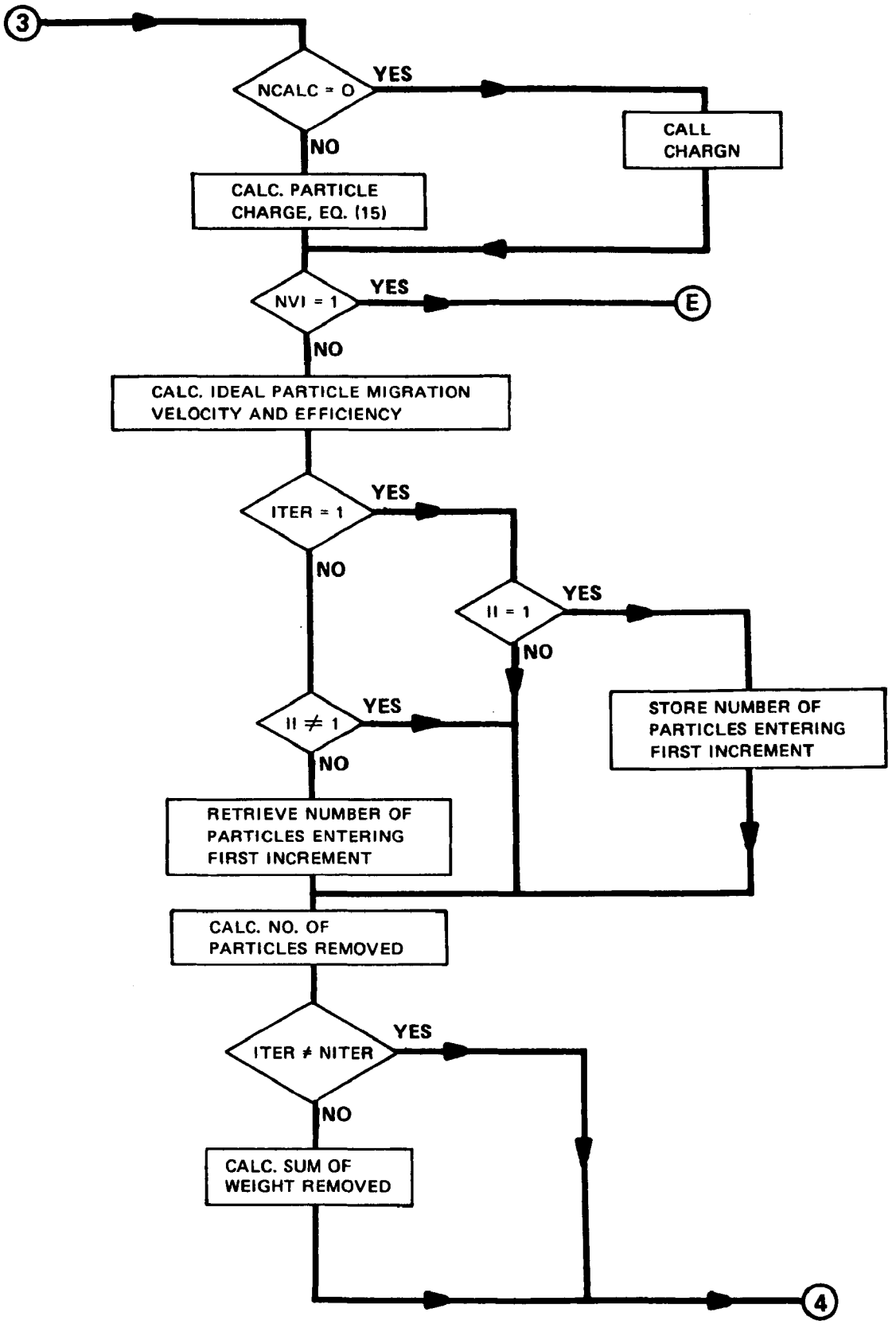

Figure 13. Simplified flow chart for logic of the entire program (sheet 4 of 7).

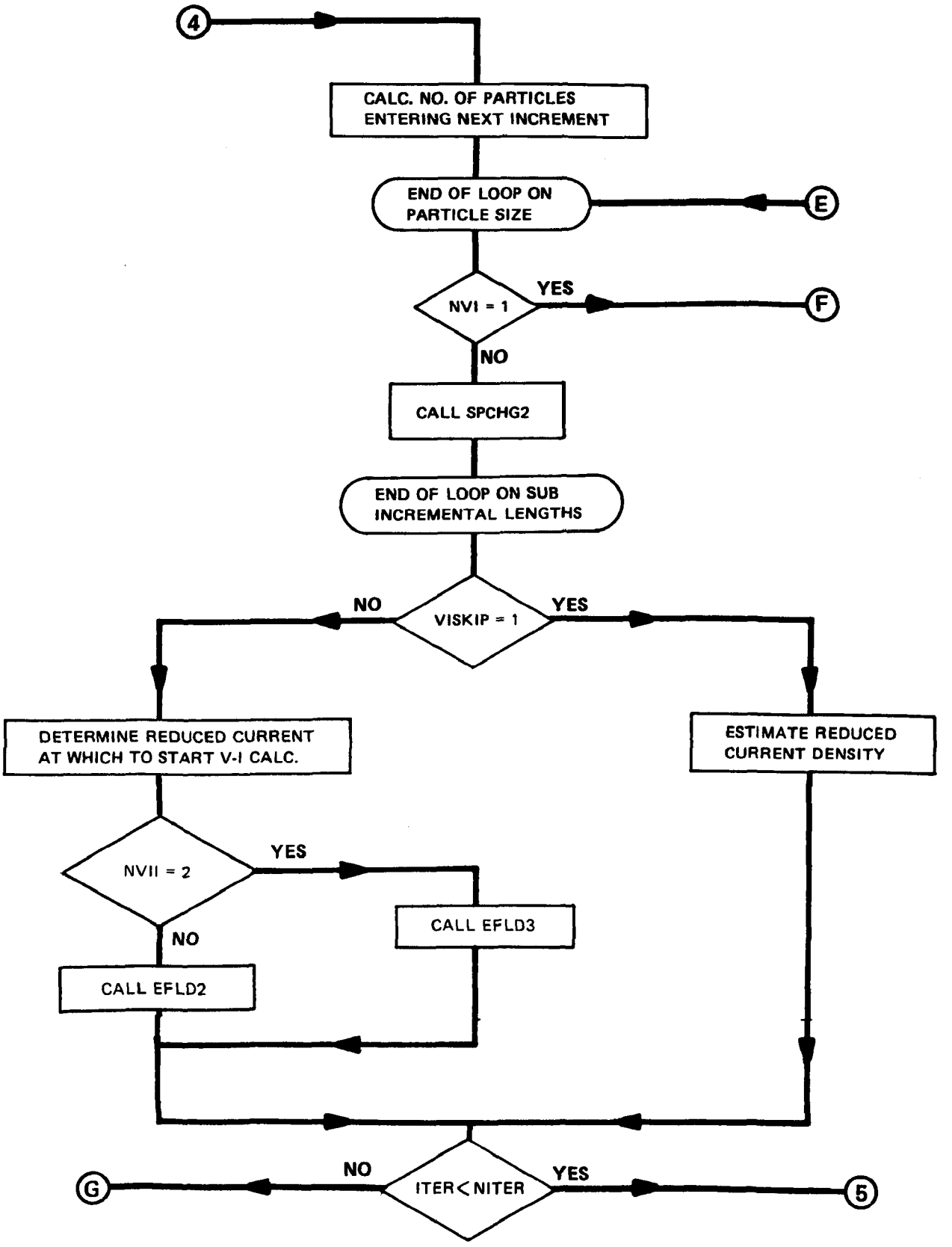

Figure 13. Simplified flow chart for logic of the entire program (sheet 5 of 7).

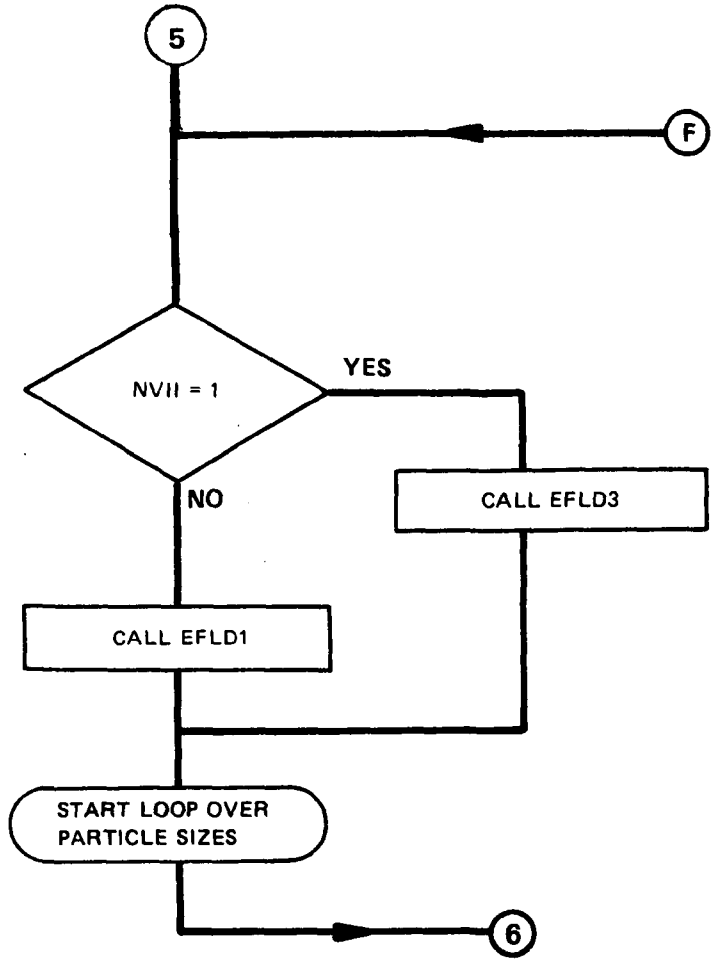

Figure 13. Simplified flow chart for logic of the entire program (sheet 6 of 7).

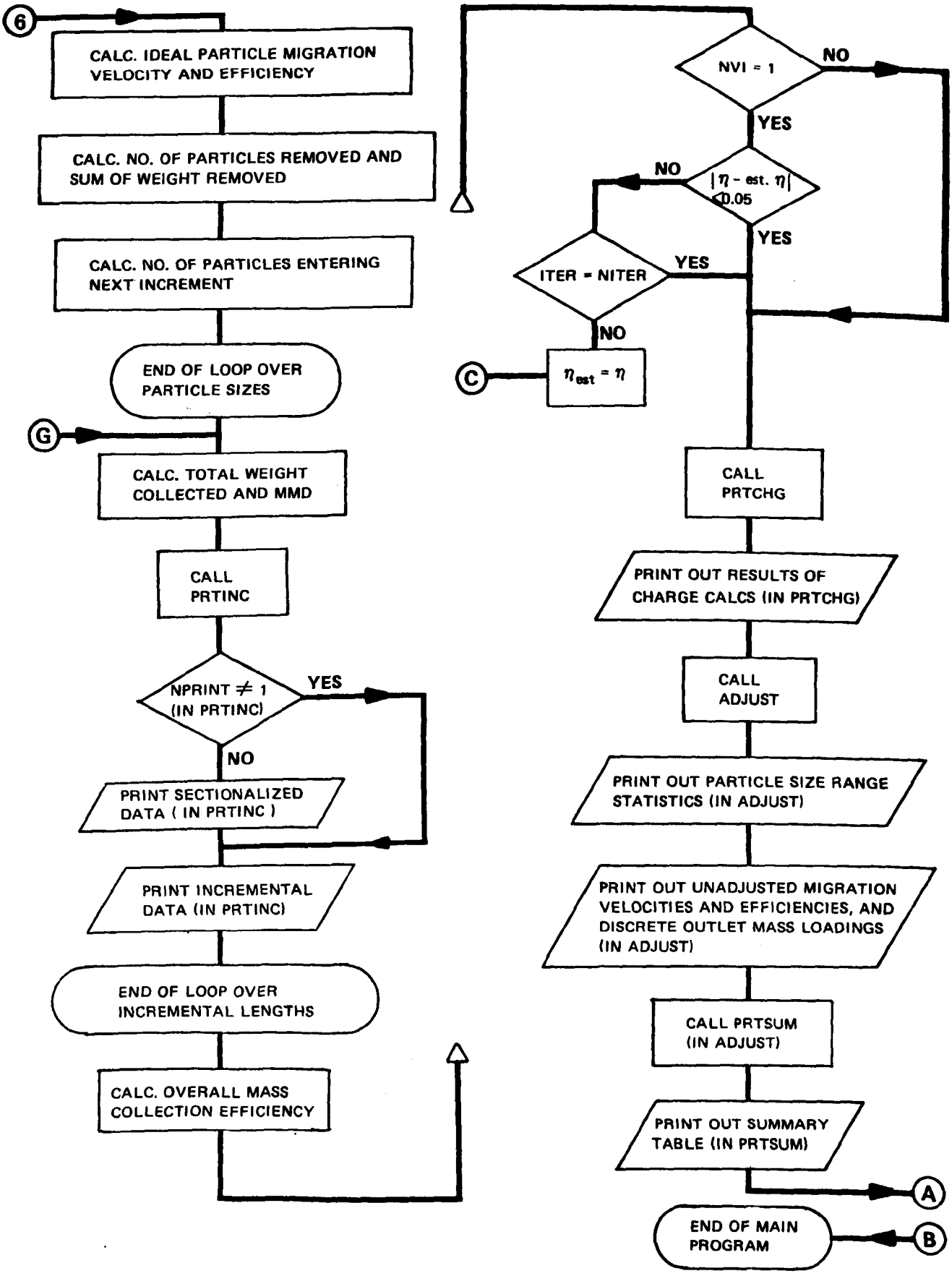

Figure 13. Simplified flow chart for logic of the entire program (sheet 7 of 7).

It is stressed that one who is not familiar with the model should read both volumes of the previous report[2,3] before trying to use the program to model precipitators. Only the information relevant to the present modifications is discussed in this report.

INPUT DATA

The formats for inputting data to the program are exactly the same as for the previous version of the model. In fact, any set of input data which would execute in the program listed in Revision 1 of the model will also execute in the program listed in this report. The only difference will be that charging is computed using Gaussian Quadratures rather than Simpson's rule.

There is one important extension to the options available in the input parameters. In addition to the values of 1 and 2, the parameter NVI can now have values of 3 and 4 as well. The parameter NVI is an indicator which determines the technique used to compute the electrical conditions. As before, when NVI = 1 the user must supply known or measured values of the operating applied voltage and current. If NVI = 2, the program will construct a voltage-current curve for a specified wire-plate geometry up to a voltage which is specified by the user. Both of these techniques for determining the electrical conditions are discussed in Volume I[2] of the previous report. When NVI has the new values of either 3 or 4, a new parameter NVII is initialized by the program. NVI is then set to either 1 or 2 so that the logic of the program proceeds as before. If NVI = 3, NVII is set to 1 and then NVI is also set to 1. If NVI = 4, NVII is set to 2 and then NVI is also set to 1. If NVII = 1, EFLD3 rather than EFLD1 is called. A calculation completely analogous to that in EFLD1 is performed except that the analytic expressions from Section 4 are used to compute the electrical properties. Under these conditions, the electric field at the surface of the wire is chosen so as to match the specified potential at the wire. In this case, Peek's condition on the field is not used. If NVII = 2, EFLD3 rather than EFLD2 is called. The resulting calculation is completely analogous to that in EFLD2 except that the electrical properties are computed from the analytic expressions described in Section 4. In this case a current-voltage curve is generated up to the operating voltage specified. The reader is referred to Volume 2[3] of the previous report for the details of constructing a complete set of input data. Since the Simpson's rule integration scheme has been replaced by Gaussian Quadratures, the parameter NUMINC is no longer used in the program. It is still read in, however. The output data will be identical to that described in Volume 2[3] of the previous report.

MACHINE-DEPENDENT ASPECTS OF THE COMPUTER PROGRAM

The computer program, presented and discussed in this report, has been developed on a Digital Equipment Corporation (DEC) PDP

15/76 computer. Although the program should compile successfully with only minor changes on most computers with a fortran compiler, there are certain machine-dependent aspects of the program that should be discussed. These machine-dependent properties can be utilized to make the usage of the program more general and to extend the application of the program.

In order to use the program on most computers, the first two executable statements in the program must be changed. These statements define the input (read) and output (write) logical unit numbers. The value of the variable NREAD specifies the input logical unit number and the value of NPRNT specifies the output logical unit number. These two changes should normally be the only modifications which are necessary to allow successful compilation of the program. The approximate time required to compile the entire program on the DEC PDP 15/76 computer was 1716 seconds.

Once the program is compiled, it will execute provided that enough core is available to store the program. The total core requirements on the DEC PDP 15/76 are 131,221 octal words (45,713 decimal words) for the program plus 7,632 octal words (3,994 decimal words) for system software necessary to implement the program. Table 3 lists the various segments of the program and their core requirements.

Due to the fact that the particular DEC PDP 15/76 which has been used to develop the program has only approximately 57,563 octal words (24,435 decimal words) of core that can be accessed at any given time, it was necessary to overlay subroutines in order to fit the program into core. The main program (ESPM), the data Block, and subroutine CMAN were kept in resident core and the overlay was established by setting up the following six links:

LINK1 = SPCHG1, EFLD1

LINK2 = SPCHG2, EFLD2

LINK3 = ADJUST, WADJST, CFIT, LNFIT, QTFE, LNDIST, PRTSUM

LINK4 = CHARGN, RATE, ZERO/ARCCOS

LINK5 = PRTINC, PRTCHG, PRTINP, CHGSUM

LINK6 = EFLD3/ARCCOS

With the above overlay, the required core is 56,275 octal words (23,741 decimal words) including system software. The core requirements were determined by the core utilized in resident core and the largest link (LINK2). Also, the link table required an additional 323 octal words (211 decimal words) of core.

In order to get the program to execute on computers with small storage capacities, an overlay similar to the one discussed

TABLE 3. CORE REQUIREMENTS FOR VARIOUS SEGMENTS OF THE COMPUTER PROGRAM

	Octal Words	Decimal Words
RESIDENT CODE		
ESPM	11,541	4,961
CMAN	1,362	754
DATA	3,411	1,801
BLK1	502	322
BLK2	62	50
BLK3	16	14
BLK4	1	1
BLK5	15	13
BLK6	1,354	748
BLK7	3,410	1,800
BLK8	170	120
BLK9	74	60
BLK10	74	60
BLK11	53	43
BLK12	202	130
BLK13	703	451
BLK14	4	4
BLK15	71	57
BLK16	5	5
BLK17	2	2
BLK18	17	15
BLK19	57	47
BLK20	263	179
BLK21	1,774	1,020
System Software	6,731	3,545
LINK1		
SPCHG1	407	263
EFLD1	13,664	6,068
LINK2		
SPCHG2	732	474
EFLD2	15,775	7,165
LINK3		
ADJUST	7,200	3,712
WADJST	610	392
CFIT	372	250
LNFIT	624	404
QTFE	160	112
LNDIST	1,567	887
PRTSUM	1,635	925
System Software	393	267
LINK4		
CHARGN	343	228
RATE	634	412
ARCCOS	200	128
ZERO	130	88
System Software	12	10
LINK5		
PRTINC	1,747	999
PRTCHG	1,563	883
PRTINP	5,352	2,794
CHGSUM	1,156	622
System Software	110	72
LINK6		
EFLD3	14,046	6,182
ARCCOS	200	128

above may be possible. On computers with large memories such as the IBM 370/158, UNIVAC 1100, or CDC 7600, no such action is necessary. When an overlay is not used, a significant amount of core could be gained by deleting subprograms EFLD1 and EFLD2. This might provide additional core for expanding some of the arrays.

Without changing the fundamental operations of the program, the dimensions of certain arrays can be decreased or increased if necessary. The dimensions of these arrays may be decreased in order to fit the program on a small computer or they may be increased to give greater flexibility on a large computer. In the version of the program presented in this report, the following quantities determine array sizes which may be changed:

- number of increments along the length of the precipitator
- number of particle size bands
- number of electrical sections in the direction of gas flow
- number of grid points used in the calculations of electrical conditions
- number of rapping puff particle size distributions
- number of sets of nonideal conditions of nonuniform gas velocity distribution and gas sneakage and/or particle reentrainment without rapping.

The above quantities have maximum values of 45, 20, 10, 225, 10, and 15, respectively.

The number of increments along the length of the precipitator that can be utilized can be changed by changing the dimension of DW and the dimension of the first subscript of XDC. DW appears in COMMON/BLK6/ and XCD appears in COMMON/BLK7/. COMMON/BLK6/ appears in the main program and subroutines PRTINP, CHGSUM, PRTINC, PRTCHG, ADJUST, and PRTSUM. COMMON/BLK7/ appears in the main program and subroutines SPCHG2 and PRTCHG. DW also appears in the dimension statement in the subroutine SPCHG1. If the storage capacity of the computer is large enough, the program should be modified to handle more than 45 increments. Although 120 increments should be sufficient to handle most cases, as many as 180 increments may be necessary in certain cases.

The number of particle size bands that can be utilized can be changed by changing the dimension of CHKSUM, DIAM, ONO, DXS, XMV, PCNT, RAD, CCF, VOL, XNO, Q, WS, QSAT, OLDQ, OLDXNO, XDC, OLDQF, OLDQT, SOLDQF, SOLDQT, YY, RPCNT, DMDLD, WUNCOR, RDMDLD, CDMDLD, PCTOT, CPCTOT, WSL, PXS, EUNCOR, and AREA. In addition, changes must be made to those variables which depend on the number

of particle diameters in the particle size histogram. These variables must have a dimension which has a value of 1 greater than those which depend on the number of size bands. These variables include PRCU, ENDPT, PRCUNR, RPRCU, PRCUC, Z, and Y. CHKSUM appears in the dimension statement in the main program. DIAM, ONO, DXS, XMV, PCNT, RAD, CCF, and PRCU appear in COMMON/BLK1/. VOL, XNO, Q, WS, QSAT, OLDQ, and OLDXNO appear in COMMON/BLK6/. XDC appears in COMMON/BLK7/. ENDPT appears in COMMON/BLK11/. OLDQF, OLDQT, SOLDQF, and SOLDQT appear in COMMON/BLK20/. COMMON/BLK1/ appears in the main program and subroutines PRTINP, PRTCHG, and ADJUST. COMMON/BLK6/ and COMMON/BLK7/ appear in those locations previously designated. COMMON/BLK11/ appears in the main program and subroutines PRTINP, ADJUST, LNFIT, and LNDIST. COMMON/BLK20/ appears in the main program and subroutine CHGSUM. QSAT and XNO appear in the dimension statement in subroutine SPCHG1. XNO, RAD, CCF, OLDQ, and Q appear in the dimension statement in subroutine SPCHG2. YY appears in the dimension statement in subroutine PRTCHG. RPCNT, DMDLD, WUNCOR, RDMDLD, CDMDLD, PCTOT, CPCTOT, WSL, PXS, PRCUNR, RPRCU, PRCUC, and EUNCOR appear in the dimension statement in subroutine ADJUST. DIAM, ONO, and PXS appear in the dimension statement in subroutine WADJST. Z and Y appear in the dimension statement in subroutine CFIT. Z, Y, and PRCU appear in the dimension statement in subroutine LNFIT. AREA, PRCU, and PCNT appear in the dimension statement in subroutine LNDIST. In changing XDC, it is the second subscript which accounts for the maximum number of size bands which can be considered.

The number of electrical sections in the direction of gas flow that can be utilized can be changed by changing the dimension of LSECT, LINCS, PS, AS, VOS, TCS, WLS, ACS, BS, SYS, VGS, VGASS, TEMPS, VISS, RFS, START1, START2, START3, VSTAR, and NWS. LSECT, LINCS, and PS appear in COMMON/BLK2/. AS, VOS, TCS, WLS, ACS, BS, SYS, VGS, VGASS, TEMPS, VISS, RFS, START1, START2, START3, and VSTAR appear in COMMON/BLK6/. NWS appears in COMMON/BLK19. COMMON/BLK2/ appears in the main program and in subroutine PRTINP and ADJUST. COMMON/BLK6/ appears in those locations previously designated. COMMON/BLK19/ appears in the main program and subroutines PRTINP, PRTCHG, and ADJUST. LSECT appears in the dimension statement in subroutine SPCHG1.

The number of grid points that can be utilized in the calculation of electrical conditions can be changed by changing the dimensions of VCOOP, RHO, EX, OLDRO, OLDV, CDNSTY, V, EY, EAVGS, CHFIDS, ECOLLS, EAVG, CHFID, ECX, ECY, X1, Y1, AX, AY, and ECOLL. VCOOP appears in COMMON/BLK13. EAVG and CHFID appear in COMMON/BLK8/. ECOLL appears in COMMON/BLK9/. ECX, ECY, X1, Y1, AX, and AY appear in COMMON/BLK21/. COMMON/BLK13/ appears in the main program and subroutines CMAN, EFLD1, EFLD2, and EFLD3. COMMON/BLK8/ appears in the main program and subroutines SPCHG2, EFLD2, EFLD3, and PRTCHG. COMMON/BLK9/ appears in the main program, subroutine EFLD2, and EFLD3. COMMON/BLK21/ appears in EFLD3 and CMAN.

RHO, EX, OLDRO, OLDV, CDNSTY, V, and EY appear in the dimension statement in subroutine EFLD1. RHO, EX, OLDRO, OLDV, CDNSTY, V, EY, EAVGS, CHFIDS, and ECOLLS appear in the dimension statement in subroutines EFLD2 and EFLD3. VCOOP, RHO, EX, OLDRO, OLDV, CDNSTY, V, EY, ECX, and ECY are doubly subscripted variables with the first subscript referring to the number of grid points in the direction perpendicular to the gas flow and the second subscript referring to the number of grid points in the direction parallel to the gas flow. EAVG, CHFID, ECOLL, EAVGS, CHFIDS, and ECOLLS are singly subscripted variables whose dimension must be a value of two less than twice the dimension of the second subscript in the variables VCOOP, RHO, EX, OLDRO, OLDV, CDNSTY, V, and EY.

The number of rapping puff particle size distributions that can be utilized can be changed by changing the dimension of ARD50 and ARSIGM. ARD50 and ARSIGM appear in COMMON/BLK12/. COMMON/BLK12/ appears in the main program and in subroutines PRTINP and ADJUST.

The number of sets of nonideal conditions of nonuniform gas velocity distribution and gas sneakage and/or particle reentrainment without rapping that can be utilized can be changed by changing the dimension of ASNUCK, AZIGGY, and AZNUMS. These variables appear in COMMON/BLK12/. COMMON/BLK12/ appears in those locations previously designated.

If any changes are made that affect arrays, these changes will also affect the limitations on the input data discussed in the previous report. The limitations on the input data discussed previously are only applicable to the version of the program presented in Appendix F of this report. If changes are made, then new limitations on the input data must be established.

EXAMPLE CASES AND COMPARISONS OF THE ANALYTIC APPROXIMATIONS WITH PREDICTIONS OF THE PREVIOUS MODEL

Example 1

In this example, the model calculations are performed using geometrical parameters corresponding to a laboratory precipitator. This device has a plate-to-plate spacing of 25.4 cm, a wire-to-wire spacing of 12.7 cm, a wire radius of 0.1191 cm, a gas velocity of 0.976 m/sec, and a current density at the plate of 25.8 nA/cm^2. These parameters are also typical of full-scale precipitators. The inlet mass loading and particle size distribution, operating voltages and currents, gas flow rate and velocity, and gas temperature and pressure were measured and are used as input data for the model. A reduced effective ion mobility of 1.65×10^{-4} m^2/v-sec is used in the model since the use of this value results in good agreement between theoretical and experimental current-voltage characteristics for corona discharge in ambient air. Although the precipitator is divided into four baffled and independent electrical sections, the last two sections were connected together during the experiment and this is reflected in the input data to the model.

Figure 14 shows a comparison of fractional collection efficiencies computed from Revision 1 of the model using electrical conditions measured in a laboratory precipitator with those computed from Revision 2 of the model using the approximate calculation of the electrical properties. Since the predictions of Revision 1 of the model have been previously compared with the experimental results, the experimental values will not be shown. Instead, a comparison of the new calculations obtained using the approximations described in Section 4 with the previous model predictions will be stressed. Revision 2 of the model contains a new charge calculation scheme as well as an approximate representation of the electrical solutions. As can be seen in Figure 14, the fractional collection efficiencies computed by the two versions of the model are in excellent agreement. The maximum difference of three percent occurs for a diameter of 0.25 micrometers. The input data card set which was used in Revision 2 of the model is shown in Table 4. The output data corresponding to the input in Table 4 are given in Appendix G. The corresponding set of output data from Revision 1 of the model are shown in Appendix H. Comparison of these two appendices will show that the overall agreement of the two versions of the model is quite good. The calculations shown in Appendix H required 2,801 seconds on the DEC PDP 15/76 computer while the corresponding calculations shown in Appendix G required only 334 seconds. These results represent a significant saving in computer time without a significant loss in accuracy.

Example 2

In this example, the geometric parameters corresponding to the laboratory precipitator were the same as in Example 1. In this case, the gas velocity was 1.49 m/sec and the average current density at the plate was 10.8 nA/cm^2. The primary difference in this example and the previous one lies in the manner in which the electrical operating conditions were determined. For this case, these quantities are predicted by the model by calculating clean-gas, current-voltage curves for each electrical section and estimating the reduction in current in each increment of length due to charged particles. A reduced effective ion mobility of 1.65×10^{-4} $m^2/V\text{-sec}$ and a roughness factor of 0.90 were used.

Figure 15 shows a comparison of the fractional collection efficiencies predicted by Revision 1 of the model using integrated electrical solutions with those predicted by Revision 2 of the model using the approximate electrical solutions discussed in Section 4. A maximum difference between the two predictions of three percent occurs at a diameter of 1.6 micrometers. Table 5 gives the input data card set used to obtain the model predictions. The output data set is shown in Appendix I. The corresponding calculations for Revision 1 of the model are shown in Appendix J. The calculations in Appendix J required 47,886 seconds on the DEC PDP 15/76 computer. The calculations in Appendix I required only 5,175 seconds.

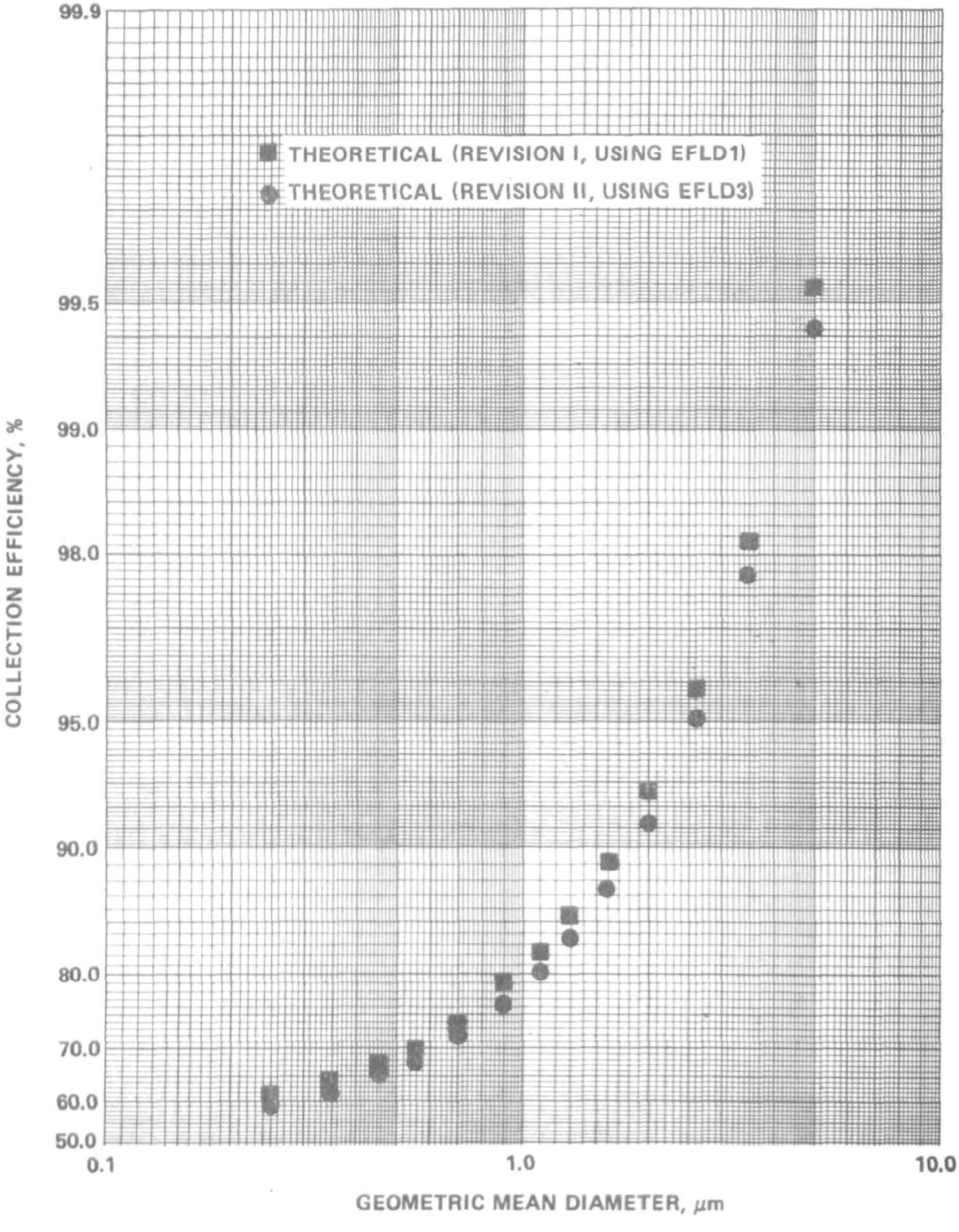

Figure 14. Comparison of fractional collection efficiencies computed from Revision I of the model using electrical conditions measured in a laboratory precipitator with those computed from Revision II of the model using the approximations.

TABLE 4. INPUT DATA CARD SET FOR EXAMPLE 1

COLUMN NUMBER

```
                1         2         3         4         5         6         7         8
      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
CARD
NUMBER
  1   1 6 0 1'
  2   L A B _ E S P : _ S C A = 1 2 5 F T 2 / 1 0 0 0 A C F M ; J = 2 4 . 0 U A / F T 2
  3   0 1 0 1 0 3 1 0 1 0 0 3 0 0 0 1 0 1 0 1 0 2
  4   0 5 0 3
  5   0 . 0 1 5 _ _ _ 1 0 . 0 _ _ _ _ 9 9 . 0 _ _ _ _ 1 0 0 0 . 0 _ _ 5 . 1 _ _ _ _ _ 1 . 0 3 _ _ _ _ 0 . 0 0 0 1 6 5 1 . 0 _ _ _ _ _ 1 5 0 0 0 0 0 . 1 . 0 0 E + 0 9
  6   0 . 0 0 0 . 0 0 4 . 0 0 0 . 1 0 0 . 1 0 4 . 0 0
  7   0 . 2 0 _ _ _ _ 0 . 3 0 _ _ _ _ 0 . 4 0 _ _ _ _ 0 . 5 0 _ _ _ _ 0 . 6 0 _ _ _ _ 0 . 8 0 _ _ _ _ 1 . 0 0 _ _ _ _ 1 . 2 0 _ _ _ _ 1 . 4 0 _ _ _ _ 1 . 8 0
  8   2 . 2 0 _ _ _ _ 3 . 0 0 _ _ _ _ 4 . 0 0 _ _ _ _ 6 . 0 0 _ _ _ _ 1 0 . 0 _ _ _ _ 2 0 . 0
  9   0 . 0 _ _ _ _ _ 0 . 0 0 0 2 _ _ 0 . 4 0 0 2 _ _ 1 . 0 0 0 2 _ _ 2 . 6 6 7 2 _ _ 7 . 6 6 7 2 _ _ 1 2 . 6 0 0 2 _ 1 7 . 6 0 0 2 _ 2 1 . 3 3 3 2 _ 2 9 . 3 3 3 2
 10   3 6 . 0 0 0 2 _ 4 6 . 6 6 7 2 _ 5 7 . 3 3 4 2 _ 6 8 . 6 6 7 2 _ 8 0 . 6 6 7 2 _ 1 0 0 . 0
 11   0 3 0 3 0 3 0 6
 12   + 6 . 2 5 0 0 E + 0 0 + 4 . 6 0 0 0 E + 0 4 + 1 . 5 0 0 0 E - 0 4 + 6 . 2 5 0 0 E + 0 0 + 4 . 6 8 7 5 E - 0 2 + 5 . 0 0 0 0 E + 0 0 + 5 . 0 0 0 0 E + 0 0
 13   + 2 . 5 0 0 0 E + 0 0 + 2 . 0 0 0 0 E + 0 2 + 3 . 2 0 0 0 E + 0 0 + 7 . 6 8 0 0 E + 0 1 + 1 . 0 0 0 0 E + 0 0 + 1 . 8 0 0 0 E - 0 5 + 8 . 3 3 3 3 E - 0 1
 14   + 6 . 2 5 0 0 E + 0 0 + 4 . 5 8 0 0 E + 0 4 + 1 . 5 0 0 0 E - 0 4 + 6 . 2 5 0 0 E + 0 0 + 4 . 6 8 7 5 E - 0 2 + 5 . 0 0 0 0 E + 0 0 + 5 . 0 0 0 0 E + 0 0
 15   + 2 . 5 0 0 0 E + 0 0 + 2 . 0 0 0 0 E + 0 2 + 3 . 2 0 0 0 E + 0 0 + 7 . 6 8 0 0 E + 0 1 + 1 . 0 0 0 0 E + 0 0 + 1 . 8 0 0 0 E - 0 5 + 8 . 3 3 3 3 E - 0 1
 16   + 1 . 2 5 0 0 E + 0 1 + 4 . 4 4 0 0 E + 0 4 + 3 . 0 0 0 0 E - 0 4 + 1 . 2 5 0 0 E + 0 1 + 4 . 6 8 7 5 E - 0 2 + 5 . 0 0 0 0 E + 0 0 + 1 . 0 0 0 0 E + 0 1
 17   + 2 . 5 0 0 0 E + 0 0 + 2 . 0 0 0 0 E + 0 2 + 3 . 2 0 0 0 E + 0 0 + 7 . 6 8 0 0 E + 0 1 + 1 . 0 0 0 0 E + 0 0 + 1 . 8 0 0 0 E - 0 5 + 8 . 3 3 3 3 E - 0 1
```

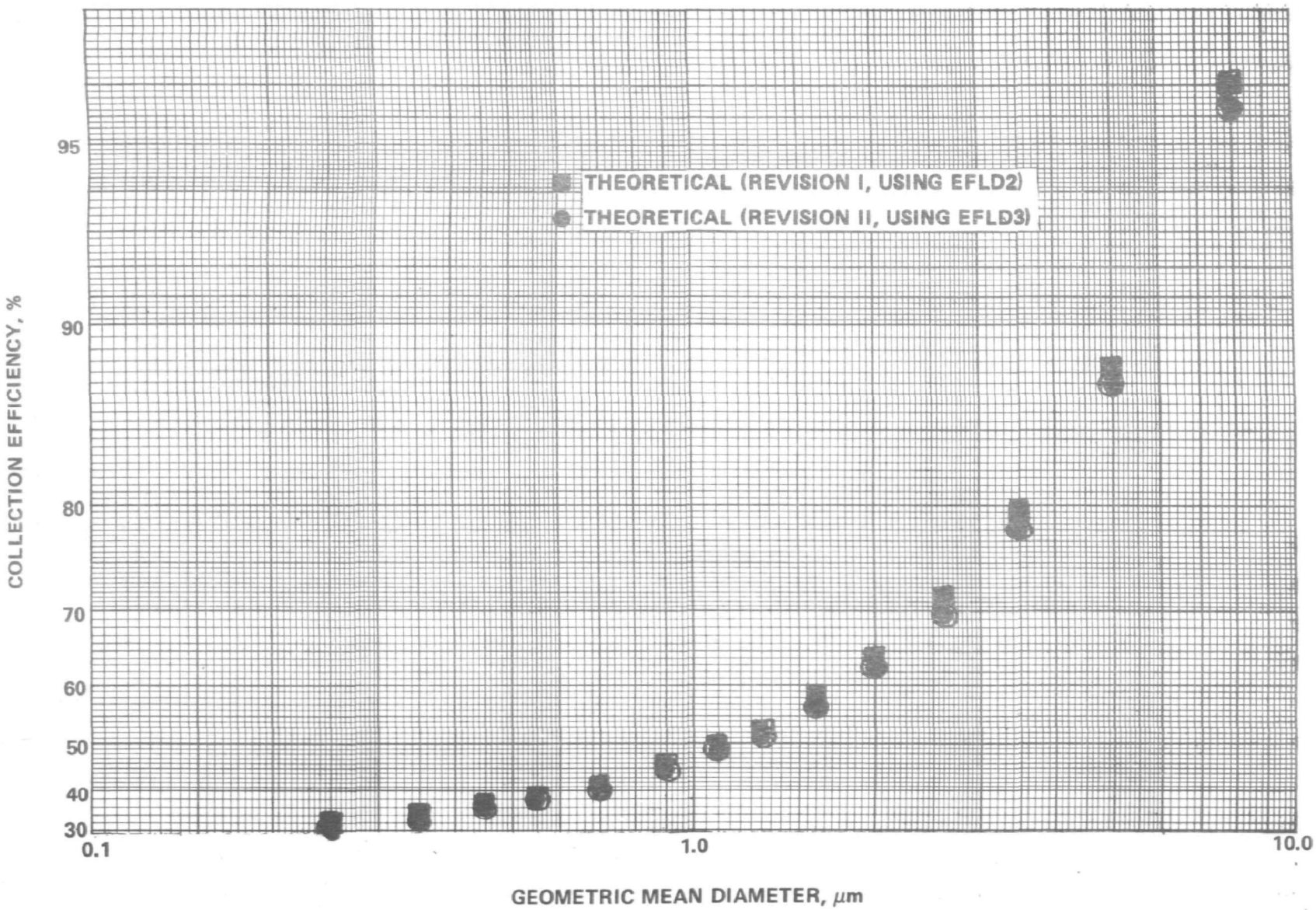

Figure 15. Comparison of fractional collection efficiencies computed from Revision I of the model using theoretical current-voltage calculations with those computed from Revision II of the model using the approximate electrical calculations.

TABLE 5. INPUT DATA CARD SET FOR EXAMPLE 2

COLUMN NUMBER

```
                    1         2         3         4         5         6         7         8
          12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
CARD
NUMBER
  1       1601
  2       LAB_ESP:_SCA=82FT2/1000ACFM;CALCULATED_V-I_FOR_EACH_ELECTRICAL_SECTION
  3       01010415150100010101 02
  4       0503
  5       2002210102
  6       0.065___10.0____99.0____1000.0__5.1_____1.03____0.0001651.0_____1500000.1.00E+09
  7       0.000.004.000.100.104.00
  8       0.20____0.30____0.40____0.50____0.60____0.80____1.00____1.20____1.40____1.80
  9       2.20____3.0_____4.0_____6.0_____10.0____20.0
 10       0.0_____0.0076__0.0563__0.2682__0.8652__2.9845__5.9695__9.5515__12.835__19.7004
 11       26.8643_38.8042_49.2516_64.1765_79.1014_100.0
 12       03060612
 13       +6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
 14       +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 15       +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
 16       +6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
 17       +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 18       +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
 19       +1.2500E+01+3.9600E+04+1.2500E-04+1.2500E+01+4.6875E-02+5.0000E+00+1.0000E+01
 20       +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 21       +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
```

Example 3

This example used the same input data as Example 2 except that the estimation procedure described in Volume I[2] of Revision 1 of the model report was employed. In this application of the estimation procedure, an I-V curve is generated to yield the operating values of current and voltage. The input data card set used in Revision 2 of the model is given in Table 6. The output data from the calculation is given in Appendix K. Since the results of the calculation using the estimation with this set of parameters was not presented in Revision 1 of the model report, the input data card set for this case is shown in Table 7. The corresponding output data are shown in Appendix L. Figure 16 shows a comparison of the fractional collection efficiencies from the two calculations. Once again there is good agreement between the two model calculations. A maximum difference in collection efficiency of three percent occurs at a diameter of about 1.3 micrometers. The time required by the DEC PDP 15/76 computer to perform the calculations shown in Appendix K was 2,568 seconds. The corresponding time required for the calculations shown in Appendix L was 10,019 seconds. These two times can be contrasted with those in Example 2 for which the more rigorous calculations took 5,175 seconds and 47,886 seconds, respectively. For a comparison of the estimation procedure with the more rigorous calculation, one should use Appendices L and J. However, it can be seen from Appendices K and I that the approximations contained in Revision 2 of the model give an adequate representation of the theory with a substantial savings in time of computation.

Example 4

In this example, the two versions of the model are compared using parameters measured at a full-scale, cold-side precipitator. Predictions of the model were compared with the experimental measurements in the previous model report. The input data card set is shown in Table 8. The output data for this calculation using the approximate electrical solutions are shown in Appendix M. The output data for the corresponding calculations using integrated electrical solutions are shown in Appendix N. In these two calculations measured values of current and voltage are used. Figure 17 shows a comparison of the fractional collection efficiencies for these two computations. The maximum difference in computed efficiencies of 1.3 percent occurs for a diameter of 0.2 micrometers. The calculations shown in Appendix N required 6,181 seconds of computer time on the DEC PDP 15/76 system. The calculations shown in Appendix M required only 789 seconds on the same system.

All the comparisons of collection efficiency made here used the ideal cases. In the case of full-scale precipitators, these predictions would not be expected to agree well with measurements. For such cases, nonideal effects described in Revision 1 of the model report would need to be taken into account. Some examples were described in detail in Volume II[3] of the previous model

TABLE 6. INPUT DATA CARD SET FOR EXAMPLE 3 (REVISION 2)

COLUMN NUMBER

```
         1         2         3         4         5         6         7         8
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
```

CARD NUMBER	
1	1601
2	LAB_ESP:_SCA=82FT2/1000ACFM;CALCULATED_V-I_FOR_EACH_ELECTRICAL_SECTION
3	02010415150100010101 02
4	0503
5	2002210102
6	0.065___10.0____99.0____1000.0__5.1_____1.03____0.0001651.0_____1500000.1.00E+09
7	0.000.004.000.100.104.00
8	0.20____0.30____0.40____0.50____0.60____0.80____1.00____1.20____1.40____1.80
9	2.20____3.0_____4.0_____6.0_____10.0____20.0
10	0.0_____0.0076__0.0563__0.2682__0.8652__2.9845__5.9695__9.5515__12.835__19.7004
11	26.8643_38.8042_49.2516_64.1765_79.1014_100.0
12	03060612
13	+6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
14	+2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
15	+9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
16	+6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
17	+2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
18	+9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
19	+1.2500E+01+3.9600E+04+1.2500E-04+1.2500E+01+4.6875E-02+5.0000E+00+1.0000E+01
20	+2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
21	+9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04

TABLE 7. INPUT DATA CARD SET FOR EXAMPLE 3 (REVISION 1)

```
                                COLUMN NUMBER
                                1         2         3         4         5         6         7         8
CARD        12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
NUMBER
  1         1601
  2         LAB_ESP:_SCA=82FT2/1000ACFM;CALCULATED_V-I_FOR_EACH_ELECTRICAL_SECTION
  3         02010215150100010101 02
  4         1020
  5         2002210102
  6         0.065___10.0____99.0____1000.0__5.1_____1.03____0.0001651.0_____1500000.1.00E+09
  7         0.000.004.000.100.104.00
  8         0.20____0.30____0.40____0.50____0.60____0.80____1.00____1.20____1.40____1.80
  9         2.20____3.0_____4.0_____6.0_____10.0____20.0
 10         0.0_____0.0076__0.0563__0.2682__0.8652__2.9845__5.9695__9.5515__12.835__19.7004
 11         26.8643_38.8042_49.2516_64.1765_79.1014_100.0
 12         03060612
 13         +6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
 14         +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 15         +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
 16         +6.2500E+00+4.0800E+04+6.2500E-05+6.2500E+00+4.6875E-02+5.0000E+00+5.0000E+00
 17         +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 18         +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
 19         +1.2500E+01+3.9600E+04+1.2500E-04+1.2500E+01+4.6875E-02+5.0000E+00+1.0000E+01
 20         +2.5000E+00+3.0533E+02+4.8853E+00+7.6000E+01+1.0000E+00+1.8000E-05+4.1667E-01
 21         +9.0000E-01+6.0000E-05+2.0000E-05+2.0000E-05+3.8000E+04
```

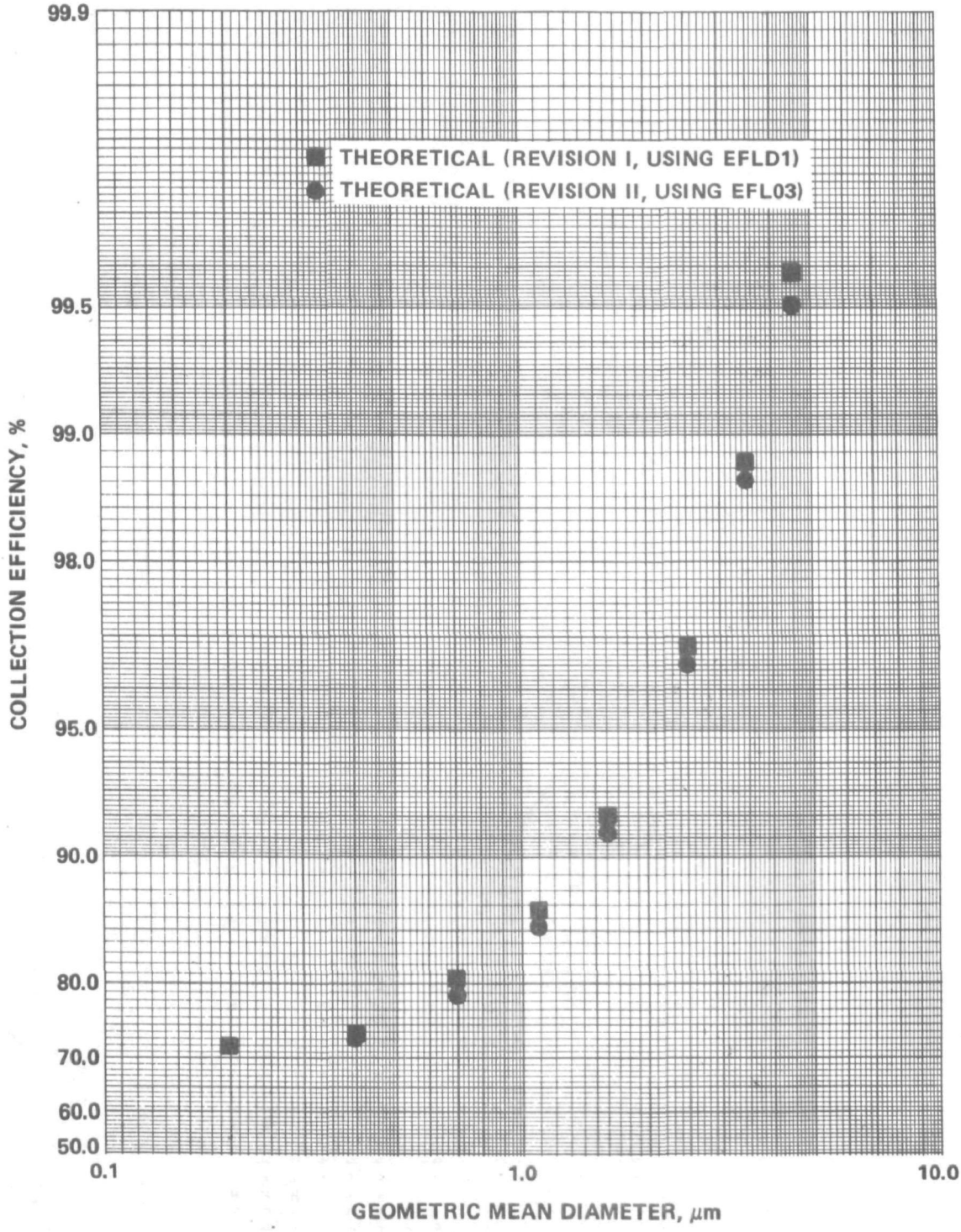

Figure 16. Comparison of fractional collection efficiencies computed from Revision I of the model using the estimation procedure and the parameters in example 2 with the corresponding calculations in Revision II using the approximations.

TABLE 8. INPUT DATA CARD SET FOR EXAMPLE 4

```
                                                  COLUMN NUMBER
                         1                   2                   3                   4                   5                   6                   7                   8
CARD      1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
NUMBER
  1       1 4 0 1
  2       F U L L - S C A L E , C O L D - S I D E _ E S P : _ P L A N T _ A ; _ S C A = 2 4 3 F T 2 / 1 0 0 0 A C F M ; J = 1 5 . 9 U A / F T 2
  3       0 1 0 1 0 3 1 0 1 0 0 3 0 0 0 1 0 1 0 1 0 2
  4       0 5 0 3
  5       1 . 9 6 6 _ _ _ 2 7 . 0 _ _ _ _ 9 9 . 6 _ _ _ _ 2 2 7 0 . 0 _ _ 1 0 0 . 0 _ _ _ 1 . 2 _ _ _ _ _ 0 . 0 0 0 2 2 _ 1 . 0 _ _ _ _ _ 1 5 0 0 0 0 0 . 5 . 0 0 E + 1 0
  6       0 . 0 0 0 . 0 0 3 . 0 0 0 . 1 0 0 . 2 5 3 . 0 0
  7       0 . 1 0 _ _ _ _ 0 . 3 0 _ _ _ _ 0 . 5 0 _ _ _ _ 0 . 9 0 _ _ _ _ 1 . 3 0 _ _ _ _ 1 . 9 0 _ _ _ _ 3 . 1 0 _ _ _ _ 3 . 9 0 _ _ _ _ 5 . 1 0 _ _ _ _ 6 . 9 0
  8       1 0 . 1 0 _ _ _ 1 4 . 9 0 _ _ _ 2 5 . 1 0 _ _ _ 2 9 . 9 0
  9       0 . 0 _ _ _ _ _ 0 . 0 3 3 _ _ _ 0 . 2 8 6 _ _ _ 1 . 1 8 9 _ _ _ 2 . 0 0 4 _ _ _ 3 . 5 2 4 _ _ _ 7 . 0 4 8 _ _ _ 8 . 7 0 _ _ _ _ 1 0 . 3 5 2 _ _ 1 2 . 3 3 4
 10       1 5 . 6 3 8 _ _ 2 0 . 4 8 4 _ _ 3 2 . 5 9 9 _ _ 1 0 0 . 0
 11       0 3 1 0 1 0 1 0
 12       + 2 . 6 4 6 0 E + 0 4 + 4 . 0 6 0 0 E + 0 4 + 2 . 7 3 0 0 E - 0 1 + 1 . 5 7 2 0 E + 0 4 + 8 . 2 5 0 0 E - 0 2 + 5 . 5 0 0 0 E + 0 0 + 1 . 2 0 0 0 E + 0 1
 13       + 3 . 6 2 5 0 E + 0 0 + 3 . 2 7 2 4 E + 0 5 + 4 . 1 0 0 0 E + 0 0 + 3 . 1 5 0 0 E + 0 2 + 1 . 0 0 0 0 E + 0 0 + 2 . 2 9 0 0 E - 0 5 + 9 . 0 0 0 0 E - 0 1
 14       + 2 . 6 4 6 0 E + 0 4 + 4 . 2 1 0 0 E + 0 4 + 4 . 3 3 0 0 E - 0 1 + 1 . 5 7 2 0 E + 0 4 + 8 . 2 5 0 0 E - 0 2 + 5 . 5 0 0 0 E + 0 0 + 1 . 2 0 0 0 E + 0 1
 15       + 3 . 6 2 5 0 E + 0 0 + 3 . 2 7 2 4 E + 0 5 + 4 . 1 0 0 0 E + 0 0 + 3 . 1 5 0 0 E + 0 2 + 1 . 0 0 0 0 E + 0 0 + 2 . 2 9 0 0 E - 0 5 + 9 . 0 0 0 0 E - 0 1
 16       + 2 . 6 4 6 0 E + 0 4 + 4 . 2 4 5 0 E + 0 4 + 5 . 5 8 0 0 E - 0 1 + 1 . 5 7 2 0 E + 0 4 + 8 . 2 5 0 0 E - 0 2 + 5 . 5 0 0 0 E + 0 0 + 1 . 2 0 0 0 E + 0 1
 17       + 3 . 6 2 5 0 E + 0 0 + 3 . 2 7 2 4 E + 0 5 + 4 . 1 0 0 0 E + 0 0 + 3 . 1 5 0 0 E + 0 2 + 1 . 0 0 0 0 E + 0 0 + 2 . 2 9 0 0 E - 0 5 + 9 . 0 0 0 0 E - 0 1
```

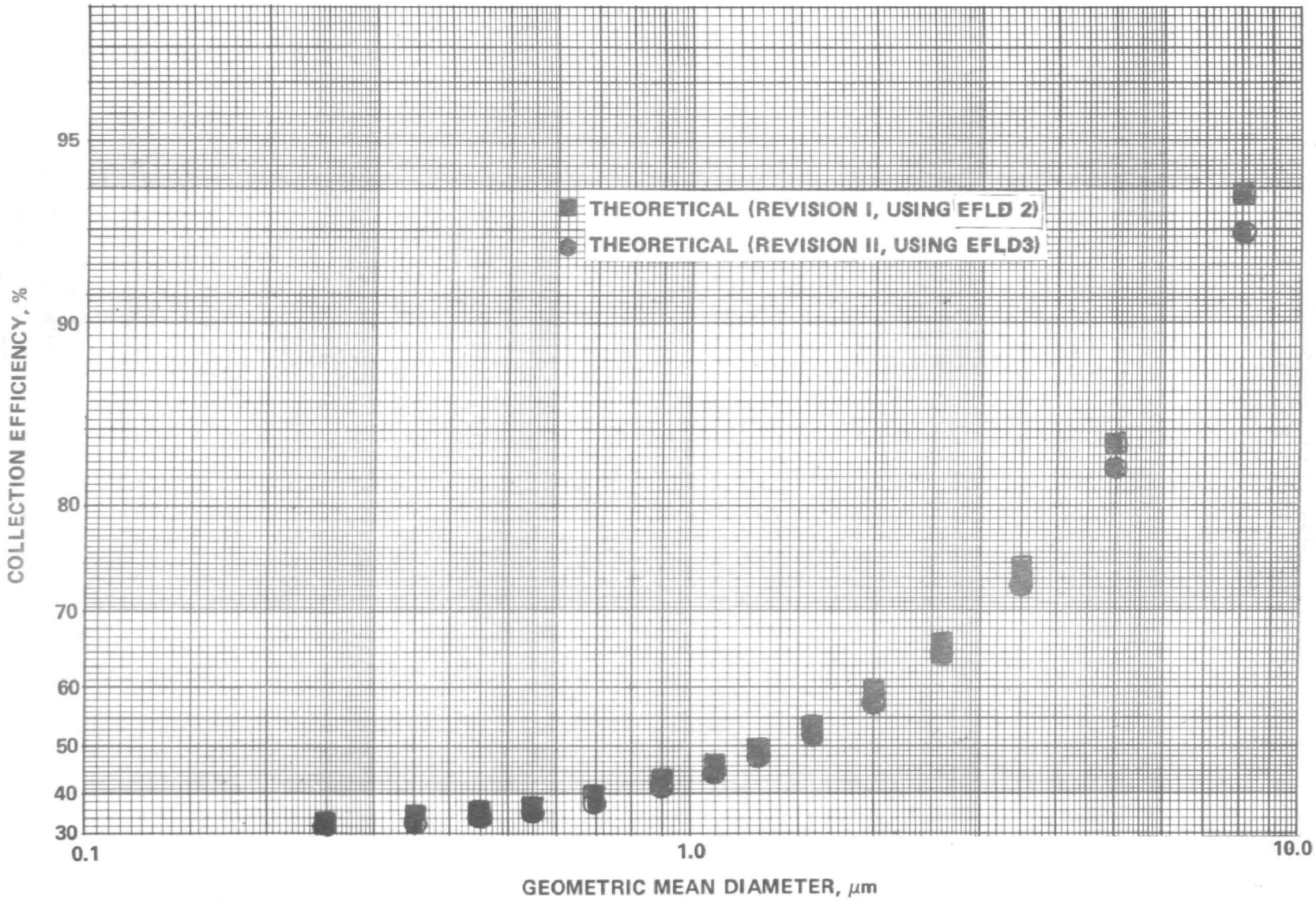

Figure 17. Comparison of fractional collection efficiencies computed from Revision I of the model using measured electrical conditions from a full-scale, cold-side precipitator with those computed from Revision II of the model using the approximations.

report. The purpose of the comparisons made here is to establish that the modifications to the model described in this report do not significantly alter the predictions made by the model. Since the modifications lead to significant savings in computer time without changing the final results appreciably their use is justified.

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APPENDIX A

LISTING OF EFLD3

```
      SUBROUTINE EFLD3 (UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACONTY,NWIRE,NEC,EBD,JI1,JI2)
C  EVALUATION OF FIELDS, SPACE CHARGE DENSITY, POTENTIAL , AND
C  CURRENT DENSITY FOR A WIRE-PLATE PRECIPITATOR
      REAL NWIRE,MAXS,MOBILT(15,15)
      LOGICAL LTEST
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CONSTY(15,15),V(15,15),EY(15,15),EAVGS(30),CHFIDS(30),ECOLLS(30)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK9/ECOLL(30)
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO,V,EX,EY
      DATA OLDRO/225*0./,OLDV/225*0./,CONSTY/225*0./,MOBILT/225*0./
      COSH(Z)=(EXP(Z)+EXP(-Z))/2.
      SINH(Z)=(EXP(Z)-EXP(-Z))/2.
      VO=-1.*VO
      VW=-1.*VSTART
      RO=AC
      RELD=(293./TDK)*(P/1.)
      ROC=100.*RO
      EORO=ROC*RF*(30.*RELD+9.*SQRT(RELD/ROC))*1.E+03
      DO 550 I=1,NX
      DO 550 J=1,NY
      MOBILT(I,J)=UEQ
  550 CONTINUE
      PI=3.1416
      EPSO=8.854E-12
      SSTART=START
      MAXS=0.
      NX1=NX-1
      NY1=NY-1
      R=0.975
      TVCK=0
      FC=AC
      DO 1001 II=1,IFINAL
      IF(II.EQ.JI1) START=DSTART
      IF(II.GE.JI2) START=CSTART
      MAXS=MAXS+START
 1526 CONTINUE
      IF((.NOT.LTEST).AND.(NVII.EQ.2))ACONTY=MAXS
      A1=PI/2./SX
      B1=2.*ACONTY/EPSO/MOBILT(NX1,1)
      B1R=SQRT(ABS(B1))
      C1=B1*SY/PI
      R1=R*SY
      VWIR=0.
      EXWIR=0.
      EYWIR=0.
      E1=0.
      E2=0.
      E3=0.
      F1=0.
      F2=0.
      NW=NWIRE
      SUM1=0.
      SIG1=0.
      DO 3401 I=1,NW
      RM=I
```

```
      CH=COSH(RM*PI*SY/SX)
      SIG1=SIG1+CH/(CH*CH-COS(A1*AC)*COS(A1*AC))
      SUM1=SUM1+ALOG(ABS((CH-COS(A1*AC))/(CH+COS(A1*AC))))
 3601 CONTINUE
      SUMW=2.*SUM1
      POT1=1./(1./SIN(A1*AC)/SIN(A1*AC)+2.*SIG1)
      SUM1=2.*SUM1+ALOG(ABS((1.-COS(A1*AC))/(1.+COS(A1*AC))))
      IF(R1.GT.SX)R1=SX
      SQON=R1*R1+4.*SX*(SX-R1)
      SQOP=R1*R1+4.*SX*(SX+R1)
      RNN=R1*(2.*SX-R1)
      RNP=R1*(2.*SX+R1)
      ARGR=PI*R1/SX/2.
      FAC1=1.
      IF(R1.LE.SY) GO TO 60
      CALL ARCCOS(SY,R1,ACOS)
      DUM=-ACOS+SY*SQRT(ABS(R1*R1-SY*SY))/R1/R1
      FAC1=(1.+2.*DUM/PI)
      ICOUNT=0
   60 CONTINUE
      EO=EORO/AC
      RLAM=SX*EO*POT1*SUM1/PI/SIN(A1*AC)
      RAD=SQRT(ABS(1.-C1/EO/EO))
      RASX=SQRT(ABS(1.+C1*(SX*SX-AC*AC)/EORO/EORO))
      RAR1=SQRT(ABS(1.+C1*(R1*R1-AC*AC)/EORO/EORO))
      RONSP=R1/(2.*B1*SY/PI/EORO/RAR1+(RAR1-1.)*EORO*(1./SQON+1./SQOP))
     1/(2.*R1*SY/PI/EORO/RAR1+(RAR1-1.)*EORO*(1./SQON+1./SQOP))
      CLAM=EORO*SX*SIN(PI*R1/2./SX)*(2.+R1*(2.*SX-R1)/(R1*R1
     1+4.*SX*(SX-R1))-R1*(2.*SX+R1)/(R1*R1+4.*SX*(SX+R1)))/PI/R1/2.
     2  *(RAR1-1.)
      WLAM=CLAM*FAC1
      VNAUT=CLAM*ALOG(ABS((1.-COS(A1*R1))/(1.+COS(A1*R1))))
     1 -2.*R1R*(SX-R1)*SQRT(ABS(SX-R1))/3.
      VT=VNAUT-EORO*(RAR1-1.  +(RAD-1.)*ALOG(R1/AC)+RAD*ALOG((RAD+1.)/
     1 (RAD+RAR1))+.25*(RAR1-1.)*(ALOG(ABS((AC*AC+4.*SX*(SX-AC))/SQON))
     2 +ALOG(ABS((AC*AC+4.*SX*(SX+AC))/SQOP))))+RLAM+WLAM*SUMW
      IF(NVIT.EQ.1)GO TO 10
      GO TO 30
   10 CONTINUE
      F=VT-VO
      IF(F.EQ.0.)GO TO 30
      IF(ABS(F).LT.1.0E-04*ABS(VO)) GO TO 30
      E3=EORO+0.10*EORO*F/ABS(F)
      IF(F.LT.0.)F1=F
      IF(F.LT.0.)E1=EORO
      IF(F.GT.0.)F2=F
      IF(F.GT.0.)E2=EORO
      IF(F1*F2.LT.0.)E3=(E1*F2-E2*F1)/(F2-F1)
      EORO=E3
      ICOUNT=ICOUNT+1
      IF(ICOUNT.EQ.100)WRITE(NPRNT,  31)
   31 FORMAT(10X,'THE APPLIED POTENTIAL COULD NOT BE MATCHED IN
     1 '100 ITERATIONS'/)
      IF(ICOUNT.GT.100)GO TO 30
      GO TO 60
   30 CONTINUE
      V(1,1)=VT
      CALL CMAN(RLAM,NX,NY,SX,SY,PI,AC,NWIRE)
      X=0.
      DO 3100 I11=1,NX
```

```
      IF(NVII.EQ.1)I11=NX
      Y=0.
      DO 3800 I12=1,NY
      IF(LTEST)X=X1(I11)
      IF(LTEST)Y=Y1(I12)
      IF(NVII.EQ.1)X=SX
      X1(I11)=X
      Y1(I12)=Y
      B1=2.*ACONTY/EPSO/MOBILT(I11,I12)
      B1R=SQRT(ABS(B1))
      C1=B1*SY/PI
      IF((I11.EQ.1).AND.(I12.EQ.1))X=AC
      SQRN=SQON+Y*Y
      SQRP=SQOP+Y*Y
      SQXN=X*X+Y*Y+4.*SX*(SX-X)
      SQXP=X*X+Y*Y+4.*SX*(SX+X)
      ARGX=PI*X/SX/2.
      ARGY=PI*Y/SX/2.
      RAXY=SQRT(ABS(1.+C1*(X*X+Y*Y-AC*AC)/EORO/EORO))
      RASXY=SQRT(ABS(1.+C1*(SX*SX+Y*Y-AC*AC)/EORO/EORO))
      RAR1Y=SQRT(ABS(1.+C1*(R1*R1+Y*Y-AC*AC)/EORO/EORO))
      COSHY=COSH(A1*Y)
      SINHY=SINH(A1*Y)
      CX=COS(A1*X)
      IF(X.GT.1.00001 *R1) GO TO 3860
      VXYJ=-EORO*(RAR1Y-RAXY+(RAD-1.)*ALOG(SQRT(ABS((R1*R1+Y*Y)/
     1(X*X+Y*Y))))+RAD*ALOG(ABS((RAD+RAXY)/(RAD+RAR1Y)))+(RAR1Y-1.)*
     2 (ALOG(ABS(SQXN/SQRN))+ALOG(ABS(SQXP/SQRP)))/4.)+VNAUT
      EXJ=-EORO*((RAXY-1.)*X/(X*X+Y*Y)-(RAR1 -1.)*((X-2.*SX)/SQXN
     1 +(X+2.*SX)/SQXP)/2.)
      EYJ=-EORO*((RAXY -1.)*Y/(X*X+Y*Y)-(RAR1Y-1.)*Y/(R1*R1+Y*Y)
     1 -(RAR1 -1.)*(Y/SQXN+Y/SQXP-Y/SQRN-Y/SQRP)/2.)
      RHOJ=-EPSO*C1/EORO/RAXY
     1  *1./(1.+((Y+1.E-09)/SY)**9*2.20)/(1.+.162*Y/SY)
     2 -EPSO*EORO*(RAXY-1.)/2.*((SQON-Y*Y)/SQRN/SQRN+(SQOP-Y*Y)/
     3   SQRP/SQRP)*0.9
      GO TO 3861
3860  CONTINUE
      VXYJ=CLAM*ALOG(ABS((COSHY-CX)/(COSHY+CX)))
     1+2.*R1R*((X-R1)*SQRT(ABS(X-R1))-(SX-R1)*SQRT(ABS(SX-R1)))/3.
      EXJ=-CLAM*PI*SIN(A1*X)*COSHY/SX/(COSHY*COSHY-CX*CX)
     1 -B1R*SQRT(ABS(X-R1))
      EYJ=-CLAM*PI*CX*SINHY/SX/(COSHY*COSHY-CX*CX)
      RHOJ=-EPSO*B1R/2./SQRT(ABS(X-R1+RONSP))
     1  *1./(1.+((Y+1.E-09)/SY)**9*2.33)/(1.+0.75*Y/SY)
3861  CONTINUE
      SUMV=0.
      SUMEX=0.
      SUMEY=0.
      COSX=COS(PI*X/2./SX)
      SINX=SIN(PI*X/2./SX)
      DO 100 I=1,NW
      RI=I
      COSHN=COSH(PI*(Y-2.*RI*SY)/2./SX)
      COSHP=COSH(PI*(Y+2.*RI*SY)/2./SX)
      SINHN=SINH(PI*(Y-2.*RI*SY)/2./SX)
      SINHP=SINH(PI*(Y+2.*RI*SY)/2./SX)
      DENON=COSHN*COSHN-COSX*COSX
      DENOP=COSHP*COSHP-COSX*COSX
      TERMV=ALOG(ABS((COSHN-COSX)/(COSHN+COSX)))
```

```
     1 +ALOG(ABS(((COSHP-COSX)/(COSHP+COSX)))
      SUMV=SUMV+TERMV
      TEREX=COSHN/DENON+COSHP/DENOP
      SUMEX=SUMEX+TEREX
      TEREY=SINHN/DENON+SINHP/DENOP
      SUMEY=SUMEY+TEREY
  100 CONTINUE
      VWIR=WLAM*SUMV
      EXWIR=-PI*WLAM*SINX*SUMEX/SX
      EYWIR=-PI*WLAM*COSX*SUMEY/SX
      VXYJ=VXYJ+VWIR
      EXJ=EXJ+EXWIR
      EYJ=EYJ+EYWIR
      V(I11,I12)=VXYJ+VCOOP(I11,I12)
      EX(I11,I12)=EXJ+ECX(I11,I12)
      EY(I11,I12)=EYJ+ECY(I11,I12)
      RHO(I11,I12)=RHOJ
      IF((I11.EQ.1).AND.(I12.EQ.1))X=0.
      Y=Y+SY/FLOAT(NY1)
 3800 CONTINUE
      X=X+SX/FLOAT(NX1)
 3100 CONTINUE
 3150 CONTINUE
      VW=V(1,1)
      EPLT=0.
      DO 1200 J=2,NY
      IF(LTEST)EPLT=EPLT+(EX(NX,J)+EX(NX,J-1))*AY(J-1)/2.
      IF(.NOT.LTEST) EPLT=
     1      EPLT+(EX(NX,J)+EX(NX,J-1))*SY/FLOAT(NX1)/2.
 1200 CONTINUE
      AEPLT=EPLT/SY
      IF(NVII.EQ.2)WRITE(NPRNT,8888) VW,ACONTY,AEPLT
 8888 FORMAT(3X,'VW = ',1PE11.4,2X,'ACONTY = ',1PE11.4,2X,'AEPLT = ',1P
     1E11.4//)
      IF(ABS(EX(NX,1)).LT.EBD) GO TO 1480
      WRITE(NPRNT,1481) VW,ACONTY
 1481 FORMAT(' THE BREAKDOWN FIELD NEAR THE PLATE IS EXCEEDED AT VW =',E
     111.4,1X,'AND ACONTY =',E11.4)
      GO TO 1525
 1480 CONTINUE
      IF(IVCK.EQ.1) GO TO 1525
      IF(ABS(VW).EQ.ABS(VO)) GO TO 1525
      IF(ABS(VW).GT.ABS(VO)) GO TO 1523
      OLDVW=VW
      OLDCO=ACONTY
      GO TO 1524
 1523 CONTINUE
      MAXS=ACONTY-((ACONTY-OLDCO)/(VW-OLDVW))*(VW-VO)
      VW=OLDVW
      IVCK=1
      GO TO 1526
 1524 CONTINUE
 1001 CONTINUE
 1525 CONTINUE
      IF(NFC.NE.0) GO TO 3000
      K=1
      DO 3001 J=1,NY1
      RSUM=0.
      ESUM=0.
      DO 3002 I=1,NX
```

```
      IF(J.EQ.1) GO TO 3005
      ESUM=ESUM+(SQRT(EX(I,J)**2+EY(I,J)**2)+SQRT(EX(I,J+1)**2+
     1EY(I,J+1)**2))/(2.*NX)
      GO TO 3006
 3005 CONTINUE
      ESUM=ESUM+SQRT(EX(I,J+1)**2+EY(I,J+1)**2)/(2.*NX)
      IF(I.EQ.NX) ESUM=ESUM-VO/(2.*8X)
 3006 CONTINUE
      RSUM=RSUM-(RHO(I,J)+RHO(I,J+1))/(2.*1.6E-19*NX)
 3002 CONTINUE
      EAVGS(K)=ESUM
      CHFIDS(K)=RSUM
      K=K+1
 3001 CONTINUE
      NYY=NY1
      DO 3003 L=1,NY1
      EAVG(L)=EAVGS(NYY)
      CHFID(L)=CHFIDS(NYY)
      NYY=NYY-1
 3003 CONTINUE
      KK=1
      M1=NY1+1
      M2=2*NY1
      DO 3004 M=M1,M2
      EAVG(M)=EAVGS(KK)
      CHFID(M)=CHFIDS(KK)
      KK=KK+1
 3004 CONTINUE
 3000 CONTINUE
      LL=1
      DO 3007 NN=1,NY1
      ECOLLS(LL)=-(EX(NX,NN)+EX(NX,NN+1))/2.
      LL=LL+1
 3007 CONTINUE
      L1=NY1
      DO 3008 L=1,NY1
      ECOLL(L)=ECOLLS(L1)
      L1=L1-1
 3008 CONTINUE
      L2=1
      I1=NY1+1
      I2=2*NY1
      DO 3009 I=I1,I2
      ECOLL(I)=ECOLLS(L2)
      L2=L2+1
 3009 CONTINUE
      VO=-1.*VO
      START=SSTART
      RETURN
      END
PROG > 4K
```

APPENDIX B

LISTING OF CMAN

```
      SUBROUTINE CMAN (VW,NX,NY,SX,SY,PI,AC,NWIRE)
C   COOPERMAN SERIES DETERMINATION FOR VOLTAGE WIRE TO PLATE
C   FOR SUBROUTINE EFIELD
      REAL NUM,M,NWIRE
      LOGICAL LTEST
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO(15,15),V(15,15),EX(15,15),EY(15,15)
      NX1=NX-1
      NY1=NY-1
      DO 402 I=1,NX
      IF(NVII-1)301,300,301
  300 I=NX
  301 CONTINUE
      DO 430 J=1,NY
      X=FLOAT(I-1)*SX/FLOAT(NX1)
      IF(LTEST)X=X1(I)
      Y=FLOAT(J-1)*SY/FLOAT(NY1)
      IF(LTEST)Y=Y1(J)
      IF(X.EQ.0..AND.Y.EQ.0.)GO TO 440
      GO TO 450
  440 VCOOP(I,J)=VW
      GO TO 430
  450 CONTINUE
      M=-NWIRE
      NUM=0.0
      DENOM=0.0
      EX0=0.
      EY0=0.
      EXSUM=0.
      EYSUM=0.
  490 E1=PI*(Y-(2.*M*SY))/(2.*SX)
      F1=PI*X/(2.*SX)
      G1=PI*M*SY/SX
      H1=PI*AC/(2.*SX)
      E2=(EXP(E1)+EXP(-E1))/2.
      F2=COS(F1)
      G2=(EXP(G1)+EXP(-G1))/2.
      H2=COS(H1)
      TT=(E2-F2)/(E2+F2)
      TB=(G2-H2)/(G2+H2)
      F=ALOG(TT)
      G=ALOG(TB)
      NUM=NUM+F
      DENOM=DENOM+G
      H3=SIN(H1)
      F3=SIN(F1)
      E3=(EXP(F1)-EXP(-E1))/2.
      G3=(EXP(G1)-EXP(-G1))/2.
      SUMX=F3/(E2-F2)+F3/(E2+F2)
      SUMY=E3/(E2-F2)-E3/(E2+F2)
      S1=H3/(G2-H2)+H3/(G2+H2)
      S2=G3/(G2-H2)-G3/(G2+H2)
      EXSUM=EXSUM+SUMX
      EYSUM=EYSUM+SUMY
      EX0=EX0+S1
      EY0=EY0+S2
      IF(M.LT.NWIRE) GO TO 408
      GO TO 410
  408 M=M+1.0
```

```
      GO TO 490
  410 VCOOP(I,J)=VW*NUM/DENOM
      ECX(I,J)=-(PI*VW/2./SX/DENOM)*FXSUM
      ECY(I,J)=-(PI*VW/2./SX/DENOM)*FYSUM
  430 CONTINUE
  402 CONTINUE
  404 CONTINUE
      ECX(1,1)=-(PI*VW/2./SX/DENOM)*FX0
      ECY(1,1)=-(PI*VW/2./SX/DENOM)*FY0
      RETURN
      END
```

APPENDIX C

LISTING OF EFLD4

```
      SUBROUTINE EFLD4 (UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACDNTY,NWIRE,NEC,EBD,JI1,JI2)
C  EVALUATION OF FIELDS, SPACE CHARGE DENSITY, POTENTIAL , AND
C  CURRENT DENSITY FOR A WIRE-PLATE PRECIPITATOR
      REAL NWIRE,MAXS,MOBILT(15,15)
      LOGICAL LTEST
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CDNSTY(15,15),V(15,15),EY(15,15),EAVGS(30),CHFIDS(30),ECOLLS(30)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK9/ECOLL(30)
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO,V,EX,EY
      DATA OLDRO/225*0./,OLDV/225*0./,CDNSTY/225*0./,MOBILT/225*0./
      NPRNT=6
      NPRNT=3
      NVII=2
      NVII=1
      IVCK=0
      VO=-1.*VO
      VW=-1.*VSTART
      RO=AC
      RELD=(293./TDK)*(P/1.)
      ROC=100.*RO
      RC=(ROC*RF*(30.*RELD+9.*SQRT(RELD/ROC)))/30.
      RC=RC/100.
      RC=AC
      EORO=ROC*RF*(30.*RELD+9.*SQRT(RELD/ROC))*1.E+03
      EO=EORO/AC
      DO 550 I=1,NX
      DO 550 J=1,NY
      MOBILT(I,J)=UEQ
  550 CONTINUE
      SSTART=START
      NITER=25
      NVITER=4000
      COEF=0.04
      VCK=0.05
      TESCF=0.005
      X1(1)=0.
      Y1(1)=0.
      PI=3.1416
      EPSO=8.854E-12
      ACDNTY=START
      MAXS=0.
      NX1=NX-1
      NY1=NY-1
      NX2=NX-2
      NY2=NY-2
      NX3=NX-3
      AX1=(SX-2.*RC)/FLOAT(NX3)
      AY1=(SY-RC)/FLOAT(NY2)
```

```
      BX=2.*(SX-2.*RC)/RC/FLOAT(NX3)/FLOAT(NX2)
      BY=2.*(SY-RC)/RC/FLOAT(NY2)/FLOAT(NY1)
      DO 2000 I=1,NX
      RI=I-1
      AX(I)=RI*BX*RC
      AX(1)=RC
      AX(1)=AC
      AX(NX1)=RC
      AX(NX)=AX(NX1)
      IF(I.EQ.1)GO TO 2000
      X1(I)=X1(I-1)+AX(I-1)
 2000 CONTINUE
      DO 2001 J=1,NY
      RJ=J-1
      AY(J)=RJ*BY*RC
      AY(1)=RC
      AY(1)=AC
      AY(NX)=AY(NX1)
      IF(J.EQ.1)GO TO 2001
      Y1(J)=Y1(J-1)+AY(J-1)
 2001 CONTINUE
      VA=ABS(VO)
      V1=ABS(VW)
      IFINA1=1
      LTEST=.TRUE.
      CALL EFLD3(UEQ,AC,VA,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINA1,VSTART,V1,ACDNTY,NWIRE,NEC,EBD,JI1,JI2)
      WRITE(NPRNT,3555)
 3555 FORMAT(1H1,10X,'ELECTROSTATIC SOLUTION AT CURRENT ONSET'//)
      CALL ENTER2(NX,NY)
      WRITE(NPRNT,8888) V(1,1),ACDNTY,AEPLT
      DO 1001 II=1,IFINAL
      IF(II.EQ.JI1) START=DSTART
      IF(II.GE.JI2) START=CSTART
      MAXS=MAXS+START
      ACDNTY=MAXS
 1526 CONTINUE
      QZERO=-2.*MAXS*SY*1.0E-03/(PI*UEQ*ROC*RF*(30.*RELD+9.*SQRT(RELD
     1/ROC)))
      VA=ABS(VO)
      V1=ABS(VW)
      IFINA1=1
      CALL EFLD3(UEQ,AC,VA,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINA1,VSTART,V1,ACDNTY,NWIRE,NEC,EBD,JI1,JI2)
      V(1,2)=V(1,1)
      V(2,1)=V(1,1)
      VW=V(1,1)
      WRITE(NPRNT,3560) ACDNTY
 3560 FORMAT(1H1,10X,'APPROXIMATE SOLUTION FOR CURRENT DENSITY OF ',
     1 1PE12.3,2X,'AMPS PER SQUARE METER'//)
      CALL OUTPUT(NX,NY)
      WRITE(NPRNT,8888) V(1,1),ACDNTY,AEPLT
      GO TO 1001
      Z=0
    2 CONTINUE
      F1=0.
      F2=0.
      V1=0.
      V2=0.
      V3=0.
```

```
    1 Z=Z+1
      IZ=Z
      IF(IZ.EQ.NITER) WRITE(NPRNT,1865)  NITER
 1865 FORMAT(1X,' CONVERGENCE ON CURRENT DENSITY CAN NOT BE OBTAINED IN'
     1 ,  I6,'  ITERATIONS')
      IF(IZ.EQ.NITER) GO TO 700
      LL=0
  300 LL=LL+1
      DO 315 I=1,NX1
      DO 315 J=1,NY
      OLDV(I,J)=V(I,J)
      OLDRO(I,J)=RHO(I,J)
  315 CONTINUE
      RHO(1,2)=QZERO
      RHO(2,1)=QZERO
      EX(2,1)=EO
      EY(1,2)=EO
      DO 301 I=1,NX
      DO 301 J=1,NY
      IF(I.EQ.1) GO TO 800
      IF(I.EQ.NX) GO TO 806
      AXS=AX(I-1)*AX(I)
      AXSUM=AX(I-1)+AX(I)
      AXS1=AX(I-1)*AX(I-1)
      AXS2=AX(I)*AX(I)
      GO TO 801
  806 CONTINUE
      AXS=AX(I-1)*AX(I-1)
      AXSUM=AX(I-1)+AX(I-1)
      AXS1=AXS
      AXS2=AXS
      GO TO 801
  800 CONTINUE
      AXS=AX(I)*AX(I)
      AXSUM=AX(I)+AX(I)
      AXS1=AX(1)*AX(1)
      AXS2=AX(1)*AX(1)
  801 CONTINUE
      IF(J.EQ.1) GO TO 802
      IF(J.EQ.NY) GO TO 803
      AYS=AY(J-1)*AY(J)
      AYSUM=AY(J-1)+AY(J)
      AYS1=AY(J-1)*AY(J-1)
      AYS2=AY(J)*AY(J)
      GO TO 804
  802 CONTINUE
      AYS=AY(J)*AY(J)
      AYSUM=AY(J)+AY(J)
      AYS1=AY(1)*AY(1)
      AYS2=AY(1)*AY(1)
      GO TO 804
  803 CONTINUE
      AYS=AY(J-1)*AY(J-1)
      AYSUM=AY(J-1)+AY(J-1)
      AYS1=AY(NY-1)*AY(NY-1)
      AYS2=AY(NY-1)*AY(NY-1)
  804 CONTINUE
      ASP=(AXS*AYS)/EPSO
      ASS=1./(2.*(AXS+AYS))
      IF((I.EQ.1.AND.J.LE.2).OR.(J.EQ.1.AND.I.LE.2)) GO TO 301
```

```
      IF(I.EQ.1.AND.J.NE.1) GO TO 304
      IF(I.EQ.NX) GO TO 340
      IF(I.NE.1.AND.J.EQ.1) GO TO 305
      IF(J.EQ.NY) GO TO 600
      GO TO 306
  600 V(I,NY)=ASS*((2.*AYS*(AX(I-1)*V(I+1,NY)+AX(I)*V(I-1,NY)))/AXSUM+
     12.*AXS*V(I,NY-1)+ASP*RHO(I,NY))
      EX(I,NY)=-(V(I+1,NY)*AX(I-1)*AX(I-1)-V(I-1,NY)*AX(I)*AX(I)-V(I,NY)
     1*(AX(I-1)*AX(I-1)-AX(I)*AX(I)))/(AX(I-1)+AX(I))/AX(I-1)/AX(I)
      EY(I,NY)=0.
      ALPHA=EPSO*(2.*AY(J-1)*EX(I,J)*MOBILT(I,J)+2.*AX(I-1)*EY(I,J)*
     1MOBILT(I,J)-AY(J-1)*EX(I,J)*MOBILT(I-1,J)-AX(I-1)*EY(I,J)*
     2MOBILT(I,J-1))/2./AX(I-1)/AY(J-1)/MOBILT(I,J)
      BETA=-EPSO*(AY(J-1)*EX(I,J)*RHO(I-1,J)+AX(I-1)*EY(I,J)*RHO(I,J-1))
     1  /AX(I-1)/AY(J-1)
      GO TO 302
  304 IF(I.EQ.1.AND.J.EQ.NY)  GO TO 350
      V(1,J)=ASS*(2.*AYS*V(2,J)+(2.*AXS*(AY(J)*V(1,J-1)+AY(J-1)*V(1,J+1)
     1))/AYSUM+ASP*RHO(1,J))
      EX(1,J)=0.
      EY(1,J)=-(V(1,J+1)*AY(J-1)*AY(J-1)-V(1,J-1)*AY(J)*AY(J)-V(1,J)
     1*(AY(J-1)*AY(J-1)-AY(J)*AY(J)))/(AY(J-1)+AY(J))/AY(J-1)/AY(J)
      ALPHA=EPSO*(2.*AY(J-1)*EX(I,J)*MOBILT(I,J)+2.*AX(1)*EY(I,J)*
     1MOBILT(I,J)-AY(J-1)*EX(I,J)*MOBILT(1,J)-AX(1)*EY(I,J)*
     2MOBILT(I,J-1))/2./AX(1)/AY(J-1)/MOBILT(I,J)
      BETA=-EPSO*(AY(J-1)*EX(I,J)*RHO(1,J)+AX(1)*EY(I,J)*RHO(I,J-1))
     1  /AX(1)/AY(J-1)
      GO TO 302
  350 V(1,NY)=ASS*(2.*AYS*V(2,NY)+2.*AXS*V(1,NY-1)+ASP*RHO(1,NY))
      EX(1,NY)=0.
      EY(1,NY)=0.
      GO TO 301
  305 V(I,1)=ASS*((2.*AYS*(AX(I-1)*V(I+1,1)+AX(I)*V(I-1,1)))/AXSUM+2.*
     1AXS*V(I,2)+ASP*RHO(I,1))
      EX(I,1)=-(V(I+1,1)*AX(I-1)*AX(I-1)-V(I-1,1)*AX(I)*AX(I)-V(I,1)*
     1(AX(I-1)*AX(I-1)-AX(I)*AX(I)))/(AX(I-1)+AX(I))/AX(I-1)/AX(I)
      EY(I,1)=0.
      ALPHA=EPSO*(2.*AY(1)*EX(I,J)*MOBILT(I,J)+2.*AX(I-1)*EY(I,J)*
     1MOBILT(I,J)-AY(1)*EX(I,J)*MOBILT(I-1,J)-AX(I-1)*EY(I,J)*
     2MOBILT(I,1))/2./AX(I-1)/AY(1)/MOBILT(I,J)
      BETA=-EPSO*(AY(1)*EX(I,J)*RHO(I-1,J)+AX(I-1)*EY(I,J)*RHO(I,1))
     1  /AX(I-1)/AY(1)
      GO TO 302
  306 V(I,J)=ASS*((2.*AYS*(AX(I-1)*V(I+1,J)+AX(I)*V(I-1,J)))/AXSUM+(2.*
     1AXS*(AY(J)*V(I,J-1)+AY(J-1)*V(I,J+1)))/AYSUM+ASP*RHO(I,J))
      EX(I,J)=-(V(I+1,J)*AX(I-1)*AX(I-1)-V(I-1,J)*AX(I)*AX(I)-V(I,J)*
     1(AX(I-1)*AX(I-1)-AX(I)*AX(I)))/(AX(I-1)+AX(I))/AX(I-1)/AX(I)
      EY(I,J)=-(V(I,J+1)*AY(J-1)*AY(J-1)-V(I,J-1)*AY(J)*AY(J)-V(I,J)*
     1(AY(J-1)*AY(J-1)-AY(J)*AY(J)))/(AY(J-1)+AY(J))/AY(J-1)/AY(J)
      ALPHA=EPSO*(2.*AY(J-1)*EX(I,J)*MOBILT(I,J)+2.*AX(I-1)*EY(I,J)*
     1MOBILT(I,J)-AY(J-1)*EX(I,J)*MOBILT(I-1,J)-AX(I-1)*EY(I,J)*
     2MOBILT(I,J-1))/2./AX(I-1)/AY(J-1)/MOBILT(I,J)
      BETA=-EPSO*(AY(J-1)*EX(I,J)*RHO(I-1,J)+AX(I-1)*EY(I,J)*RHO(I,J-1))
     1  /AX(I-1)/AY(J-1)
      GO TO 302
  340 CONTINUE
      V(NX,J)=0.
      EY(NX,J)=0.
      EX(NX,J)=V(NX1,J)/AX(NX1)
      ALPHA=EPSO*(2.*AY(J-1)*EX(I,J)-AY(J-1)*EX(I,J)*MOBILT(I-1,J)/
```

```
     1  MOBILT(I,J))/2./AX(I-1)/AY(J-1)
      BETA=-EPSO*EX(NX,J)*RHO(NX1,J)/AX(NX1)
  302 CONTINUE
      RHO(I,J)=-ALPHA-SQRT(ABS(ALPHA*ALPHA-BETA))
  301 CONTINUE
      IF(LL.EQ.NVITER) WRITE(NPRNT,1866)  NVITER
 1866 FORMAT(1X,' CONVERGENCE ON POTENTIAL GRID CAN NOT BE OBTAINED IN
     1,I6,'  ITERATIONS ')
      IF(LL.EQ.NVITER) GO TO 700
      DO 320 I=1,NX1
      DO 320 J=1,NY
      IF(ABS(V(I,J)-OLDV(I,J)).LT. VCK) GO TO 320
      GO TO 300
  320 CONTINUE
      CDNSTY(NX,1)=EX(NX,1)*MOBILT(NX,1)*RHO(NX,1)
      ACDNTY=CDNSTY(NX,1)*AY(1)
  950 DO 900 J=2,NY
      CDNSTY(NX,J)=EX(NX,J)*MOBILT(NX,J)*RHO(NX,J)
  900 CONTINUE
      DO 901 J=2,NY1
      ACDNTY=ACDNTY+(CDNSTY(NX,J)+CDNSTY(NX,J+1))*AY(J)/2.
  901 CONTINUE
      ACDNTY=ACDNTY/SY
C        ***************************************************
      IF(ACDNTY.LT.1.0E-08) GO TO 980
C        ***************************************************
 1000 CONTINUE
      F=ACDNTY-MAXS
      TEST=ABS(ACDNTY-MAXS)
      TEST1=TESCF*MAXS
      IF(TEST.LT.TEST1) GO TO 980
      V3=V(2,1)-COEF*V(2,1)*F/ABS(F)
      IF(F.EQ.0.)GO TO 980
      IF(F.LT.0.)F1=F
      IF(F.LT.0.)V1=V(2,1)
      IF(F.GT.0.)F2=F
      IF(F.GT.0.)V2=V(2,1)
      IF(F1*F2.LT.0.)V3=(V1+V2)/2.
      IF(F1*F2.LT.0.)V3=(V1*F2-V2*F1)/(F2-F1)
      WRITE(NPRNT,3710) F,V(2,1),ACDNTY,LL,IZ
 3710 FORMAT(10X,'F=',E11.3,5X,'V(2,1)',E11.3,5X,'ACDNTY=',
     1 E11.3,5X,'LL=',I5,5X,'IZ=',I5)
      V(2,1)=V3
      V(1,2)=V(2,1)
      ARG=ABS(2.*(V2-V1)/(V2+V1))
      FUN=ABS(1.-ACDLST/ACDNTY)
      IF(ARG.LT.1.0E-04.AND.FUN.LT.5.0E-02)GO TO 2
      ACDLST=ACDNTY
      GO TO 1
  980 CONTINUE
      V(1,2)=V(2,1)
      VW=V(2,1)+EO*(RC-AC)
      V(1,1)=VW
      EPLT=0.
      DO 1200 J=2,NY
      EPLT=EPLT+(EX(NX,J)+EX(NX,J-1))*AY(J-1)/2.
 1200 CONTINUE
      AEPLT=EPLT/SY
  700 CONTINUE
      WRITE (NPRNT,3565) ACDNTY
```

```
3565 FORMAT(1H1,10X,'NUMERICALLY INTEGRATED SOLUTION FOR CURRENT DENSIT
    1Y OF',1PE12.3,2X,'AMPS PER SQUARE METER'//)
      CALL OUTPUT(NX,NY)
      WRITE(NPRNT,8888) VW,ACDNTY,AEPLT
8888 FORMAT(38X,'VW = ',1PE11.4,2X,'ACDNTY = ',1PE11.4,2X,'AEPLT = ',1P
    1E11.4//)
      WRITE(NPRNT,3720) LL,IZ
3720 FORMAT(10X,'LL=',I5,5X,'IZ=',I5)
      IF(ABS(EX(NX,1)).LT.EBD) GO TO 1480
      WRITE(NPRNT,1481) VW,ACDNTY
1481 FORMAT(' THE BREAKDOWN FIELD NEAR THE PLATE IS EXCEEDED AT VW =',E
    111.4,1X,'AND ACDNTY =',E11.4)
      GO TO 1525
1480 CONTINUE
      IF(IVCK.EQ.1) GO TO 1525
      IF(ABS(VW).EQ.ABS(VO)) GO TO 1525
      IF(ABS(VW).GT.ABS(VO)) GO TO 1523
      OLDVW=VW
      OLDCD=ACDNTY
      GO TO 1524
1523 CONTINUE
      MAXS=ACDNTY-((ACDNTY-OLDCD)/(VW-OLDVW))*(VW-VO)
      VW=OLDVW
      IVCK=1
      GO TO 1526
1524 CONTINUE
1001 CONTINUE
1525 CONTINUE
      IF(NEC.NE.0) GO TO 3000
      K=1
      DO 3001 J=1,NY1
      RSUM=0.
      ESUM=0.
      DO 3002 I=1,NX
      IF(J.EQ.1) GO TO 3005
      ESUM=ESUM+(SQRT(EX(I,J)**2+EY(I,J)**2)+SQRT(EX(I,J+1)**2+
    1EY(I,J+1)**2))/(2.*NX)
      GO TO 3006
3005 CONTINUE
      ESUM=ESUM+SQRT(EX(I,J+1)**2+EY(I,J+1)**2)/(2.*NX)
      IF(I.EQ.NX) ESUM=ESUM-VO/(2.*SX)
3006 CONTINUE
      RSUM=RSUM-(RHO(I,J)+RHO(I,J+1))/(2.*1.6E-19*NX)
3002 CONTINUE
      EAVGS(K)=ESUM
      CHFIDS(K)=RSUM
      K=K+1
3001 CONTINUE
      NYY=NY1
      DO 3003 L=1,Ny1
      EAVG(L)=EAVGS(NYY)
      CHFID(L)=CHFIDS(NYY)
      NYY=NYY-1
3003 CONTINUE
      KK=1
      M1=NY1+1
      M2=2*NY1
      DO 3004 M=M1,M2
      EAVG(M)=EAVGS(KK)
      CHFID(M)=CHFIDS(KK)
```

```
      KK=KK+1
 3004 CONTINUE
 3000 CONTINUE
      LL=1
      DO 3007 NN=1,NY1
      ECOLLS(LL)=-(EX(NX,NN)+EX(NX,NN+1))/2.
      LL=LL+1
 3007 CONTINUE
      L1=NY1
      DO 3008 L=1,NY1
      ECOLL(L)=ECOLLS(L1)
      L1=L1-1
 3008 CONTINUE
      L2=1
      I1=NY1+1
      I2=2*NY1
      DO 3009 I=I1,I2
      ECOLL(I)=ECOLLS(L2)
      L2=L2+1
 3009 CONTINUE
      VO=-1.*VO
      START=SSTART
      RETURN
      END
```

APPENDIX D

LISTING OF OUTPUT

```
      SUBROUTINE  OUTPUT(NX,NY)
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CDNSTY(15,15),V(15,15),EY(15,15),EAVGS(30),CHFIDS(30),ECOLLS(30)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK9/ECOLL(30)
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO,V,EX,EY
      COMMON/BLK17/NREAD,NPRNT
      COMMON /BLK20/ R ,LVAR,LCMAN ,EORO,EPSO,PI,LINTEG,FAC,NHALF,NVITER
     1,  NITER,VCK,IPOT,COEF,TESCF,RELD,FAC2,VCOR,ECOR
      NPRNT=6
      NPRNT=3
      N2=(NY-1)/9
      N1=NY-8*N2
      WRITE(NPRNT,10) (J,J=1,9)
   10 FORMAT(14X,      9('Y(',I2,')',8X))
      WRITE(NPRNT,11)  (Y1(J),J=1,9)
   11 FORMAT(9X,9(1PE13.3)//)
      DO 292 I=1,NX
      WRITE(NPRNT,30)
     1            I,(RHO(I,J),J=1,9),(V(I,J),J=1,9),X1(I),(EX(I,J),J=1,9)
     1 ,(EY(I,J),J=1,9)
   30 FORMAT(4X,'X(',I2,')',9E13.5/9X,9F13.3/3X,F6.4,   9E13.5/9X,
     1  9E13.5/)
  292 CONTINUE
      WRITE(NPRNT,850) (CDNSTY(NX,J),J=1,9)
  850 FORMAT(3X,9E13.5)
      WRITE(NPRNT,15)  (J,J=N1,NY,N2)
   15 FORMAT(/14X, 9('Y(',I2,')',8X))
      WRITE(NPRNT,11)  (Y1(J),J=N1,NY,N2)
      DO 293 I=1,NX
      WRITE(NPRNT,30)I,(RHO(I,J),J=N1,NY,N2),(V(I,J),J=N1,NY,N2),X1(I),
     1  (EX(I,J),J=N1,NY,N2),(EY(I,J),J=N1,NY,N2)
  293 CONTINUE
      WRITE(NPRNT,850) (CDNSTY(NX,J),J=N1,NY,N2)
      RETURN
      ENTRY ENTER2(NX,NY)
      N2=(NY-1)/9
      N1=NY-8*N2
      WRITE(NPRNT,15) (J,J=1,9)
      WRITE(NPRNT,11)  (Y1(J),J=1,9)
      DO 3510 I=1,NX
 3510 WRITE(NPRNT,3550)I,(VCOOP(I,J),J=1,9),(ECX(I,J),J=1,9),X1(I),
     1     (ECY(I,J),J=1,9)
      WRITE(NPRNT,15)  (J,J=N1,NY,N2)
      WRITE(NPRNT,11)  (Y1(J),J=N1,NY,N2)
      DO 3520 I=1,NX
 3520 WRITE(NPRNT,3550)I,(VCOOP(I,J),J=N1,NY,N2),(ECX(I,J),J=N1,NY,N2),


     1 X1(I),(ECY(I,J),J=N1,NY,N2)
 3550 FORMAT(4X,'X(',I2,')',9F13.0/9X,9E13.3/3X,F6.4,   9E13.3/)
      RETURN
      END
```

APPENDIX E

LISTING OF RATE

```
      FUNCTION RATE (ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,
     *CMKS,RR,FCONST,FACTOR,COEFF,AFID,NTIME,NUMBER)
      REAL INTGRL,NE,NUMBER,NTIME
      DIMENSION T(3),A(3)
      DATA T/-0.77459667,0.0,0.77459667/
      DATA A/0.55555556,0.88888889,0.55555556/
      NE=-NUMBER*ECHARG
      PI=3.1415927
      IF(NUMBER-SCHARG)7005,7006,7006
 7005 CALL ARCCOS(NUMBER,SCHARG,THZERO)
      IF(THZERO.LE.1.E-05) GO TO 7006
      IF(1.57-THZERO) 7011,7011,7015
 7015 CONTINUE
      GO TO 7007
 7006 THZERO=0.
 7007 YFUC=0.0
      DO 7002 I=1,3
      THETA=T(I)*(PI-2.*THZERO)/4.+(PI+2.*THZERO)/4.
      CTHETA=COS(THETA)
      TCONST=CONST*CTHETA
      ECOS=EZERO*CTHETA
      C1=-NE/(CMKS*ECOS)
      CO=TCONST/(2.*ECOS)
      CALL ZERO(C1,CO,RZERO)
      ARG1=-(NUMBER*V*(RZERO-RSIZE)/RZERO+(ECONST-RR*RZERO+FCONST/RZERO*
     1*2)*CTHETA)
      IF(ABS(ARG1).GT.30.0) GO TO 7025
      YVAL=EXP(ARG1)*SIN(THETA)
      GO TO 7026
 7025 YVAL=0.
 7026 CONTINUE
      YFUC=YFUC+A(I)*YVAL
 7002 CONTINUE
      RATE1=(PI-2.*THZERO)/4.*YFUC*FACTOR*AFID
      GO TO 7012
 7011 RATE1=0.
 7012 CONTINUE
      ARG3=-V*NUMBER
      IF(ABS(ARG3).GT.30.0) GO TO 7031
      RATE2=FACTOR*EXP(ARG3)*AFID
      GO TO 7032
 7031 RATE2=0.
 7032 CONTINUE
      IF(NUMBER-SCHARG)7008,7009,7009
 7008 RATE3=COEFF*(1.-NUMBER/SCHARG)**2*AFID
      GO TO 7010
 7009 RATE3=0.
 7010 CONTINUE
      RATE=RATE1+RATE2+RATE3
      RETURN
      END
```

APPENDIX F

COMPLETE LISTING OF THE COMPUTER PROGRAM

```
001     C                          ******************************************************
002     C                          *                                                    *
003     C                          *                E.P.A.-SO.R.I. ESP MODEL            *
004     C                          *  THIS PROGRAM IS DESIGNED TO COMPUTE PERFORMANCE   *
005     C                          *  OF A WIRE-PLATE PRECIPITATOR USING DESIGN AND     *
006     C                          *  OPERATING PARAMETERS. THE PROGRAM WAS DEVELOPED BY *
007     C                          *  PERSONNEL OF THE SOUTHERN RESEARCH INSTITUTE FOR  *
008     C                          *  DR. LES SPARKS OF THE PARTICULATE TECHNOLOGY      *
009     C                          *  BRANCH, INDUSTRIAL ENVIRONMENTAL RESEARCH LAB,    *
010     C                          *  ENVIRONMENTAL PROTECTION AGENCY, PROJECT OFFICER. *
011     C                          *              REVISION 2, AUG., 1979                *
012     C                          *                                                    *
013     C                          ******************************************************
014     C
015     C
016           REAL  NWIRE,LTHICK,JPART,JION,LINC,NWS,LINCS
017           INTEGER VISKIP,VISAME
018           DIMENSION CHKSUM(20)
019           COMMON/BLK1/DIAM(20),DND(20),DXS(20),XMV(20),PCNT(20),RAD(20),
020          1CCF(20),PRCU(21)
021           COMMON/BLK2/LSECT(10),LINCS(10),PS(10)
022           COMMON/BLK3/VG,ATOTAL,DD,ETAD,DL,PL,RHO
023           COMMON/BLK4/NS
024           COMMON/BLK5/ZMMDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
025           COMMON/BLK6/VOL(20),XNO(20),Q(20),WS(20),ITL(40),DW(45),AS(10),
026          1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
027          2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
028          3OLDO(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
029          4VSTAR(10)
030           COMMON/BLK7/XDC(45,20)
031           COMMON/BLK8/EAVG(30),CHFID(30)
032           COMMON/BLK9/ECOLL(30)
033           COMMON/BLK10/ECLEAN(30)
034           COMMON/BLK11/ENDPT(21),NENDPT
035           COMMON/BLK12/ARD50(10),ARSIGM(10),ASNUCK(15),AZNUMS(15),AZIGGY(15)
036           COMMON /BLK13/VCOOP(15,15),NVIT
037           COMMON/BLK14/TMFP,NVI,NV1
038           COMMON/BLK15/NPRINT,NSECT,SLNGTH,A,VO,TC,B,AC,WL,CL,CD,ET,SY,
039          1VGAS,P,VTS,W,LINC,XPI,RIOVR,EPLT,AFID,XCD,ZMD,
040          2WT,LTHICK,JPART,JION,I,ROVRI
041           COMMON/BLK16/NCALC,NT,VRATIO,NF
042           COMMON/BLK17/NREAD,NPRNT
043           COMMON/BLK18/SCOREF,CZMOL,CSIGMO,NRUN,SNUCK,ZIGGY,RMMD,RSIGMA
044           COMMON/BLK19/LK,DV,NN,NUMINC,NX,NY,NDATA,NEST,NDIST,NITER,IFINAL,
045          1JI1,JI2,VISKIP,VISAME,US,FPATH,EBD,NDSET,NWS(10),D50,SIGMAP
046           COMMON/BLK20/SCHARG,CHRFID,TIMEI,TIMEF,V,FACTRE,RSIZE,CNUMBR,J,IT,
047          1ITER,OLDQF(20),OLDQT(20),SOLDQF(20),SOLDQT(20)
048           EXTERNAL RATE
049           NREAD=2
050           NPRNT=3
051     C
052     C   CONSTANTS
053     C
054           NVII=0
055           IFINAL=1
056           JI1=0
057           JI2=0
058           PI = 3.1415927
059           E = 1.6E-19
060           BC=1.38E-23
```

```
      EPSO = 8.85E-12
      CMKS=4.*PI*EPSO
 4000 CONTINUE
C
C
      NDSET=0
      READ(NREAD,5) NENDPT,NDATA
    5 FORMAT(2I2)
      IF(NENDPT-99) 4500,9999,9999
 4500 CONTINUE
      NS=NENDPT-1
      READ(NREAD,7) ITL
    7 FORMAT(40A2)
      GO TO(9400,9401,9402,9403),NDATA
 9400 CONTINUE
      READ(NREAD,4864) NFST,NDIST,NVT,NX,NY,NITER,NCALC,NRAPD,NEFF,
     1NTEMP,NONID
 4864 FORMAT(11I2)
      NV1=NVI
      IF(NVI.EQ.3)NVII=1
      IF(NVI.EQ.3)NVT=1
      IF(NVI.EQ.4)NVTI=2
      IF(NVI.EQ.4)NVI=2
      IF(NCALC.EQ.0) READ(NREAD,5) NN,NUMINC
      IF(NVI.EQ.2) READ(NREAD,8530) TFINAL,JI1,JI2,VISKIP,VISAME
 8530 FORMAT(5I2)
      READ(NREAD,6) DL,PL,ETAO,DD,FPS,VRATIO,US,FPATH,ERD,RHO
    6 FORMAT(9F8.0,E8.2)
C
C        CONVERSION
C
      PL = PL * 0.305
      DL = DL * 2.29E-03
      RHO = RHO/100.0
      DV = DL / DD
C
      IF(NRAPD.GT.1) READ(NREAD,8531) (ARD50(I),ARSIGM(I),I=2,NRAPD)
 8531 FORMAT(10(2F4.0))
      READ(NREAD,8532) (ASNUCK(I),AZIGGY(I),AZNUMS(I),I=1,NONID)
 8532 FORMAT(6(3F4.0))
      READ(NREAD,4) (ENDPT(I),I=1,NENDPT)
    4 FORMAT(10F8.0)
      DO 4740 I=1,NS
      DIAM(I)=((ENDPT(I)+ENDPT(I+1))/2.)*1.E-06
      RAD(I)=DIAM(I)/2.
 4740 CONTINUE
 9401 CONTINUE
      IF(NDIST.EQ.2) READ(NREAD,8533) D50,SIGMAP
 8533 FORMAT(2F8.0)
      IF(NDIST.EQ.1) READ(NREAD,4) (PRCU(I),I=1,NENDPT)
      IF(NDIST.EQ.2) GO TO 8521
      DO 3 I=1,NS
      PCNT(I)=(PRCU(I+1)-PRCU(I))*1.E-02
    3 CONTINUE
      CALL LNFIT(PRCU,D50,SIGMAP,GFIT)
      ZMMDT=D50
      SIGMI=SIGMAP
      GO TO 8522
 8521 CONTINUE
      CALL LNDIST(D50,SIGMAP,PRCU,PCNT)
```

```
      ZMMDI=D50
      SIGMI=SIGMAP
 8522 CONTINUE
      IF(NDATA.GT.1) GO TO 8534
      READ(NREAD,770) NUMSEC,(LSECT(I),I=1,NUMSEC)
  770 FORMAT(I2,10I2)
      DO 1143 NSECT=1,NUMSEC
      READ(NREAD,762) AS(NSECT),VOS(NSECT),TCS(NSECT),WLS(NSECT),
     1ACS(NSECT),BS(NSECT),WWS(NSECT),SYS(NSECT),VGS(NSECT)
     2,VGASS(NSECT),TEMPS(NSECT),PS(NSECT),VISS(NSECT),LINCS(NSECT)
  762 FORMAT(7(E11.4))
      IF(NVI.EQ.1) GO TO 1143
      READ(NREAD,762) RFS(NSECT),START1(NSECT),START2(NSECT),START3
     1(NSECT),VSTAR(NSECT)
 1143 CONTINUE
      GO TO 8534
 9402 CONTINUE
      READ(NREAD,9410) (VGS(I),VGASS(I),I=1,NUMSEC)
 9410 FORMAT (3(2E11.4))
      GO TO 8534
 9403 CONTINUE
      READ(NREAD,9410) (VOS(I),TCS(I),I=1,NUMSEC)
 8534 CONTINUE
      LK=0
      WRITE(NPRNT,17)
   17 FORMAT('1')
      NI = 2*NV - 2
      NF=0
      DO 4649 KA=1,NUMSEC
      NF=NF+LSECT(KA)
 4649 CONTINUE
C
C
C
      DO 1 I = 1 ,NS
      VOL(I) = PCNT(I) * DV
    1 CONTINUE
      NPRINT=0
      IF(NVI.EQ.1) ITER=0
  305 CONTINUE
      IF(NVI.EQ.1) ITER=ITER+1
      DO 9 I = 1, NS
      DXS(I)=0.
      XNO(I) = VOL(I)/ ( 4./3. * PI * RAD(I)**3 )
      DNO(I) = XNO(I)
    9 CONTINUE
      CALL PRTINP
C
C
C*********************************************************************
C
C       START  INCREMENTAL ANALYSIS OF PRECIPITATOR
C
C*********************************************************************
C
      LK=1
      ZWT=0.
      RATIO=(FPS-1.)/(FPS+2.)
      G=FPS+2.
      INDEX=0
```

```
      NSECT=1
      NCOOP=0
      DO 3000 I=1,NF
      IF(NVI.EQ.2) ITER=0
      INDEX=INDEX+1
      IF(I.EQ.1) GO TO 761
      IF(INDEX-LSECT(NSECT)) 760,760,761
  761 CONTINUE
      NCOOP=1
      NPRINT=1
      IF(I.EQ.1) GO TO 760
      NSECT=NSECT+1
      INDEX=1
  760 CONTINUE
      IF(NCOOP.NE.1) GO TO 764
      A=AS(NSECT)*9.3E-02
      VO=VOS(NSECT)
      TC=TCS(NSECT)
      WL=WLS(NSECT)*0.305
      AC=ACS(NSECT)*2.54E-02
      SX=HS(NSECT)*2.54E-02
      SY=SYS(NSECT)*2.54E-02
      NWIRE=NWS(NSECT)
      VG=VGS(NSECT)*4.73E-04
      VGAS=VGASS(NSECT)*.305
      TEMP=TEMPS(NSECT)+459.
      P=PS(NSECT)
      VIS=VISS(NSECT)
      LINC=LINCS(NSECT)*0.305
      RF=RFS(NSECT)
      START=START1(NSECT)
      DSTART=START2(NSECT)
      CSTART=START3(NSECT)
      VSTART=VSTAR(NSECT)
      SLNGTH=FLOAT(LSECT(NSECT))*LINC
      B=SX
C
C CALCULATE ION MEAN FREE PATH
C
      TDK=TEMP/1.8
      ZNV=8.205E-05*TDK/P
      ZMFP=(8.205E-05*TDK)/(1.414*PI*1.6E-19*6.02E+23*P)
      TMFP=ZMFP*FPATH
      VAVG=SQRT((8.*8.314E+07*TDK)/(3.14*32.))
      VAVC=VAVG/100.
      VC=E**2/(BC*TDK)
      FACTRC=(PI*VAVC)/2.
C
C   COMPUTE ION MOBILITY CORRECTED FOR TEMPERATURE AND PRESSURE
C
      U=(TDK/273.16)*US*(1.0/P)
C
      COEFFC=PI*U*E
      TINC=LINC/VGAS
      IF(NVI.EQ.1) GO TO 4675
      DTINC = TINC/FLOAT(NI)
 4675 CONTINUE
C
C     COMPUTE WEIGHT OF DUST
C
```

```
      W = DL * VG
C
      DO 6993 J=1,NS
      CCF(J)=1+(ZMFP/RAD(J))*(1.257+.4*EXP(-1.1*RAD(J)/ZMFP))
 6993 CONTINUE
      IF(NVI.EQ.2) GO TO 4676
      ERAVG=VO/SX
      DO 6989 L=1,NS
      QSAT(L)=(4.*PI*EPSO*(RAD(L)+TMFP)**2)*ERAVG*(1.+2.*((EPS-1.)/
     1(EPS+2.))*(RAD(L)/(RAD(L)+TMFP))**3)*VRATIO
 6989 CONTINUE
      R=(E*ERAVG)/(BC*TDK*(EPS+2.))
      RR=(E*ERAVG)/(BC*TDK)
      RG=R*G
 4676 CONTINUE
      NCOOP=0
      IF(NVI.EQ.2) GO TO 4677
      IF(NFST.EQ.2) GO TO 4678
      VW=-1.*VO
      CALL CMAN(VW,NX,NY,SX,SY,PI,AC,NWIRE)
      GO TO 4678
 4677 CONTINUE
      UEQ=U
      NEC=0
      IF((VISAME.EQ.1).AND.(NSECT.GT.1)) GO TO 5564
      IF((VISAME.EQ.1).AND.(NDSET.GT.1)) GO TO 5564
      WRITE(NPRNT,7140) NSECT
 7140 FORMAT(//23X,'CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE
     1 RELATIONSHIP FOR SECTION NO. ',I2//)
      IF(NVII.EQ.2)CALL EFLD3(UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACONTY,NWIRE,NEC,ERD,JI1,JI2)
      IF(NVII.NE.2)CALL EFLD2(UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACONTY,NWIRE,NEC,ERD,JI1,JI2)
      DO 7919 NZ=1,NT
      ECLEAN(NZ)=ECOLL(NZ)
 7919 CONTINUE
      CDCLN=ACONTY
 5564 CONTINUE
      VDS(NSECT)=-VW
 4678 CONTINUE
      IF(NVI.EQ.2) TC=CDCLN*A
C
C   COMPUTE CURRENT DENSITY
      CD = TC / A
C
C
C   COMPUTE ELECTRIC FIELD IN DEPOSIT
      ET = CD * RHO
C
C
C   COMPUTE CURRENT PER M. OF CORONA WIRE
C
      CL = TC / WL
C
  764 CONTINUE
      IF(NVI.EQ.1) GO TO 4679
      ITER=ITER+1
      USUM=0.
      WSSUM=0.
      RHOSUM=0.
```

```
      GO TO 4680
 4679 CONTINUE
      CALL SPCHG1(SW,ROVRI,OROVRI,XS,ETAPF,DW,QSAT,XNO,W,LSECT,TC,VG,
     1ETAD,FID,AFID,AVGFID,XCD,U,UEQ,I,NSECT,LINC,PL,CD,E,ERAVG,NS,XPI)
      CHRFID=AFID
 4680 CONTINUE
C
C*********************************************************************
C
C          START PARTICLE SIZE LOOP
C
C*********************************************************************
C
      PROT=0.0
      WT = 0.
      JPART=0.
C
C   COMPUTE CHARGE ON EACH PARTICLE AFTER ONE INCREMENT OF TRAVEL
C
      IF(NVI.EQ.1) GO TO 4681
      II = 0
      SERAVG = 0.0
 6337 CONTINUE
      II = II + 1
      CHRFID=CHFID(II)
      ERAVG=EAVG(II)
      SERAVG = SERAVG + ERAVG/NI
      DO 9130 L=1,NS
      QSAT(L)=(4.*PI*EPS0*(RAD(L)+TMFP)**2)*ERAVG*(1.+2.*((EPS-1.)/
     1(EPS+2.))*(RAD(L)/(RAD(L)+TMFP))**3)*VRATIO
 9130 CONTINUE
      R=(E*ERAVG)/(BC*TDK*(EPS+2.))
      RR=(E*ERAVG)/(BC*TDK)
      RG=R*G
 4681 CONTINUE
      DO 2900 J = 1, NS
      IF(NVI.EQ.1) GO TO 4682
      OLDQ(J)=Q(J)
      IF(II.NE.1) GO TO 426
 4682 CONTINUE
      IF(I.NE.1) GO TO 426
      IF(J.GT.1) GO TO 428
      TIMEI=0.
      XIPC=0.
      IF(NVI.EQ.2) GO TO 4683
      TIMEF=TINC
      IF(NCALC.EQ.0) H=TINC/NN
      GO TO 4684
 4683 CONTINUE
      TIMEF=DTINC
      IF(NCALC.EQ.0) H=DTINC/NN
 4684 CONTINUE
      GO TO 428
  426 CONTINUE
      IF(NVI.EQ.1) GO TO 4685
      IF(J.GT.1) GO TO 429
      TIMEI=TIMEF
      IF((ITER.GT.1).AND.(II.EQ.1)) TIMEI=TIMEI-TINC
      TIMEF=TIMEF+DTINC
      IF(NCALC.EQ.0) H=DTINC/NN
```

```
  429 CONTINUE
      IF(IT.NE.1) GO TO 8242
      XIPC=XDC(I-1,J)/1.6E-19
      GO TO 8243
 8242 CONTINUE
      XIPC=XDC(I,J)/1.6E-19
 8243 CONTINUE
      GO TO 4686
 4685 CONTINUE
      IF(J.GT.1) GO TO 4687
      TIMEI=FLOAT(I-1)*TINC
      TIMEF=FLOAT(I)*TINC
      IF(NCALC.EQ.0) H=TINC/NN
 4687 XIPC=XDC(I-1,J)/1.6E-19
 4686 CONTINUE
  428 CONTINUE
      RSIZE=RAD(J)
      SCHARG=QSAT(J)/1.6E-19
      DCONST=RATIO*RSIZE**3
      CONST=2.*DCONST*ERAVG
      S=3.*RSIZE
      V=VC/(RSIZE*CMKS)
      ECONST=S*R
      FCONST=RG*DCONST
      FACTRE=FACTRC*RSIZE**2
      COEFF=(COEFFC*SCHARG)/CMKS
      IF(I.LE.2) GO TO 5850
      IF(NVI.EQ.1) GO TO 5851
      IF((II.EQ.1).AND.(ITER.EQ.1)) GO TO 5851
      GO TO 5852
 5851 CONTINUE
      IF(I.EQ.3) GO TO 5853
      IF(NSECT.EQ.1) GO TO 5680
      IF((INDEX.EQ.1).AND.(VOS(NSECT).GT.VOS(NSECT-1))) GO TO 5850
 5680 CONTINUE
      IF(CHKSUM(J).LE.0.005) GO TO 5854
 5853 CONTINUE
      CHKSUM(J)=(XDC(I-1,J)-XDC(I-2,J))/XDC(I-1,J)
 5852 CONTINUE
      IF(NSECT.EQ.1) GO TO 5681
      IF((INDEX.EQ.1).AND.(VOS(NSECT).GT.VOS(NSECT-1))) GO TO 5850
 5681 CONTINUE
      IF(CHKSUM(J).GT.0.005) GO TO 5850
 5854 CONTINUE
      Q(J)=XDC(I-1,J)
      GO TO 5855
 5850 CONTINUE
      IF((NCALC.EQ.1).OR.(NFST.EQ.2)) GO TO 8180
      CALL CHARGN(F,SCHARG,NUMINC,CONST,ERAVG,V,RSIZE,ECONST,CMKS,RR,
     1FCONST,FACTRE,COEFF,CHRFID,RATE,H,TIMEI,XIPC,NN,CTIME,CNUMBR)
      GO TO 8181
 8180 CONTINUE
      CALL CHGSUM
 8181 CONTINUE
      Q(J)=CNUMBR*1.6E-19
      IF((TIMEI.EQ.0.).AND.(CNUMBR.GT.SCHARG)) Q(J)=SCHARG*1.6E-19
 5855 CONTINUE
      XDC(I,J)=Q(J)
      IF(NVI.EQ.1) GO TO 2900
C
```

```
C    COMPUTE MIGRATION VELOCITY FOR EACH SIZE RANGE
C
        EMV=(Q(J)*ECOLL(II))/(6.*PI*RAD(J)*VIS)
        IF(ITER.EQ.1) EMV=(Q(J)*ECLEAN(II))/(6.*PI*RAD(J)*VIS)
        EMV=CCF(J)*EMV
        XMV(J)=EMV
C
C    COMPUTE EFFICIENCY FOR EACH SIZE RANGE
C
        X=(-A*EMV)/(VG*FLOAT(LSECT(NSECT))*FLOAT(NI))
C
        EFF =  1. - EXP( X )
C
C       COMPUTE NUMBER OF PARTICLES REMOVED IN EACH SIZE RANGE
C
        IF(ITER.EQ.1) GO TO 3761
        IF(II.NE.1) GO TO 3763
        XNO(J)=OLDXNO(J)
        GO TO 3763
 3761   CONTINUE
        IF(II.NE.1) GO TO 3763
        OLDXNO(J)=XNO(J)
 3763   CONTINUE
        DXNO=XNO(J)*EFF
        IF(ITER.NE.NITER) GO TO 3765
        DXS(J)=DXS(J)+DXNO
        WSSUM=DXNO*(1.33333*PI*RAD(J)**3)*DD
        WS(J)=WS(J)+WSSUM
        WT=WT+WSSUM
C
C    CALCULATE THE CURRENT DENSITY AT THE PLATE DUE TO THE PARTICULATE
        JPART=JPART+(FLOAT(LSECT(NSECT))*VG*DXNO*Q(J)*FLOAT(NI))/A
 3765   CONTINUE
        XNO(J)=XNO(J)-DXNO
C
 2900   CONTINUE
        IF(NVI.EQ.1) GO TO 9131
        CALL SPCHG2(NS,XNO,VIS,RAD,LINC,E,U,ERAVG,DNSION,
       1DELTNP,SUMMOB,PNUM,RHOP,TCHRG,PMOB,TDNSP,RDNSI,AFID,UEQ,AVGFID,
       2RIOVR,I,XS,ETAO,PL,ETAPF,CCF,XPI,OLDQ,Q,II,NSECT)
        USUM=USUM+UEQ
        RHOSUM=RHOSUM+RIOVR
 5676   CONTINUE
        IF(II.LT.NI) GO TO 6337
        UEQ=USUM/FLOAT(NI)
        RIOVR=RHOSUM/FLOAT(NI)
        IF(I.EQ.1) GO TO 376
        IF(RIOVR.GT.0.99) GO TO 375
  376   CONTINUE
        IF((VISKIP.EQ.1).OR.(NEST.EQ.2)) GO TO 3187
        WRITE(NPRNT,7141) I
 7141   FORMAT(//23X,'DIRTY GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE
       1 RELATIONSHIP FOR INCREMENT NO. ',I2//)
        NEC=1
        START=START1(NSECT)*(UEQ/U)
        IF(NVIT.EQ.2)CALL EFLD3(UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
       1START,DSTART,CSTART,IFINAL,VSTART,VW,ACDNTY,NWIRE,NEC,FRD,JI1,JI2)
        IF(NVIT.NE.2)CALL EFLD2(UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
       1START,DSTART,CSTART,IFINAL,VSTART,VW,ACDNTY,NWIRE,NEC,FRD,JI1,JI2)
        GO TO 3188
```

```
 3187 CONTINUE
      ACONTY=COCLN*(UEQ/U)
 3188 CONTINUE
      EPLT=-1.*AEPLT
      XCD=ACONTY*100000.
  375 CONTINUE
      IF(ITER.NE.NITER) GO TO 1050
      IF(INDEX.EQ.1) SUMCD=0.
      IF(INDEX.EQ.1) SUMVO=0.
      SUMCD=SUMCD+ACONTY
      SUMVO=SUMVO+VW
      IF(INDEX.EQ.LSECT(NSECT)) TCS(NSECT)=(SUMCD*A)/FLOAT(LSECT(NSECT))
      IF(INDEX.EQ.LSECT(NSECT)) VOS(NSECT)=SUMVO/FLOAT(LSECT(NSECT))
 1050 CONTINUE
      IF(ITER.LT.NITER) GO TO 764
      JPART=JPART/FLOAT(NI)
      GO TO 4688
 9131 CONTINUE
      IF(UEQ.LT.1.0E-4)UEQ=1.0E-4
      IF(INDEX.EQ.1) GO TO 377
      IF(UEQ.NE.1.0E-4) GO TO 9133
      IF(UEQ.EQ.1.0E-4)EPLT=SKIP
      GO TO 9132
 9133 CONTINUE
      SIGMA=OROVRI-ROVRI
      SIGMA=ABS(SIGMA)
      IF(SIGMA.LT..01) GO TO 9132
  377 CONTINUE
      IF(NEST.EQ.2) GO TO 8182
      FF=1.0
      IF(NVIT.EQ.1)CALL EFLD3(UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,CD,NWIRE,NFC,EBD,JI1,JI2)
      IF(NVIT.NE.1)CALL EFLD1(UEQ,CD,AC,VO,SX,SY,NX,NY,TDK,P,AEPLT,
     1VERGE,CVERGE)
      EPLT=-1.*AEPLT
      GO TO 8183
 8182 CONTINUE
      EPLT=ERAVG/1.75
 8183 CONTINUE
      SKIP=EPLT
 9132 OROVRI=ROVRI
      DO 2965 J=1,NS
C
C   COMPUTE MIGRATION VELOCITY FOR EACH SIZE RANGE
C
      EMV=(Q(J)*EPLT)/(6.*PI*RAD(J)*VIS)
      EMV=CCF(J)*EMV
      XMV(J)=EMV
C
C   COMPUTE EFFICIENCY FOR EACH SIZE RANGE
C
      X=(-A*EMV)/(VG*FLOAT(LSECT(NSECT)))
C
      EFF =  1. - EXP( X )
C
C     COMPUTE NUMBER OF PARTICLES REMOVED IN EACH SIZE RANGE
C
      DXNO=XNO(J)*EFF
      DXS(J)=DXS(J)+DXNO
      WS(J)=DXNO*(1.33333*PI*RAD(J)**3)*DD
```

```
      XNO(J)=XNO(J)-DXNO
      WT=WT+WS(J)
C
C   CALCULATE THE CURRENT DENSITY AT THE PLATE DUE TO THE PARTICULATE
      JPART=JPART+(FLOAT(LSECT(NSECT))*VG*DXNO*Q(J))/A
C
 2965 CONTINUE
 4688 CONTINUE
      ZWT=ZWT+WT
C
C   CALCULATE THE CURRENT DENSITY AT THE PLATE DUE TO IONS
      JION=CD-JPART
C
C
C   CALCULATE THICKNESS OF DUST LAYER IN (MM/MIN)/INCREMENT
C
      LTHICK=(WT*VG*FLOAT(LSECT(NSECT))*6.0E+04)/(1.0E+03*A)
C
C
C  CALCULATE MMD AND WEIGHT COLLECTED FOR EACH INCREMENT
C
      ZTM=0.
      DO 2901 J=1,NS
      ZTM=ZTM+WS(J)
      CZA=ZTM/WT
      IF(CZA-0.5)2901,2901,2902
 2901 CONTINUE
 2902 CZB=(ZTM-WS(J))/WT
      TL1=CZA-CZB
      TL2=0.50-CZB
      KJ=J-1
      IF(KJ)2910,2910,2911
 2910 ZMD=DIAM(J)
      GO TO 2912
 2911 ZMD=DIAM(KJ)+(TL2/TL1)*(DIAM(J)-DIAM(KJ))
 2912 CONTINUE
      IF(NVI.EQ.2) ERAVG = SERAVG
      CALL PRTINC
 3000 CONTINUE
C
      ETC=(ZWT/DL)*100.
      IF(NVI.EQ.2) GO TO 1620
      DIFF=ETC-ETAO
      DIFF=ABS(DIFF)
      IF(DIFF-0.05)60,300,300
  300 CONTINUE
      WRITE(NPRNT,8656) ETAO,ETC
 8656 FORMAT(/' EST. EFFICIENCY =',F6.2,5X,'UNCORRECTED COMPUTED EFFICIE
     1NCY =',F6.2)
      IF(ITER.EQ.NITER) GO TO 60
      ETAO=ETC
      GO TO 305
   60 CONTINUE
      GO TO 1621
 1620 CONTINUE
      WRITE(NPRNT,1622) ETAO,ETC
 1622 FORMAT(/' DESIGN EFFICIENCY =',F6.2,5X,'UNCORRECTED COMPUTED EFFIC
     1IENCY =',F6.2)
 1621 CONTINUE
      ATOTAL=0.
```

```
601              VG=0.
602              DO 4985 I=1,NUMSEC
603              ATOTAL=ATOTAL+AS(I)*9.3E-02
604              VG=VG+(VGS(I)*4.73E-04)
605        4985  CONTINUE
606              VG=VG/FLOAT(NUMSEC)
607              CALL PRTCHG
608              CALL ADJUST
609              GO TO 4000
610        9999  STOP 11111
611              END
 PROG > 4K
```

```
      SUBROUTINE PRTINP
      REAL LINCS,NWS
      INTEGER VISKIP,VISAME
      DIMENSION IBLNK(21)
      COMMON/BLK1/DIAM(20),ONO(20),DXS(20),XMV(20),PCNT(20),RAD(20),
     1CCF(20),PRCU(21)
      COMMON/BLK2/LSECT(10),LINCS(10),PS(10)
      COMMON/BLK3/VG,ATOTAL,DD,ETAO,DL,PL,RHO
      COMMON/BLK5/ZMMDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
      COMMON/BLK6/VOL(20),XNO(20),G(20),WS(20),ITL(40),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,F,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK11/ENDPT(21),NENDPT
      COMMON/BLK12/ARD50(10),ARSIGM(10),ASNUCK(15),AZNUMS(15),AZIGGY(15)
      COMMON/BLK14/TMFP,NVI,NV1
      COMMON/BLK16/NCALC,NI,VRATIO,NF
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK19/LK,DV,NN,NUMINC,NX,NY,NDATA,NEST,NDIST,NITER,IFINAL,
     1JI1,JI2,VISKIP,VISAME,US,FPATH,EBD,NDSET,NWS(10),D50,SIGMAP
      DATA IBLNK/21*' '/
      IF(LK) 111,111,160
  111 CONTINUE
      WRITE(NPRNT,5850)
 5850 FORMAT(40X,'*****************************************')
      WRITE(NPRNT,5851)
 5851 FORMAT(40X,'*',35X,'*')
      WRITE(NPRNT,5852)
 5852 FORMAT(40X,'*',9X,'E.P.A. ESP MODEL',10X,'*')
      WRITE(NPRNT,5851)
      WRITE(NPRNT,5853)
 5853 FORMAT(40X,'*',4X,'I.E.R.L.-R.T.P. AND SO.R.I.',4X,'*')
      WRITE(NPRNT,5851)
      WRITE(NPRNT,5854)
 5854 FORMAT(40X,'*',7X,'REVISION II. AUG., 1979',5X,'*')
      WRITE(NPRNT,5851)
      WRITE(NPRNT,5850)
      NDSET=NDSET+1
      DLB=DL/2.29E-03
      PLB=PL/0.305
      RHOCGS=100.*RHO
      NCARD=0
      WRITE(NPRNT,2000) NDSET
 2000 FORMAT(//'  PRINTOUT OF INPUT DATA FOR DATA SET NUMBER ',I2//)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
 2001 FORMAT(//'  DATA ON CARD NUMBER ',I3//)
      WRITE(NPRNT,1000) NENDPT,NDATA
 1000 FORMAT('  NENDPT = ',I2,2X,' NDATA = ',I2)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1001) ITL
 1001 FORMAT(2X,40A2)
      GO TO(6000,6001,6002,6002),NDATA
 6000 CONTINUE
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1002) NEST,NDIST,NV1,NX,NY,NITER,NCALC,NRAPD,NEFF,
     1NTEMP,NONID
```

```
 1002 FORMAT(' NEST = ',I2,2X,'NDIST = ',I2,2X,'NVI = ',I2,2X,'NX = '
     1,I2,2X,'NY = ',I2,2X,'NITER = ',I2,2X,'NCALC = ',I2,2X,'NRAPD = ',
     2I2,2X,'NEFF = ',I2,2X,'NTEMP = ',I2,2X,'NONID = ',I2)
      IF(NCALC.NE.0) GO TO 1003
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1004) NN,NUMINC
 1004 FORMAT(' NN = ',I2,2X,'NUMINC = ',I2)
 1003 CONTINUE
      IF(NVI.EQ.1) GO TO 1005
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1006) IFINAL,JI1,JI2,VISKIP,VISAME
 1006 FORMAT(' IFINAL = ',I2,2X,'JI1 = ',I2,2X,'JI2 = ',I2,2X,'VISKIP =
     1',I2,2X,'VISAME = ',I2)
 1005 CONTINUE
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1007) DL8,PL8,ETAO,DD,EPS
 1007 FORMAT(' DL = ',F8.5,' GRN/ACF',2X,'PL = ',F8.4,' FT',2X,'ETAO =
     1',F8.5,' %',2X,'DD = ',F8.2,' KG/M**3',2X,'EPS = ',1PE10.3/)
      WRITE(NPRNT,1008) VRATIO,U8,FPATH,EBD,RHOCGS
 1008 FORMAT(' VRATIO = ',F8.4,2X,'U8 = ',F8.6,' M**2/V-SEC',2X,'FPATH
     1= ',F8.4,2X,'EBD = ',F8.0,' V/M',2X,'RHOCGS = ',1PE9.2,' OHM-CM')
      IF(NRAPD.EQ.1) GO TO 1009
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1010) (I,ARD50(I),I,ARSIGM(I),I=2,NRAPD)
 1010 FORMAT(' ARD50(',I2,') = ',F4.1,' UM',2X,'ARSIGM(',I2,') = ',F4.1
     1/)
 1009 CONTINUE
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      DO 1011 I=1,NONID
      IF(I.EQ.7) NCARD=NCARD+1
      IF(I.EQ.7) WRITE(NPRNT,2001) NCARD
      IF(I.EQ.13) NCARD=NCARD+1
      IF(I.EQ.13) WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,6570) I,ASNUCK(I),I,AZIGGY(I),I,AZNUMS(I)
 6570 FORMAT(' ASNUCK(',I2,') = ',F4.2,2X,'AZIGGY(',I2,') = ',F4.2,2X,'
     1AZNUMS(',I2,') = ',F4.1/)
 1011 CONTINUE
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      NDCARD=2
      IF(NENDPT.LE.10) NDCARD=1
      IF(NENDPT.GT.20) NDCARD=3
      GO TO(1012,1013,1014),NDCARD
 1012 CONTINUE
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=1,NENDPT)
 1015 FORMAT(5(1X,A1,'ENDPT(',I2,') = ',F8.3,' UM',1X)/)
      GO TO 1016
 1013 CONTINUE
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=1,10)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=11,NENDPT)
      GO TO 1016
 1014 CONTINUE
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=1,10)
```

```
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=11,20)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1015) (IBLNK(I),I,ENDPT(I),I=21,NENDPT)
 1016 CONTINUE
 6001 CONTINUE
      IF(NDIST.EQ.1) GO TO 1017
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1018) D50,SIGMAP
 1018 FORMAT('  D50 = ',F8.4,' UM',2X,'SIGMAP = ',F8.4)
 1017 CONTINUE
      IF(NDIST.EQ.2) GO TO 1019
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      GO TO(1020,1021,1022),NDCARD
 1020 CONTINUE
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=1,NENDPT)
 1023 FORMAT(5(1X,A1,'PRCU(',I2,') = ',F8.4,' %',1X)/)
      GO TO 1024
 1021 CONTINUE
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=1,10)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=11,NENDPT)
      GO TO 1024
 1022 CONTINUE
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=1,10)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=11,20)
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1023) (IBLNK(I),I,PRCU(I),I=21,NENDPT)
 1024 CONTINUE
 1019 CONTINUE
      IF(NDATA.GT.1) GO TO 5000
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      IF(NUMSEC.GT.5) GO TO 1026
      WRITE(NPRNT,1025) NUMSEC,(IBLNK(I),I,LSECT(I),I=1,NUMSEC)
 1025 FORMAT('  NUMSEC = ',I2,2X,5(1X,A1,'LSECT(',I2,') = ',I2))
      GO TO 1027
 1026 CONTINUE
      WRITE(NPRNT,1025) NUMSEC,(IBLNK(I),I,LSECT(I),I=1,5)
      WRITE(NPRNT,8570) (IBLNK(I),I,LSECT(I),I=6,NUMSEC)
 8570 FORMAT(/5(1X,A1,'LSECT(',I2,') = ',I2))
 1027 CONTINUE
      DO 1028 I=1,NUMSEC
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1029) I,AS(I),I,VOS(I),I,TCS(I),I,WLS(I)
 1029 FORMAT('  AS(',I2,') = ',1PE11.4,' FT**2',2X,'VOS(',I2,') = ',1PE1
     11.4,' V',2X,'TCS(',I2,') = ',1PE11.4,' A',2X,'WLS(',I2,') = ',1PE1
     21.4,' FT'/)
      WRITE(NPRNT,1030) I,ACS(I),I,BS(I),I,NWS(I)
 1030 FORMAT('  ACS(',I2,') = ',1PE11.4,' IN',2X,'BS(',I2,') = ',1PE11.4
     1,' IN',2X,'NWS(',I2,') = ',1PE11.4)
```

```
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1031) I,SYS(I),I,VGS(I),I,VGASS(I),I,TEMPS(I)
 1031 FORMAT('  SYS(',I2,') = ',1PE11.4,' IN',2X,'VGS(',I2,') = ',1PE11.
     14,' FT**3/MIN',2X,'VGASS(',I2,') = ',1PE11.4,' FT/SEC',2X,'TEMPS('
     2,I2,') = ',1PE11.4,' F'/)
      WRITE(NPRNT,1032) I,PS(I),I,VISS(I),I,LINCS(I)
 1032 FORMAT('  PS(',I2,') = ',1PE11.4,' ATM',2X,'VISS(',I2,') = ',1PE11
     1.4,' KG/M-SEC',2X,'LINCS(',I2,') = ',1PE11.4,' FT')
      IF(NVI.EQ.1) GO TO 1028
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      WRITE(NPRNT,1033) I,RFS(I),I,START1(I),I,START2(I)
 1033 FORMAT('  RFS(',I2,') = ',1PE11.4,2X,'START1(',I2,') = ',1PE11.4,'
     1 A/M**2',2X,'START2(',I2,') = ',1PE11.4,' A/M**2'/)
      WRITE(NPRNT,1034) I,START3(I),I,VSTAR(I)
 1034 FORMAT('  START3(',I2,') = ',1PE11.4,' A/M**2',2X,'VSTAR(',I2,') =
     1 ',1PE11.4,' V')
 1028 CONTINUE
      GO TO 5000
 6002 CONTINUE
      NCARD=NCARD+1
      WRITE(NPRNT,2001) NCARD
      DO 1035 I=1,NUMSEC
      IF(I.EQ.4) NCARD=NCARD+1
      IF(I.EQ.4) WRITE(NPRNT,2001) NCARD
      IF(I.EQ.7) NCARD=NCARD+1
      IF(I.EQ.7) WRITE(NPRNT,2001) NCARD
      IF(I.EQ.10) NCARD=NCARD+1
      IF(I.EQ.10) WRITE(NPRNT,2001) NCARD
      IF(NDATA.EQ.4) GO TO 1036
      WRITE(NPRNT,1037) I,VGS(I),I,VGASS(I)
 1037 FORMAT('  VGS(',I2,') = ',1PE11.4,' FT**3/MIN',2X,'VGASS(',I2,') =
     1 ',1PE11.4,' FT/SEC'/)
      GO TO 1035
 1036 CONTINUE
      WRITE(NPRNT,1038) I,VOS(I),I,TCS(I)
 1038 FORMAT('  VOS(',I2,') = ',1PE11.4,' V',2X,'TCS(',I2,') = ',1PE11.4
     1,' A'/)
 1035 CONTINUE
 5000 CONTINUE
      WRITE(NPRNT,1039)
 1039 FORMAT(1H1)
  160 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SPCHG1 (SW,ROVRI,OROVRI,XS,ETAPF,DW,QSAT,XNO,W,LSECT,
     1TC,VG,ETAO,FID,AFID,AVGFID,XCD,U,UEQ,I,NSECT,LINC,PL,CD,E,ERAVG,
     2NS,XPI)
      REAL LINC
      DIMENSION DW(45),QSAT(20),XNO(20),LSECT(10)
      IF(I.NE.1) GO TO 1286
      SW = 0.0
      ROVRI=10.
      OROVRI=20.0
C
C   COMPUTE VALUE OF EXPONENT IN DEUTSCH EQUATION FOR THE STATED EFF.
C
      XS=ALOG(100./(100.-ETAO))
C
 1286 CONTINUE
C
C   COMPUTE EFFICIENCY PER LENGTH INCREMENT
C
      ETAPF = 1.-EXP(-LINC*XS/PL)
C
C   COMPUTE AMOUNT OF MATERIAL REMOVED PER INCR.ON A TOTAL WEIGHT BASIS
C
      DW(I) = (W - SW) * ETAPF
      SW = SW + DW(I)
      FID=CD/(E*U*ERAVG)
      SUM=0.0
      DO 1300 L=1,NS
 1300 SUM=SUM+QSAT(L)*XNO(L)
      ZC=200.*(DW(I)/W)*(FLOAT(LSECT(NSECT))/TC)*VG*SUM
      ROVRI=ZC+1.0
      AFID=FID/ROVRI
      AVGFID=AFID*1.E-06
      XCD=CD*100000.
C
C   COMPUTE EFFECTIVE MOBILITY
C
      UEQ=U/ROVRI
C
      XPI=ETAPF*100.
      RETURN
      END
```

```
      SUBROUTINE SPCHG2 (NS,XNO,VIS,RAD,LINC,E,U,ERAVG,DNSION,
     1DELTNP,SUMMOB,PNUM,RHOP,TCHRG,PMOB,TONSP,RDNSI,AFID,UEQ,AVGFID,
     2RIOVR,I,XS,ETAO,PL,ETAPF,CCF,XPI,OLDQ,Q,II,NSECT)
      REAL LINC
      DIMENSION XNO(20),RAD(20),CCF(20),OLDQ(20),Q(20)
      COMMON/BLK7/XDC(45,20)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK17/NREAD,NPRNT
      IF(I.NE.1) GO TO 1286
C
C   COMPUTE VALUE OF EXPONENT IN DEUTSCH EQUATION FOR THE DESIGN EFF.
C
      XS=ALOG(100./(100.-ETAO))
C
 1286 CONTINUE
C
C   COMPUTE EFFICIENCY PER LENGTH INCREMENT
C
      ETAPF = 1.-EXP(-LINC*XS/PL)
C
      DELTNP=0.
      SUMMOB=0.
      PNUM=0.
      RHOP=0.
      DO 1 J=1,NS
      TCHRG=XNO(J)*XDC(I,J)
      RHOP=RHOP+TCHRG
      SUMMOB=SUMMOB+(TCHRG*CCF(J))/(6.*3.14159*VIS*RAD(J))
      PNUM=PNUM+XNO(J)
      DIFF=XDC(I,J)
      IF((II.NE.1).OR.(I.NE.1)) DIFF=Q(J)-OLDQ(J)
      DELTNP=DELTNP+XNO(J)*DIFF
    1 CONTINUE
      PMOB=SUMMOB/PNUM
      TONSP=RHOP/1.6E-19
      DNSION=CHFID(II)
      DELTNP=DELTNP/1.6E-19
      RDNSI=DNSION-DELTNP
      IF(RDNSI.GT.0.) GO TO 10
      PIR=DELTNP/DNSION
      RDNSI=0.
      WRITE(NPRNT,11) PIR,I,II
   11 FORMAT(1X,' A FACTOR OF ',F8.3,' MORE IONS NEEDED IN INCREMENT ',I
     12,', INTERVAL ',I2,' TO MEET CHARGING RATE')
   10 CONTINUE
      AFID=RDNSI
      AVGFID=AFID*1.E-06
      UEQ=(U*AFID*E+PMOB*RHOP)/(AFID*E+RHOP)
      RIOVR=(AFID*E)/(AFID*E+RHOP)
      XPI=ETAPF*100.
      RETURN
      END
```

```
      SUBROUTINE EFLD1 (UEQ,CD,AC,VO,SX,SY,NX,NY,TDK,P,AEPLT,VERGE,
     1CVERGE)
C  EVALUATION OF FIELDS, SPACE CHARGE DENSITY, POTENTIAL , AND
C  CURRENT DENSITY FOR A WIRE-PLATE PRECIPITATOR
      REAL MAXJ,MINJ,MOBILT(15,15)
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CDNSTY(15,15),V(15,15),EY(15,15)
      COMMON /BLK13/VCOOP(15,15),NVIT
      COMMON/BLK17/NREAD,NPRNT
      DATA RHO/225*0./,V/225*0./,EX/225*0./,EY/225*0./,OLDRO/225*0./,
     1OLDV/225*0./,CDNSTY/225*0./,MOBILT/225*0./
      VO=-1.*VO
      PI=3.1416
      EPSO=8.854E-12
      RO = AC
      ROC = 100.0*RO
      RF = 1.0
      RELD = (293.0/TDK)*(P/1.0)
      EORO = ROC*RF*(30.0*RELD + 9.0*SQRT(RELD/ROC))*1.0E03
C
C   COMPUTE INITIAL ESTIMATE OF SPACE CHARGE DENSITY AT WIRE
C
      VERGE=(-2.*CD*(1.01 + 0.99)*SY)/(2.*PI*UEQ*EORO)
C
      QZERO=VERGE
      DO 550 I=1,NX
      DO 550 J=1,NY
      MOBILT(I,J)=UEQ
  550 CONTINUE
      MAXJ=CD*1.01
      MINJ=CD*0.99
      NX1=NX-1
      NY1=NY-1
      AX=SX/NX1
      AY=SY/NY1
      AXS=AX*AX
      AYS=AY*AY
      ASP=(AXS*AYS)/EPSO
      ASS=1./(2.*(AXS+AYS))
      Z=0.
      DO 4615 I=1,NX
      DO 4615 J=1,NY
 4615 V(I,J)=VCOOP(I,J)
    1 Z=Z+1.
      IZ=Z
      IF(Z.EQ.25) WRITE(NPRNT,1865)
 1865 FORMAT(1X,' CONVERGENCE ON CURRENT DENSITY CAN NOT BE OBTAINED IN
     125 ITERATIONS')
      IF(Z.EQ.25.) GO TO 700
      LL=0
  300 LL=LL+1
      RHO(1,1)=QZERO
      EX(1,1)=0.0
      EY(1,1)=0.0
      DO 201 I=2,NX
      EY(I,1)=0.
      EX(I,1)=(V(I-1,1)-V(I,1))/AX
      Q1=2.*MOBILT(I,1)
      Q2=Q1*AX
      Q3=Q1*AY
```

```
      Q4=Q2*AY
      Q5=-EPS0*EX(I,1)*(Q3-AY*MOBILT(I-1,1))
      Q6=Q5*Q5
      Q7=Q1*Q4*EPS0*AY*EX(I,1)*RHO(I-1,1)
      Q8=-SQRT(Q6+Q7)
      RHO(I,1)=(Q5+Q8)/Q4
  201 CONTINUE
      DO 203 J=2,NY
      EX(1,J)=0.
      EY(1,J)=(V(1,J-1)-V(1,J))/AY
      P1=2.*MOBILT(1,J)
      P2=P1*AX
      P3=P1*AY
      P4=P2*AY
      P5=-EPS0*EY(1,J)*(P2-AX*MOBILT(1,J-1))
      P6=P5*P5
      P7=P1*P4*EPS0*AX*EY(1,J)*RHO(1,J-1)
      P8=-SQRT(P6+P7)
      RHO(1,J)=(P5+P8)/P4
  203 CONTINUE
      DO 202 I=2,NX
      EY(I,NY)=0.
      EX(I,NY)=(V(I-1,NY)-V(I,NY))/AX
      R1=2.*MOBILT(I,NY)
      R2=R1*AX
      R3=R1*AY
      R4=R2*AY
      R5=-EPS0*EX(I,NY)*(R3-AY*MOBILT(I-1,NY))
      R6=R5*R5
      R7=R1*R4*EPS0*AY*EX(I,NY)*RHO(I-1,NY)
      R8=-SQRT(R6+R7)
      RHO(I,NY)=(R5+R8)/R4
  202 CONTINUE
      DO 307 I=2,NX
      DO 307 J=2,NY1
  313 EX(I,J)=(-1.)*(V(I,J)-V(I-1,J))/AX
      EY(I,J)=(-1.)*(V(I,J)-V(I,J-1))/AY
      D1=2.*MOBILT(I,J)
      D2=D1*AX
      D3=D1*AY
      D4=D2*AY
      D5=-EPS0*(EX(I,J)*(D3-AY*MOBILT(I-1,J))+EY(I,J)*(D2-AX*MOBILT(I,J-
     11)))
      D6=D5*D5
      D7=D1*D4*EPS0*(AY*EX(I,J)*RHO(I-1,J)+AX*EY(I,J)*RHO(I,J-1))
      D8=-SQRT(D6+D7)
      RHO(I,J)=(D5+D8)/D4
  307 CONTINUE
      DO 301 I=1,NX1
      DO 301 J=1,NY
      OLDV(I,J)=V(I,J)
      OLDRO(I,J)=RHO(I,J)
      IF(I.EQ.1.AND.J.EQ.1) GO TO 301
      IF(I.EQ.1.AND.J.NE.1) GO TO 304
      IF(I.NE.1.AND.J.EQ.1) GO TO 305
      IF(J.EQ.NY) GO TO 600
      GO TO 306
  600 V(I,NY)=ASS*(AYS*(V(I-1,NY)+V(I+1,NY))+2.*AXS*V(I,NY-1)+ASP*RHO(I,
     1NY))
      GO TO 301
```

```
      304 IF(I.EQ.1.AND.J.EQ.NY)  GO TO 350
          V(1,J)=ASS*(2.*AYS*V(2,J)+AXS*(V(1,J+1)+V(1,J-1))+ASP*RHO(1,J))
          GO TO 301
      350 V(1,NY)=ASS*(2.*AYS*V(2,NY)+2.*AXS*V(1,NY-1)+ASP*RHO(1,NY))
          GO TO 301
      305 V(I,1)=ASS*(AYS*(V(I+1,1)+V(I-1,1))+2.*AXS*V(I,2)+ASP*RHO(I,1))
          GO TO 301
      306 V(I,J)=ASS*(AYS*(V(I+1,J)+V(I-1,J))+AXS*(V(I,J-1)+V(I,J+1))+ASP*RH
         1O(I,J))
      301 CONTINUE
          IF(LL.EQ.2000) WRITE(NPRNT,1866)
     1866 FORMAT(1X,' CONVERGENCE ON POTENTIAL GRID CAN NOT BE OBTAINED IN 2
         1000 ITERATIONS')
          IF(LL.EQ.2000) GO TO 700
          DO 320 I=1,NX1
          DO 320 J=1,NY1
          IF(ABS(V(I,J)-OLDV(I,J)).LT.1.) GO TO 320
          GO TO 300
      320 CONTINUE
          CDNSTY(NX,1)=EX(NX,1)*MOBILT(NX,1)*RHO(NX,1)
          ACDNTY=CDNSTY(NX,1)
      950 DO 900 J=2,NY
          CDNSTY(NX,J)=EX(NX,J)*MOBILT(NX,J)*RHO(NX,J)
          ACDNTY=ACDNTY+CDNSTY(NX,J)
      900 CONTINUE
          ACDNTY=ACDNTY/NY
          IF(ACDNTY.GT.MAXJ) GO TO 910
          IF(ACDNTY.LT.MINJ) GO TO 920
          GO TO 980
     910  QZERO=MINJ/ACDNTY*QZERO
          GO TO 1
     920  QZERO=MAXJ/ACDNTY*QZERO
          GO TO 1
      980 EPLT=EX(NX,1)
          DO 1000 J=2,NY
          EPLT=EPLT+EX(NX,J)
    1000  CONTINUE
          AEPLT=EPLT/NY
     700  CONTINUE
          CVERGE=QZERO
          VO=-1.*VO
          RETURN
          END
 PROG > 4K
```

```
      SUBROUTINE EFLD2 (UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACDNTY,NWIRE,NEC,EBD,JI1,JI2)
C  EVALUATION OF FIELDS, SPACE CHARGE DENSITY, POTENTIAL , AND
C  CURRENT DENSITY FOR A WIRE-PLATE PRECIPITATOR
      REAL MAXJ,MINJ,MOBILT(15,15),NWIRE,MAXS
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CDNSTY(15,15),V(15,15),EY(15,15),EAVGS(30),CHFIDS(30),ECOLLS(30)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK9/ECOLL(30)
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK17/NREAD,NPRNT
      DATA RHO/225*0./,V/225*0./,EX/225*0./,EY/225*0./,OLDRO/225*0./,
     1OLDV/225*0./,CDNSTY/225*0./,MOBILT/225*0./
      IVCK=0
      VO=-1.*VO
      VW=-1.*VSTART
      RO=AC
      RELD=(293./TDK)*(P/1.)
      ROC=100.*RO
      EORO=ROC*RF*(30.*RELD+9.*SQRT(RELD/ROC))*1.E+03
      DO 550 I=1,NX
      DO 550 J=1,NY
      MOBILT(I,J)=UEQ
  550 CONTINUE
      PI=3.1416
      EPSO=8.854E-12
      SSTART=START
      MINJ=0.
      MAXS=0.
      NX1=NX-1
      NY1=NY-1
      AX=SX/NX1
      AY=SY/NY1
      AXS=AX*AX
      AYS=AY*AY
      ASP=(AXS*AYS)/EPSO
      ASS=1./(2.*(AXS+AYS))
      DO 1001 II=1,IFINAL
      IF(II.EQ.JI1) START=DSTART
      IF(II.GE.JI2) START=CSTART
      MAXS=MAXS+START
 1526 CONTINUE
      MAXJ=MAXS*1.01
      MINJ=MAXS*.99
      QZERO=-(2.*(MAXJ+MINJ)*SY*1.E-03)/(2.*PI*UEQ*ROC*RF*(30.*RELD+9.*
     1SQRT(RELD/ROC)))
      CALL CMAN(VW,NX,NY,SX,SY,PI,AC,NWIRE)
      Z=0
      DO 4615 I=1,NX
      DO 4615 J=1,NY
 4615 V(I,J)=VCOOP(I,J)
    1 Z=Z+1
      IZ=Z
      IF(Z.EQ.25) WRITE(NPRNT,1865)
 1865 FORMAT(1X,' CONVERGENCE ON CURRENT DENSITY CAN NOT BE OBTAINED IN
     125 ITERATIONS')
      IF(Z.EQ.25) GO TO 700
      LL=0
  300 LL=LL+1
      RHO(1,1)=QZERO
```

```
      V(1,1)=VW
      EX(1,1)=0.0
      EY(1,1)=0.0
      DO 201 I=2,NX
      EY(I,1)=0.
      EX(I,1)=(V(I-1,1)-V(I,1))/AX
      Q1=2.*MOBILT(I,1)
      Q2=Q1*AX
      Q3=Q1*AY
      Q4=Q2*AY
      Q5=-EPS0*EX(I,1)*(Q3-AY*MOBILT(I-1,1))
      Q6=Q5*Q5
      Q7=Q1*Q4*EPS0*AY*EX(I,1)*RHO(I-1,1)
      Q7=ABS(Q7)
      Q8=-SQRT(Q6+Q7)
      RHO(I,1)=(Q5+Q8)/Q4
  201 CONTINUE
      DO 203 J=2,NY
      EX(1,J)=0.
      EY(1,J)=(V(1,J-1)-V(1,J))/AY
      P1=2.*MOBILT(1,J)
      P2=P1*AX
      P3=P1*AY
      P4=P2*AY
      P5=-EPS0*EY(1,J)*(P2-AX*MOBILT(1,J-1))
      P6=P5*P5
      P7=P1*P4*EPS0*AX*EY(1,J)*RHO(1,J-1)
      P7=ABS(P7)
      P8=-SQRT(P6+P7)
      RHO(1,J)=(P5+P8)/P4
  203 CONTINUE
      DO 202 I=2,NX
      EY(I,NY)=0.
      EX(I,NY)=(V(I-1,NY)-V(I,NY))/AX
      R1=2.*MOBILT(I,NY)
      R2=R1*AX
      R3=R1*AY
      R4=R2*AY
      R5=-EPS0*EX(I,NY)*(R3-AY*MOBILT(I-1,NY))
      R6=R5*R5
      R7=R1*R4*EPS0*AY*EX(I,NY)*RHO(I-1,NY)
      R7=ABS(R7)
      R8=-SQRT(R6+R7)
      RHO(I,NY)=(R5+R8)/R4
  202 CONTINUE
      DO 307 I=2,NX
      DO 307 J=2,NY1
  313 EX(I,J)=(-1.)*(V(I,J)-V(I-1,J))/AX
      EY(I,J)=(-1.)*(V(I,J)-V(I,J-1))/AY
      D1=2.*MOBILT(I,J)
      D2=D1*AX
      D3=D1*AY
      D4=D2*AY
      D5=-EPS0*(EX(I,J)*(D3-AY*MOBILT(I-1,J))+EY(I,J)*(D2-AX*MOBILT(I,J-
     11)))
      D6=D5*D5
      D7=D1*D4*EPS0*(AY*EX(I,J)*RHO(I-1,J)+AX*EY(I,J)*RHO(I,J-1))
      D7=ABS(D7)
      D8=-SQRT(D6+D7)
      RHO(I,J)=(D5+D8)/D4
```

```
  307 CONTINUE
      DO 301 I=1,NX1
      DO 301 J=1,NY
      OLDV(I,J)=V(I,J)
      OLDRO(I,J)=RHO(I,J)
      IF(I.EQ.1.AND.J.EQ.1) GO TO 301
      IF(I.EQ.1.AND.J.NE.1) GO TO 304
      IF(I.NE.1.AND.J.EQ.1) GO TO 305
      IF(J.EQ.NY) GO TO 600
      GO TO 306
  600 V(I,NY)=ASS*(AYS*(V(I-1,NY)+V(I+1,NY))+2.*AXS*V(I,NY-1)+ASP*RHO(I,
     1NY))
      GO TO 301
  304 IF(I.EQ.1.AND.J.EQ.NY)  GO TO 350
      V(1,J)=ASS*(2.*AYS*V(2,J)+AXS*(V(1,J+1)+V(1,J-1))+ASP*RHO(1,J))
      GO TO 301
  350 V(1,NY)=ASS*(2.*AYS*V(2,NY)+2.*AXS*V(1,NY-1)+ASP*RHO(1,NY))
      GO TO 301
  305 V(I,1)=ASS*(AYS*(V(I+1,1)+V(I-1,1))+2.*AXS*V(I,2)+ASP*RHO(I,1))
      GO TO 301
  306 V(I,J)=ASS*(AYS*(V(I+1,J)+V(I-1,J))+AXS*(V(I,J-1)+V(I,J+1))+ASP*RH
     1O(I,J))
  301 CONTINUE
      IF(LL.EQ.2000) WRITE(NPRNT,1866)
 1866 FORMAT(1X,' CONVERGENCE ON POTENTIAL GRID CAN NOT BE OBTAINED IN 2
     1000 ITERATIONS')
      IF(LL.EQ.2000) GO TO 700
      DO 320 I=1,NX1
      DO 320 J=1,NY
      IF(ABS(V(I,J)-OLDV(I,J)).LT.1.) GO TO 320
      GO TO 300
  320 CONTINUE
      CDNSTY(NX,1)=EX(NX,1)*MOBILT(NX,1)*RHO(NX,1)
      ACDNTY=CDNSTY(NX,1)
  950 DO 900 J=2,NY
      CDNSTY(NX,J)=EX(NX,J)*MOBILT(NX,J)*RHO(NX,J)
      ACDNTY=ACDNTY+CDNSTY(NX,J)
  900 CONTINUE
      ACDNTY=ACDNTY/NY
      IF(ACDNTY.GT.MAXJ) GO TO 910
      IF(ACDNTY.LT.MINJ) GO TO 920
      GO TO 980
  910 VW=VW+1.*VW*(MAXJ-ACDNTY)/MAXJ
      GO TO 1000
  920 VW=VW+1.*VW*(MINJ-ACDNTY)/MINJ
 1000 CONTINUE
      TEST=ABS(ACDNTY-(MAXJ+MINJ)/2.)
      TEST1=0.01*ACDNTY
      IF(TEST.LT.TEST1) GO TO 980
      GO TO 1
  980 CONTINUE
      EPLT=EX(NX,1)
      DO 1200 J=2,NY
      EPLT=EPLT+EX(NX,J)
 1200 CONTINUE
      AEPLT=EPLT/NY
  700  CONTINUE
      WRITE(NPRNT,8888) VW,ACDNTY,AEPLT
 8888 FORMAT(38X,'VW = ',1PE11.4,2X,'ACDNTY = ',1PE11.4,2X,'AEPLT = ',1P
     1E11.4//)
```

```
      IF(ABS(EX(NX,1)).LT.EBD) GO TO 1480
      WRITE(NPRNT,1481) VW,ACDNTY
 1481 FORMAT(' THE BREAKDOWN FIELD NEAR THE PLATE IS EXCEEDED AT VW =',E
     111.4,1X,'AND ACDNTY =',E11.4)
      GO TO 1525
 1480 CONTINUE
      IF(IVCK.EQ.1) GO TO 1525
      IF(ABS(VW).EQ.ABS(VO)) GO TO 1525
      IF(ABS(VW).GT.ABS(VO)) GO TO 1523
      OLDVW=VW
      OLDCD=ACDNTY
      GO TO 1524
 1523 CONTINUE
      MAXS=ACDNTY-((ACDNTY-OLDCD)/(VW-OLDVW))*(VW-VO)
      VW=OLDVW
      IVCK=1
      GO TO 1526
 1524 CONTINUE
 1001 CONTINUE
 1525 CONTINUE
      IF(NEC.NE.0) GO TO 3000
      K=1
      DO 3001 J=1,NY1
      RSUM=0.
      ESUM=0.
      DO 3002 I=1,NX
      IF(J.EQ.1) GO TO 3005
      ESUM=ESUM+(SQRT(EX(I,J)**2+EY(I,J)**2)+SQRT(EX(I,J+1)**2+
     1EY(I,J+1)**2))/(2.*NX)
      GO TO 3006
 3005 CONTINUE
      ESUM=ESUM+SQRT(EX(I,J+1)**2+EY(I,J+1)**2)/(2.*NX)
      IF(I.EQ.NX) ESUM=ESUM-VO/(2.*SX)
 3006 CONTINUE
      RSUM=RSUM-(RHO(I,J)+RHO(I,J+1))/(2.*1.6E-19*NX)
 3002 CONTINUE
      EAVGS(K)=ESUM
      CHFIDS(K)=RSUM
      K=K+1
 3001 CONTINUE
      NYY=NY1
      DO 3003 L=1,NY1
      EAVG(L)=EAVGS(NYY)
      CHFID(L)=CHFIDS(NYY)
      NYY=NYY-1
 3003 CONTINUE
      KK=1
      M1=NY1+1
      M2=2*NY1
      DO 3004 M=M1,M2
      EAVG(M)=EAVGS(KK)
      CHFID(M)=CHFIDS(KK)
      KK=KK+1
 3004 CONTINUE
 3000 CONTINUE
      LL=1
      DO 3007 NN=1,NY1
      ECOLLS(LL)=-(EX(NX,NN)+EX(NX,NN+1))/2.
      LL=LL+1
 3007 CONTINUE
```

```
      L1=NY1
      DO 3008 L=1,NY1
      ECOLL(L)=ECOLL8(L1)
      L1=L1-1
 3008 CONTINUE
      L2=1
      I1=NY1+1
      I2=2*NY1
      DO 3009 I=I1,I2
      ECOLL(I)=ECOLL8(L2)
      L2=L2+1
 3009 CONTINUE
      VO=-1.*VO
      START=SSTART
      RETURN
      END
 PROG > 4K
```

```
      SUBROUTINE CHARGN (ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST
     *,CMKS,RR,FCONST,FACTOR,COEFF,AFID,RATE,H,XI,YI,NN,X,Y)
      H2=H/2.
      Y=YI
      X=XI
      DO 2 I=1,NN
      T1=H*RATE(ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,CMKS,RR,
     *FCONST,FACTOR,COEFF,AFID,X,Y)
      T2=H*RATE(ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,CMKS,RR,
     *FCONST,FACTOR,COEFF,AFID,X+H2,Y+T1/2.)
      T3=H*RATE(ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,CMKS,RR,
     *FCONST,FACTOR,COEFF,AFID,X+H2,Y+T2/2.)
      T4=H*RATE(ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,CMKS,RR,
     *FCONST,FACTOR,COEFF,AFID,X+H,Y+T3)
      Y=Y+(T1+2.*T2+2.*T3+T4)/6.
      X=X+H
    2 CONTINUE
      RETURN
      END
```

```
      FUNCTION RATE (ECHARG,SCHARG,NUMINC,CONST,EZERO,V,RSIZE,ECONST,
     *CMKS,RR,FCONST,FACTOR,COEFF,AFID,NTIME,NUMBER)
      REAL INTGRL,NE,NUMBER,NTIME
      DIMENSION T(3),A(3)
      DATA T/-0.77459667,0.0,0.77459667/
      DATA A/0.55555556,0.88888889,0.55555556/
      NE=-NUMBER*ECHARG
      PI=3.1415927
      IF(NUMBER-SCHARG)7005,7006,7006
 7005 CALL ARCCOS(NUMBER,SCHARG,THZERO)
      IF(THZERO.LE.1.E-05) GO TO 7006
      IF(1.57-THZERO) 7011,7011,7015
 7015 CONTINUE
      GO TO 7007
 7006 THZERO=0.
 7007 YFUC=0.0
      DO 7002 I=1,3
      THETA=T(I)*(PI-2.*THZERO)/4.+(PI+2.*THZERO)/4.
      CTHETA=COS(THETA)
      TCONST=CONST*CTHETA
      ECOS=EZERO*CTHETA
      C1=-NE/(CMKS*ECOS)
      CO=TCONST/(2.*ECOS)
      CALL ZERO(C1,CO,RZERO)
      ARG1=-(NUMBER*V*(RZERO-RSIZE)/RZERO+(ECONST-RR*RZERO+FCONST/RZERO*
     1*2)*CTHETA)
      IF(ABS(ARG1).GT.30.0) GO TO 7025
      YVAL=EXP(ARG1)*SIN(THETA)
      GO TO 7026
 7025 YVAL=0.
 7026 CONTINUE
      YFUC=YFUC+A(I)*YVAL
 7002 CONTINUE
      RATE1=(PI-2.*THZERO)/4.*YFUC*FACTOR*AFID
      GO TO 7012
 7011 RATE1=0.
 7012 CONTINUE
      ARG3=-V*NUMBER
      IF(ABS(ARG3).GT.30.0) GO TO 7031
      RATE2=FACTOR*EXP(ARG3)*AFID
      GO TO 7032
 7031 RATE2=0.
 7032 CONTINUE
      IF(NUMBER-SCHARG)7008,7009,7009
 7008 RATE3=COEFF*(1.-NUMBER/SCHARG)**2*AFID
      GO TO 7010
 7009 RATE3=0.
 7010 CONTINUE
      RATE=RATE1+RATE2+RATE3
      RETURN
      END
```

```
      SUBROUTINE ARCCOS (A,B,ACOS)
      RATIO=A/B
      T=1.
      SUM=0.
      TERM=RATIO
    1 U=2.*T-1.
      V=2.*T
      W=2.*T+1.
      TERM=TERM/V*U**2/W*RATIO**2
      SUM=SUM+TERM
      T=T+1.
      IF(TERM-5.E-05)3,3,1
    3 ACOS=1.5707963-SUM-RATIO
      RETURN
      END
```

```
      SUBROUTINE ZERO (C1,CO,RZERO)
      B=SQRT((27.*CO*CO)/(C1*C1*C1))
      CALL ARCCOS(B,1.,C)
      D=-2.*SQRT(C1/3.)
      RZERO=D*COS((C+6.28318)/3.)
      RETURN
      END
```

```
      SUBROUTINE CHGSUM
      REAL LINC,LTHICK,JPART,JION
      COMMON/BLK5/ZMMDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
      COMMON/BLK6/VOL(20),XNO(20),Q(20),WS(20),ITL(40),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK14/TMFP,NVI,NV1
      COMMON/BLK15/NPRINT,NSECT,SLNGTH,A,VO,TC,B,AC,WL,CL,CD,ET,SY,
     1VGAS,P,VIS,W,LINC,XPI,RIOVR,EPLT,AFID,XCD,ZMD,
     2WT,LTHICK,JPART,JION,I,ROVRI
      COMMON/BLK20/SCHARG,CHRFID,TIMEI,TIMEF,V,FACTRE,RSIZE,CNUMBR,J,II,
     1ITER,OLDQF(20),OLDQT(20),SOLDQF(20),SOLDQT(20)
      IF(NVI.EQ.1) GO TO 50
      IF((I.EQ.1).AND.(II.EQ.1)) GO TO 51
      GO TO 52
   51 CONTINUE
      OLDQF(J)=0.
      OLDQT(J)=0.
   52 CONTINUE
      IF(ITER.NE.1) GO TO 53
      IF(II.GT.1) GO TO 50
      SOLDQF(J)=OLDQF(J)
      SOLDQT(J)=OLDQT(J)
   53 CONTINUE
      IF((ITER.GT.1).AND.(II.EQ.1)) GO TO 54
      GO TO 55
   54 CONTINUE
      OLDQF(J)=SOLDQF(J)
      OLDQT(J)=SOLDQT(J)
   55 CONTINUE
   50 CONTINUE
      IF(NVI.EQ.2) GO TO 56
      IF(I.GT.1) GO TO 56
      OLDQF(J)=0.
      OLDQT(J)=0.
   56 CONTINUE
      SATCHG=E*SCHARG
      IF(OLDQF(J).GE.SATCHG) GO TO 1
      CF1=((CHRFID*U*E)/(4.*EPSO))*(TIMEF-TIMEI)
      CF2=1./(1.-OLDQF(J)/SATCHG)
      QF=SATCHG*((CF1+CF2-1.)/(CF1+CF2))
      IF(QF.GT.SATCHG) QF=SATCHG
      GO TO 2
    1 CONTINUE
      QF=OLDQF(J)
    2 CONTINUE
      OLDQF(J)=QF
      ARG=(V*OLDQT(J))/E
      IF(ARG.GT.30.) GO TO 10
      QT=(E/V)*ALOG(((E**2*RSIZE*VAVC*CHRFID)/(4.*EPSO*BC*TDK))*(TIMEF-
     1TIMEI)+EXP(ARG))
      OLDQT(J)=QT
      GO TO 9
   10 CONTINUE
      QT=OLDQT(J)
    9 CONTINUE
      CNUMBR=(QF+QT)/E
      RETURN
```

```
      SUBROUTINE PRTINC
      REAL LINC,LTHICK,JPART,JION
      COMMON/BLK3/VG,ATOTAL,DD,ETAO,DL,PL,RHO
      COMMON/BLK5/ZMHDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
      COMMON/BLK6/VOL(20),XNO(20),Q(20),WS(20),ITL(40),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK14/TMFP,NVI,NV1
      COMMON/BLK15/NPRINT,NSECT,SLNGTH,A,VO,TC,B,AC,WL,CL,CD,ET,SY,
     1VGAS,P,VIS,W,LINC,XPI,RIOVR,EPLT,AFID,XCD,ZMD,
     2WT,LTHICK,JPART,JION,I,ROVRI
      COMMON/BLK17/NREAD,NPRNT
      IF(NPRINT.NE.1) GO TO 8439
      IF(NSECT.GT.1) GO TO 1585
      WRITE(NPRNT,6550)
 6550 FORMAT(///' INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE'//)
      WRITE(NPRNT,3010) ITL
 3010 FORMAT('0',40A2/)
 1585 CONTINUE
      NPRINT=0
      WRITE(NPRNT,7820) NSECT,SLNGTH
 7820 FORMAT(/' CALCULATION IS IN SECTION NO. =',I2,' AND THE SECTION LE
     1NGTH IS =',F8.4,' M')
      WRITE(NPRNT,7715) A,VO,TC
 7715 FORMAT(/' COLLECTION AREA =',1PE11.3,' M2',T41,'APPLIED VOLTAGE ='
     1,E11.3,' VOLTS',7X,'TOTAL CURRENT =',E11.3,' AMPS')
      WRITE(NPRNT,7716) B,AC,WL
 7716 FORMAT(' WIRE TO PLATE =',1PE11.3,' M',T41,'CORONA WIRE RADIUS =',
     1E11.3,' M',8X,'CORONA WIRE LENGTH =',E11.3,' M')
      WRITE(NPRNT,7717) CL,CD,ET
 7717 FORMAT(' CURRENT/M =',1PE11.3,' AMP/M',T41,'CURRENT DENSITY =',E11
     1.3,' AMP/M2',6X,'DEPOSIT E FIELD =',E11.3,' VOLT/M')
      WRITE(NPRNT,7718) SY,VG,VGAS
 7718 FORMAT(' 1/2 WIRE TO WIRE =',1PE11.3,' M',T41,'GAS FLOW RATE =',E1
     11.3,' M3/SEC',8X,'GAS VELOCITY =',E11.3,' M/SEC')
      WRITE(NPRNT,7731) TDK,P,VIS
 7731 FORMAT(' TEMPERATURE =',F8.3,' K',T41,'PRESSURE =',F8.3,' ATM',19X
     1,'VISCOSITY =',1PE11.3,' KG/M-SEC')
      WRITE(NPRNT,7732) U,VAVC,TMFP
 7732 FORMAT(' ION MOBILITY =',1PE11.3,' M2/VOLT-SEC',T41,'MEAN THERMAL
     1SPEED =',E11.3,' M/SEC',4X,'PART. PATH PARAM. =',E11.3,' M')
      WRITE(NPRNT,7733) W,LINC,XPI
 7733 FORMAT(' DUST WEIGHT =',1PE11.3,' KG/SEC',T41,'LENGTH INCR. =',0PF
     110.8,' M',15X,'INPUT EFF./INCR. =',F6.2)
      IF(NVI.EQ.1) GO TO 4689
      WRITE(NPRNT,4322)
 4322 FORMAT(//T2,'RIOVR',5X,'ERAVG',8X,'EPLT',8X,'AFID',6X,'CMCD',6X,'M
     1MD',8X,'WEIGHT',4X,'DUST LAYER',3X,'J(PART)',6X,'J(ION)',3X,'INCR.
     2 NO.'/)
      GO TO 4690
 4689 CONTINUE
      WRITE(NPRNT,4333)
 4333 FORMAT(//T2,'ROVRI',5X,'ERAVG',8X,'EPLT',8X,'AFID',6X,'CMCD',6X,'M
     1MD',8X,'WEIGHT',4X,'DUST LAYER',3X,'J(PART)',6X,'J(ION)',3X,'INCR.
     2 NO.'/)
 4690 CONTINUE
 8439 CONTINUE
      IF(NVI.EQ.1) GO TO 4691
```

```
      WRITE(NPRNT,4323) RIOVR,ERAVG,EPLT,AFID,XCD,ZMD,WT,LTHICK,
     1JPART,JION,I
 4323 FORMAT(T2,F6.4,1X,1PE11.3,1X,E11.4,1X,E11.4,1X,0PF7.1,1X,1PE10.2,1
     1X,E11.3,1X,E11.3,1X,E10.2,2X,E10.2,6X,I2)
      GO TO 3000
 4691 CONTINUE
      WRITE(NPRNT,4334) ROVRI,ERAVG,EPLT,AFID,XCD,ZMD,WT,LTHICK,
     1JPART,JION,I
 4334 FORMAT(T2,F6.4,1X,1PE11.3,1X,E11.4,1X,E11.4,1X,0PF7.1,1X,1PE10.2,1
     1X,E11.3,1X,E11.3,1X,E10.2,2X,E10.2,6X,I2)
 3000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRTCHG
      REAL NWS
      INTEGER VISKIP,VISAME
      DIMENSION YY(20)
      COMMON/BLK1/DIAM(20),ONO(20),DXS(20),XMV(20),PCNT(20),RAD(20),
     1CCF(20),PRCU(21)
      COMMON/BLK4/NS
      COMMON/BLK6/VOL(20),XNO(20),Q(20),WS(20),ITL(40),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK7/XDC(45,20)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK14/TMFP,NVI,NV1
      COMMON/BLK16/NCALC,NI,VRATIO,NF
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK19/LK,DV,NN,NUMINC,NX,NY,NDATA,NEST,NDIST,NITER,IFINAL,
     1JI1,JI2,VISKIP,VISAME,US,FPATH,EBD,NDSET,NWS(10),D50,SIGMAP
C
C OUTPUT FROM CHARGING ROUTINE
C
      WRITE(NPRNT,9992)
 9992 FORMAT(1H1)
      WRITE(NPRNT,356)
  356 FORMAT(/T3,'CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHAR
     1GN OR CHGSUM'/)
      IF((NCALC.EQ.1).OR.(NEST.EQ.2)) GO TO 1880
      WRITE(NPRNT,1879)
 1879 FORMAT(/T3,'SRI THEORY USED FOR PARTICLE CHARGING')
      GO TO 1881
 1880 CONTINUE
      WRITE(NPRNT,1882)
 1882 FORMAT(/T3,'SUM OF CLASSICAL FIELD AND DIFFUSIONAL CHARGES USED FO
     1R PARTICLE CHARGING')
 1881 CONTINUE
      WRITE(NPRNT,2500)
 2500 FORMAT(//T2,'INCREMENT NO.',T20,'Q/QSATF FOR INDICATED PARTICLE SI
     1ZES')
      JS=1
      KS=8
 6544 CONTINUE
      IF(KS-NS) 6541,6542,6542
 6542 CONTINUE
      KS=NS
 6541 CONTINUE
      WRITE(NPRNT,357) (DIAM(J),J=JS,KS)
 357  FORMAT(//T4,10(E11.4,2X)//)
      DO 360 I=1,NP
      DO 359 J=JS,KS
      IF(NVI.EQ.1) GO TO 4692
      N = NI/2
      QSATM=(4.*PI*EPSO*(RAD(J)+TMFP)**2)*EAVG(N)*(1.+2.*((EPS-1.)/
     1(EPS+2.))*(RAD(J)/(RAD(J)+TMFP))**3)*VRATIO
      YY(J)=XDC(I,J)/QSATM
      GO TO 359
 4692 CONTINUE
      YY(J)=XDC(I,J)/QSAT(J)
  359 CONTINUE
      WRITE(NPRNT,358) I,(YY(J),J=JS,KS)
```

```
  358 FORMAT(T3,I2,T6,10(F7.4,6X))
  360 CONTINUE
      IF(KS.EQ.NS) GO TO 6543
      JS=JS+8
      KS=KS+8
      GO TO 6544
 6543 CONTINUE
      WRITE(NPRNT,9992)
      WRITE(NPRNT,432)
  432 FORMAT(/T5,'CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT
     1'//T3,'INCREMENT',T20,'CHARGE FOR INDICATED PARTICLE SIZES')
      JS=1
      KS=8
 6565 CONTINUE
      IF(KS-NS) 6566,6567,6567
 6567 CONTINUE
      KS=NS
 6566 CONTINUE
      WRITE(NPRNT,425) (DIAM(J),J=JS,KS)
 425  FORMAT(//T8,10(E11.4,3X)//)
      DO 431 I=1,NF
      WRITE(NPRNT,430) I,(XDC(I,J),J=JS,KS)
 430  FORMAT(T3,I2,T6,10(E13.5,1X))
 431  CONTINUE
      IF(KS.EQ.NS) GO TO 6568
      JS=JS+8
      KS=KS+8
      GO TO 6565
 6568 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ADJUST
C                                 ***********************************************
C                                 *                                             *
C                                 *  RAPPING REENTRAINMENT PROCEDURE IN         *
C                                 *                                             *
C                                 *  THIS SUBROUTINE WAS DEVELOPED UNDER        *
C                                 *                                             *
C                                 *  THE SPONSORSHIP OF E.P.R.I. BY SO.R.I.     *
C                                 *                                             *
C                                 ***********************************************
      DOUBLE PRECISION EFESR,DLOG,EFFWR
      REAL LINCS
      DIMENSION RPCNT(20),DMDLD(20),WUNCOR(20),RDMDLD(20),CDMDLD(20),
     1PCTOT(20),CPCTOT(20),WSL(20),PXS(20),PRCUNR(21),RPRCU(21),
     2PRCUC(21),EUNCOR(20)
      COMMON/BLK1/DIAM(20),DNO(20),DXS(20),XMV(20),PCNT(20),RAD(20),
     1CCF(20),PRCU(21)
      COMMON/BLK2/LSECT(10),LINCS(10),PS(10)
      COMMON/BLK3/VG.ATOTAL,DD,ETAO,DL.PL,RHO
      COMMON/BLK4/NS
      COMMON/BLK5/ZMMDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
      COMMON/BLK6/VOL(20),XNO(20),G(20),WS(20),ITL(60),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK11/ENDPT(21),NENDPT
      COMMON/BLK12/ARD50(10),ARSIGM(10),ASNUCK(15),AZNUMS(15),AZIGGY(15)
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK18/SCOREF,CZMDL,CSIGMO,NRUN,SNUCK,ZIGGY,RMMD,RSIGMA
      COMMON/BLK19/LK,DV,NN,NUMINC,NX,NY,NDATA,NEST,NDIST,NITER,IFINAL,
     1JI1,JI2,VISKIP,VISAME,US,FPATH,EBD,NDSET,NWS(10),D50,SIGMAP
      NRUN = 0
      NS1=NS+1
      NUMS1=NUMSEC-1
      CONVF=3.67E+03*(TDK/PS(NUMSEC))
      NRAPDC=0
      X=0.0
      DO 1555 I=1,NS
      EFESR=DXS(I)/DNO(I)
      IF(EFESR.GT.0.999999) EFESR=0.999999
      X=X+EFESR*PCNT(I)
 1555 CONTINUE
 1713 CONTINUE
      NRAPDC=NRAPDC+1
      IF(NRAPDC.EQ.1) GO TO 6078
      GO TO 6080
 6078 CONTINUE
      ARD50(1)=6.0
      ARSIGM(1)=2.5
      RMMD=6.0
      RSIGMA=2.5
      GO TO 6079
 6080 CONTINUE
      RMMD=ARD50(NRAPDC)
      RSIGMA=ARSIGM(NRAPDC)
 6079 CONTINUE
      CALL LNDIST(RMMD,RSIGMA,RPRCU,RPCNT)
      DO 7575 I=1,NS
      RPCNT(I)=RPCNT(I)*1.E+02
```

```
061      7575 CONTINUE
062           NONCK=0
063      1867 CONTINUE
064           NONCK=NONCK+1
065           SNUCK=ASNUCK(NONCK)
066           ZIGGY=AZIGGY(NONCK)
067           ZNUMS=AZNUMS(NONCK)
068           WRITE(NPRNT,18)
069        18 FORMAT(1H1,' PARTICLE SIZE RANGE STATISTICS'/)
070           WRITE(NPRNT,1868) NONCK
071      1868 FORMAT(/' CORRECTIONS FOR NONIDEALITIES USING SET NO. ',I2,' OF CO
072          1RRECTION PARAMETERS'/)
073      C
074      C       PRINT DIAM., PERCENT, AND EFFICIENCY FOR EACH SIZE RANGE
075      C
076           WRITE(NPRNT,19)
077        19 FORMAT(4X,'SIZE',5X,'CCF',2X,'INLET X',1X,'OUTLET X',1X,'COR. OUTL
078          1ET X',1X,'NO-RAP EFF.',1X,'NO-RAP W',2X,'NO-RAP P',2X,'COR. EFF.',
079          23X,'COR. W',5X,'COR. P')
080      C
081      C
082           Y=0.0
083           DO 2990 I=1,NS
084           EFESR=DXS(I)/ONO(I)
085           IF (EFESR .GT..999999 ) EFESR = .999999
086           XEP=EFESR*100.D0
087           IF (XEP .GE. 99.9999  ) XEP = 99.9999
088           IF(EFESR.GE.0.99999)WY=XMV(I)*100.
089           IF(EFESR.LT.0.99999)WY=(VG/ATOTAL)*100.*ALOG(100./(100.-XEP))
090           IF(ZIGGY-0.0)4704,4704,4705
091      4704 F1=1.
092           GO TO 4706
093      4705 CONTINUE
094           F1=1.+.766*EFESR*ZIGGY**1.786+.0755*ZIGGY*DLOG(1.D0/(1.D0-EFESR))
095      4706 CONTINUE
096           IF(SNUCK-0.0)4701,4701,4702
097      4701 F2=1.
098           GO TO 4703
099      4702 F2=DLOG(1.-EFESR)/(ZNUMS*DLOG(SNUCK+(1.-SNUCK)*(1.0-EFESR)**(1./
100          1ZNUMS)))
101      4703 CONTINUE
102           WYS=WY/F2
103           WYV=WY/F1
104           ZNLFF = F1*F2
105           WYSV=WY/ZNLFF
106           WUNCOR(I)=WY
107           EUNCOR(I)=EFESR*100.
108           CALL WADJST(DIAM,I,WYSV,ONO,PXS,ATOTAL,VG,EFESR)
109           IF (EFESR .GT..999999 ) EFESR = .999999
110           XEP=EFESR*100.D0
111           IF (XEP .GE. 99.9999  ) XEP = 99.9999
112           IF(EFESR.GE.0.99999)WY=XMV(I)*100.
113           IF(EFESR.LT.0.99999)WY=(VG/ATOTAL)*100.*ALOG(100./(100.-XEP))
114           PXS(I)=EFESR*ONO(I)
115           Y = Y + EFESR * PCNT(I)
116      2990 CONTINUE
117           IDC=0.
118           SPO=0.
119           SCPO=0.
120           IX=0
```

```
 1341 CONTINUE
      SCOREF = 0.0
      IDC=IDC+1
      DO 3540 I=1,NS
      IX=IX+1
      EFESR=PXS(I)/ONO(I)
      IF (EFESR .GT. .999999 ) EFESR = .999999
      XEP=EFESR*100.D0
      IF (XEP .GE. 99.9999  ) XEP = 99.9999
      IF(EFESR.GE.0.99999)WY=XMV(I)*100.
      IF(EFESR.LT.0.99999)WY=(VG/ATOTAL)*100.*ALOG(100./(100.-XEP))
      XY=PCNT(I)*100.
      PENTR=100.-XEP
      PCTOT(I)=PENTR*PCNT(I)*1.E-02
      IF(IX.GT.1) GO TO 7130
      CLPTLS=0.
      DO 1 IS=1,NUMS1
      CLPTLS=CLPTLS+FLOAT(LSECT(IS))*LINCS(IS)*0.305
    1 CONTINUE
      NYX=0
 1430 CONTINUE
      NYX=NYX+1
      IF(NYX.EQ.2) GO TO 1431
      XEFF=Y
      IF(NEFF.EQ.2) XEFF=X
      EXPONT=ALOG(1./(1.-XEFF))
      XMELS=DL*EXP(-(EXPONT*CLPTLS)/PL)
      XMCLS=XMELS*(1.-EXP(-(EXPONT*FLOAT(LSECT(NUMSEC))*LINCS(NUMSEC)*0.
     1305)/PL))
      XMLLS=XMELS-XMCLS
      XMCLS=XMCLS*CONVF
      IF(NTEMP.EQ.1) RAPLOS=0.155*XMCLS**0.905
      IF(NTEMP.EQ.2) RAPLOS=0.618*XMCLS**0.894
      GO TO 1432
 1431 CONTINUE
      EXPONT=ALOG(1./(1.-Y))
      YMELS=DL*EXP(-(EXPONT*CLPTLS)/PL)
      YMCLS=YMELS*(1.-EXP(-(EXPONT*FLOAT(LSECT(NUMSEC))*LINCS(NUMSEC)*0.
     1305)/PL))
      YMLLS=YMELS-YMCLS
      YMCLS=YMCLS*CONVF
 1432 CONTINUE
      IF(NYX.EQ.1) GO TO 1430
 7130 CONTINUE
      RNS=((RAPLOS/(DD*CONVF))*RPCNT(I)*1.E-02)/((3.14159*DIAM(I)**3)/6.
     1)
      WYSV=WY
      EFFWR=(ONO(I)*(1.-EXP(-(ATOTAL*WYSV)/(100.*VG)))-RNS)/ONO(I)
      CRNP = ONO(I)*(1.-EXP(-(ATOTAL*WYSV)/(100.*VG)))- RNS
      IF(CRNP.LE.0.0) EFFWR = EFESR
      IF(EFFWR.GT.999999) EFFWR=.999999
      COREFF=EFFWR*100.D0
      IF(COREFF.GE.99.9999) COREFF=99.9999
      IF(EFFWR.GE.0.99999) WYP=WYSV
      IF(EFFWR.LT.0.99999) WYP=(VG/ATOTAL)*100.*ALOG(100./(100.-COREFF))
      SCOREF = SCOREF + COREFF*PCNT(I)
      CPENTR=100.-COREFF
      CPCTOT(I)=CPENTR*PCNT(I)*1.E-02
      IF(IDC.NE.1) GO TO 1343
      SPO=SPO+PCTOT(I)
```

```
      SCPO=SCPO+CPCTOT(I)
 1343 CONTINUE
      SL=(1.0-EFESR)*DNO(I)
      WSL(I)=SL*(1.33333*3.14159*RAD(I)**3)*DD
      IF(IDC.EQ.1) GO TO 1344
      PCTOT(I)=(PCTOT(I)/SPO)*100.
      CPCTOT(I)=(CPCTOT(I)/SCPO)*100.
      DLD=ALOG10(ENDPT(I+1))-ALOG10(ENDPT(I))
      DMDLD(I)=(PCTOT(I)*YMLLS*CONVF*1.E-02)/DLD
      RDMDLD(I)=(RPCNT(I)*RAPLOS*1.E-02)/DLD
      CDMDLD(I)=DMDLD(I)+RDMDLD(I)
      WRITE(NPRNT,2291) DIAM(I),CCF(I),XY,PCTOT(I),CPCTOT(I),XEP,WY,
     1PENTR,COREFF,WYP,CPENTR
 2291 FORMAT(1X,1PE10.3,1X,0PF6.3,1X,F6.3,2X,F7.4,5X,F7.4,4X,F8.4,3X,F7.
     13,2X,F8.4,3X,F8.4,2X,F7.3,4X,F8.4)
 1344 CONTINUE
 3540 CONTINUE
      IF(IDC.EQ.1) GO TO 1341
C
      Y=Y*100.
      X = X * 100.
      WRITE(NPRNT,2292) ETAO,X
 2292 FORMAT('0',4X,'EFFICIENCY - STATED = ',F5.2,5X,'COMPUTED =' ,F8.4
     3,5X,'CONVERGENCE OBTAINED')
      X=X/100.
      WRITE(NPRNT,3675) Y
 3675 FORMAT(//5X,23HADJUSTED NO-RAP EFF. = ,F8.4)
      WRITE(NPRNT,5802) ZMMDI
 5802 FORMAT(5X,'MMD OF INLET SIZE DISTRIBUTION =',1PE11.3)
      WRITE(NPRNT,5803) SIGMI
 5803 FORMAT(5X,'SIGMAP OF INLET SIZE DISTRIBUTION =',1PE11.3)
      IF(NDIST.EQ.1) WRITE(NPRNT,9250) GFIT
 9250 FORMAT(5X,'LOG-NORMAL GOODNESS OF FIT = ',F6.3)
C
C CALCULATE MMD OF EFFLUENT UNDER NO-RAP CONDITIONS
C
      PRCUNR(1)=0.
      SUMNR=PRCUNR(1)
      DO 1750 I=1,NS
      SUMNR=SUMNR+PCTOT(I)
      PRCUNR(I+1)=SUMNR
 1750 CONTINUE
      CALL LNFIT(PRCUNR,ZMDL,SIGMO,ZGFIT)
 2982 WRITE(NPRNT,2997) ZMDL
 2997 FORMAT(5X,'MMD OF EFFLUENT UNDER NO-RAP CONDITIONS =',1PE11.3)
      WRITE(NPRNT,5801) SIGMO
 5801 FORMAT(5X,'SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS =',1PE11.3)
      WRITE(NPRNT,9250) ZGFIT
      COREFW=(VG/ATOTAL)*100.*ALOG(100./(100.-SCOREF))
      WZ=(VG/ATOTAL)*100.*ALOG(100./(100.-Y))
      WRITE(NPRNT,2998) WZ
 2998 FORMAT(5X,'PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS ='
     1,F7.3//)
      PRCUC(1)=0.
      SUMC=PRCUC(1)
      DO 1751 I=1,NS
      SUMC=SUMC+CPCTOT(I)
      PRCUC(I+1)=SUMC
 1751 CONTINUE
      CALL LNFIT(PRCUC,CZMDL,CSIGMO,CGFIT)
```

```
      WRITE(NPRNT,4615) ZIBGY,SNUCK,ZNUMS
 4615  FORMAT(5X,'SIGMAG=',2X,F7.3,2X,'WITH',F7.3,' SNEAKAGE OVER',2X,
     1F7.3,2X,'STAGES')
      WRITE(NPRNT,7900) NTEMP
 7900 FORMAT(5X,'NTEMP =',I2)
      WRITE(NPRNT,7901) RMMD
 7901 FORMAT(5X,'RMMD =',F6.2)
      WRITE(NPRNT,7902) RSIGMA
 7902 FORMAT(5X,'RSIGMA =',F5.2)
      WRITE(NPRNT,5002) SCOREF
 5002  FORMAT(5X,'CORR. EFF. = ',F8.4)
      WRITE(NPRNT,8352) CZMDL
 8352 FORMAT(5X,'CORRECTED MMD OF EFFLUENT =',1PE11.3)
      WRITE(NPRNT,5800) CSIGMO
 5800 FORMAT(5X,'CORRECTED SIGMAP OF EFFLUENT =',1PE11.3)
      WRITE(NPRNT,9250) CGFIT
      WRITE(NPRNT,5003) COREFW
 5003 FORMAT(5X,'CORRECTED PRECIPITATION RATE PARAMETER =',F8.2)
      WRITE(NPRNT,6565)
 6565 FORMAT(1H1,' UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND
     1 DISCRETE OUTLET MASS LOADINGS'//)
      WRITE(NPRNT,1980)
 1980 FORMAT(1X,16HIDEAL UNADJUSTED,3X,16HIDEAL UNADJUSTED,7X,6HNO-RAP,1
     10X,12HRAPPING PUFF,6X,15HNO-RAP+RAP PUFF,5X,12HRAPPING PUFF,4X,8HP
     2ARTICLE)
      WRITE(NPRNT,1981)
 1981 FORMAT(1X,17HMIG. VEL.(CM/SEC),4X,13HEFFICIENCY(%),4X,17HDM/DLOGD(
     1MG/DSCM),2X,17HDM/DLOGD(MG/DSCM),2X,17HDM/DLOGD(MG/DSCM),2X,15HDIS
     2TRIBUTION(%),2X,8HDIAM.(M))
      DO 1982 M=1,NS
      WRITE(NPRNT,1983) WUNCOR(M),FUNCOR(M),DMDLD(M),RDMDLD(M),
     1CDMDLD(M),RPCNT(M),DIAM(M)
 1983 FORMAT(1X,1PE10.3,4(10X,1PE10.3),7X,1PE10.3,6X,1PE10.3)
 1982 CONTINUE
      NRUN = NRUN + 1
      CALL PRTSUM
      IF(NONCK.LT.NONID) GO TO 1867
      IF(NRAPDC.LT.NRAPD) GO TO 1713
      RETURN
      END
```

```
      SUBROUTINE WADJST (DIAM,I,WY,ONO,PXS,ATOTAL,VG,EFESR)
C                                        ******************************************
C                                        *                                        *
C                                        *  CORRECTION FACTORS IN THIS SUBROUTINE *
C                                        *                                        *
C                                        *  ARE BASED ON DATA TAKEN UNDER         *
C                                        *                                        *
C                                        *  E.P.R.I. SPONSORSHIP BY SO.R.I.       *
C                                        *                                        *
C                                        ******************************************
      DOUBLE PRECISION EFESR
      DIMENSION DIAM(20),ONO(20),PXS(20),CFACT(24),DCHECK(24)
      DATA CFACT/2.43,2.325,2.24,2.17,2.11,2.05,2.00,1.965,1.92,1.885,1.
     185,1.82,1.79,1.76,1.74,1.71,1.685,1.5,1.37,1.27,1.18,1.115,1.05,1.
     200/
      DATA DCHECK/.2E-06,.25E-06,.3E-06,.35E-06,.4E-06,.45E-06,.5E-06,.5
     15E-06,.6E-06,.65E-06,.7E-06,.75E-06,.8E-06,.85E-06,.9E-06,.95E-06,
     21.E-06,1.5E-06,2.E-06,2.5E-06,3.E-06,3.5E-06,4.E-06,4.5E-06/
      IF((DIAM(I).LT.2.0E-07).OR.(DIAM(I).GE.4.5E-06)) GO TO 6
      DO 3 L=1,23
      IF((DIAM(I).GE.DCHECK(L)).AND.(DIAM(I).LE.DCHECK(L+1))) GO TO 4
      GO TO 3
    4 CONTINUE
      WFACT=CFACT(L)-((DIAM(I)-DCHECK(L))/(DCHECK(L+1)-DCHECK(L)))*
     1(CFACT(L)-CFACT(L+1))
      WY=WY*WFACT
      EFESR=1.-EXP(-(ATOTAL*WY)/(100.*VG))
      PXS(I)=EFESR*ONO(I)
      GO TO 5
    3 CONTINUE
    6 CONTINUE
      EFESR=1.-EXP(-(ATOTAL*WY)/(100.*VG))
      PXS(I)=EFESR*ONO(I)
    5 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LNDIST (D50,SIGMAP,PRCU,PCNT)
      DIMENSION Y(100),Z(100),AREA(20),PRCU(21),PCNT(20)
      COMMON/BLK4/NS
      COMMON/BLK11/ENDPT(21),NENDPT
      PI=3.1416
      SIGMAZ=ALOG(SIGMAP)
      N=NS+2
      NINC=100
      ASUM=0.
      K=0
      DO 240 J=1,N
      IF(J.EQ.1)GO TO 230
      IF(J.EQ.(N))GO TO 232
      X2=ALOG(ENDPT(J))
      X1=ALOG(ENDPT(J-1))
      GO TO 233
230   CONTINUE
      X1=ALOG(0.01)
      X2=ALOG(ENDPT(J))
      GO TO 233
232   CONTINUE
      X1=ALOG(ENDPT(J-1))
      X2=ALOG(1000.)
233   CONTINUE
      DX=(X2-X1)/99.
      D=X1
      SGT1=1./(SIGMAZ*(2.*PI)**.5)
      SGT2=2.*SIGMAZ**2
      DO 234 I=1,NINC
      Y(I)=SGT1*EXP(-(D-ALOG(D50))**2/SGT2)
      D=D+DX
234   CONTINUE
      CALL QTFE(DX,Y,Z,NINC)
      ASUM=ASUM+Z(NINC)
      IF(J.LT.N) PRCU(J)=ASUM
      IF((J.EQ.1).OR.(J.EQ.N))GO TO 240
      K=K+1
      AREA(K)=Z(NINC)
240   CONTINUE
      DO 241 I=1,NS
      PCNT(I)=AREA(I)/ASUM
241   CONTINUE
      SUM=0.
      DO 2 I=1,NS
      SUM=SUM+PCNT(I)
2     CONTINUE
      CHECK1 = 1.0 - SUM
      PCNT(NS)=PCNT(NS)+CHECK1
      CHECK2 = 1.0 - PRCU(NENDPT)
      PRCU(NENDPT)=PRCU(NENDPT)+CHECK2
      RETURN
      END
```

```
      SUBROUTINE QTFE (DX,Y,Z,NINC)
      DIMENSION Y(1),Z(1)
      SUM2=0.
      IF(NINC - 1) 4,3,1
    1 DDX=.5*DX
C
C     INTEGRATION LOOP
      DO2 I=2,NINC
      SUM1=SUM2
      SUM2=SUM2+DDX*(Y(I)+Y(I-1))
    2 Z(I-1)=SUM1
    3 Z(NINC)=SUM2
    4 RETURN
      END
```

```
      SUBROUTINE LNFIT (PRCU,D50,SIGMAP,GFIT)
C     THIS SUBROUTINE FITS CUMPERCENT CURVE TO A LOGNORMAL DISTRIBUTION
      DIMENSION Z(21),Y(21),PRCU(21)
      COMMON/BLK11/ENDPT(21),NENDPT
      NSTAG=0
      J=0
      DO 1 I=1,NENDPT
      IF(PRCU(I).LE.0.0)GO TO 1
      J=J+1
      Z(J)=ALOG(ENDPT(I))
      IF(PRCU(I).GE.99.0) GO TO 4
      IF(PRCU(I).GT.50.)GO TO 3
      XY=PRCU(I)/100.
2     XYY=SQRT(ALOG(1.0/XY**2))
      Y(J)=XYY-((2.515517+0.802853*XYY+0.010328*XYY**2)/(1.0+1.432788*X
     1YY+0.189269*XYY**2+0.001308*XYY**3))
      IF(PRCU(I).GT.50.)GO TO 5
      Y(J)=-Y(J)
      GO TO 5
3     XY=1.0-(PRCU(I)/100.)
      GO TO 2
5     NSTAG=NSTAG+1
1     CONTINUE
C     CALL CURVE FIT ROUTINE
4     CALL CFIT(A,B,GFIT,NSTAG,Z,Y)
C     CALCULATE D50 AND SIGMAP
      D50=EXP(-A/B)
      SIGMAP=EXP(1.0/B)
      RETURN
      END
```

```
      SUBROUTINE CFIT (A,B,R,NSTAG,Z,Y)
C     THIS SUBROUTINE FITS A STRAIGHT LINE, Y=A+BX, USING LEAST SQUARES
      DIMENSION Z(21),Y(21)
      XN=0.0
      SUMX=0.0
      SUMY=0.0
      SUMXY=0.0
      SUMXX=0.0
      SUMYY=0.0
      DO 6 I=1,NSTAG
      SUMX=SUMX+Z(I)
      SUMY=SUMY+Y(I)
      SUMXY=SUMXY+Z(I)*Y(I)
      SUMXX=SUMXX+Z(I)**2
      SUMYY=SUMYY+Y(I)**2
      XN=XN+1.0
    6 CONTINUE
C     CALCULATE A,B
      B=(XN*SUMXY-SUMX*SUMY)/(XN*SUMXX-SUMX**2) .
      A=(SUMXX*SUMY-SUMX*SUMXY)/(XN*SUMXX-SUMX**2)
      R=SQRT(B*((XN*SUMXY-SUMX*SUMY)/(XN*SUMYY-SUMY**2)))
      RETURN
      END
```

```
      SUBROUTINE PRTSUM
      REAL LINCS
      COMMON/BLK2/LSECT(10),LINCS(10),PS(10)
      COMMON/BLK3/VG,ATOTAL,DD,ETAD,DL,PL,RHO
      COMMON/BLK5/ZMMDI,SIGMI,NONID,NRAPD,TDK,NUMSEC,NEFF,NTEMP,GFIT
      COMMON/BLK6/VOL(20),XNO(20),Q(20),WS(20),ITL(40),DW(45),AS(10),
     1VOS(10),TCS(10),WLS(10),ACS(10),BS(10),SYS(10),VGS(10),VGASS(10),
     2TEMPS(10),VISS(10),QSAT(20),U,E,EPSO,PI,ERAVG,BC,TEMP,EPS,VAVC,
     3OLDQ(20),OLDXNO(20),RFS(10),START1(10),START2(10),START3(10),
     4VSTAR(10)
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK18/SCOREF,CZMDL,CSIGMO,NRUN,SNUCK,ZIGGY,RHMD,RSIGMA
      SCA=ATOTAL/VG
      VOSUM=0.
      CDSUM=0.
      DO 6571 I=1,NUMSEC
      VOSUM=VOS(I)*FLOAT(LSECT(I))*LINCS(I)*0.305+VOSUM
      CDSUM=(TCS(I)/(AS(I)*9.3E-02))*1.E+05*FLOAT(LSECT(I))*LINCS(I)*
     10.305+CDSUM
 6571 CONTINUE
      AVO=VOSUM/PL
      ACD=CDSUM/PL
      RHOCGS=RHO*100.
      WRITE(NPRNT,1994)
 1994 FORMAT(1H1)
      WRITE(NPRNT,9520)
 9520 FORMAT(9X,'*************************************************************
     1*************************************************************')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
 1060 FORMAT(9X,'*',118X,'*')
      WRITE(NPRNT,9500)
 9500 FORMAT(9X,'*',39X,'SUMMARY TABLE OF ESP OPERATING',45X,'*')
      WRITE(NPRNT,9501)
 9501 FORMAT(9X,'*',41X,'PARAMETERS AND PERFORMANCE',47X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9502) NRUN
 9502 FORMAT(9X,'*',46X,'DATA SET NUMBER ',I3,49X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9503) SCOREF,SCA
 9503 FORMAT(9X,'*',12X,'ESP PERFORMANCE:',5X,'EFFICIENCY = ',F8.4,' %',
     15X,'SCA = ',1PE10.3,' M**2/(M**3/SEC)',21X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9504) AVO
 9504 FORMAT(9X,'*',12X,'ELECTRICAL CONDITIONS:',5X,'AVG. APPLIED VOLTAG
     1E = ',1PE10.3,' V',40X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9505) ACD
 9505 FORMAT(9X,'*',39X,'AVG. CURRENT DENSITY = ',F7.2,' NA/CM**2',36X,'
     1*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9506) RHOCGS
 9506 FORMAT(9X,'*',39X,'RESISTIVITY = ',1PE10.3,' OHM-CM',44X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
```

```
      WRITE(NPRNT,9507) ZMMDI,SIGMI
 9507 FORMAT(9X,'*',12X,'SIZE DISTRIBUTIONS:',5X,'INLET MMD = ',1PE10.3,
     1' UM',5X,'INLET SIGMAP = ',1PE10.3,23X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9508) CZMDL,CSIGMO
 9508 FORMAT(9X,'*',36X,'OUTLET MMD = ',1PE10.3,' UM',5X,'OUTLET SIGMAP
     1= ',1PE10.3,21X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9509) SNUCK,ZIGGY
 9509 FORMAT(9X,'*',12X,'NONIDEAL PARAMETERS:',5X,'GAS SNEAKAGE FRACTION
     1 = ',F4.2,' /SECTION',5X,'GAS VELOCITY SIGMAG = ',F4.2,9X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9510) RMMD,RSIGMA
 9510 FORMAT(9X,'*',37X,'RAPPING MMD = ',1PE10.3,' UM',5X,'RAPPING SIGMA
     1P = ',1PE10.3,18X,'*')
      WRITE(NPRNT,1060)
      WRITE(NPRNT,1060)
      WRITE(NPRNT,9520)
      RETURN
      END
```

```
001          BLOCK DATA
002          LOGICAL LTEST
003          COMMON /BLK22/ LTEST,RHO(15,15),V(15,15),EX(15,15),EY(15,15)
004          DATA LTEST/.FALSE./,RHO/225*0./,V/225*0./,EX/225*0./,EY/225*0./
005          END
```

```
      SUBROUTINE CMAN (VW,NX,NY,SX,SY,PI,AC,NWIRE)
C   COOPERMAN SERIES DETERMINATION FOR VOLTAGE WIRE TO PLATE
C   FOR SUBROUTINE EFIELD
      REAL NUM,M,NWIRE
      LOGICAL LTEST
      COMMON /BLK13/VCOOP(15,15),NVII
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO(15,15),V(15,15),EX(15,15),EY(15,15)
      NX1=NX-1
      NY1=NY-1
      DO 402 I=1,NX
      IF(NVII-1)301,300,301
  300 I=NX
  301 CONTINUE
      DO 430 J=1,NY
      X=FLOAT(I-1)*SX/FLOAT(NX1)
      IF(LTEST)X=X1(I)
      Y=FLOAT(J-1)*SY/FLOAT(NY1)
      IF(LTEST)Y=Y1(J)
      IF(X.EQ.0..AND.Y.EQ.0.)GO TO 440
      GO TO 450
  440 VCOOP(I,J)=VW
      GO TO 430
  450 CONTINUE
      M=-NWIRE
      NUM=0.0
      DENOM=0.0
      EX0=0.
      EY0=0.
      EXSUM=0.
      EYSUM=0.
  490 E1=PI*(Y-(2.*M*SY))/(2.*SX)
      F1=PI*X/(2.*SX)
      G1=PI*M*SY/SX
      H1=PI*AC/(2.*SX)
      E2=(EXP(E1)+EXP(-E1))/2.
      F2=COS(F1)
      G2=(EXP(G1)+EXP(-G1))/2.
      H2=COS(H1)
      TT=(E2-F2)/(E2+F2)
      TB=(G2-H2)/(G2+H2)
      F=ALOG(TT)
      G=ALOG(TB)
      NUM=NUM+F
      DENOM=DENOM+G
      H3=SIN(H1)
      F3=SIN(F1)
      E3=(EXP(E1)-EXP(-E1))/2.
      G3=(EXP(G1)-EXP(-G1))/2.
      SUMX=F3/(E2-F2)+F3/(E2+F2)
      SUMY=E3/(E2-F2)-E3/(E2+F2)
      S1=H3/(G2-H2)+H3/(G2+H2)
      S2=G3/(G2-H2)-G3/(G2+H2)
      EXSUM=EXSUM+SUMX
      EYSUM=EYSUM+SUMY
      EX0=EX0+S1
      EY0=EY0+S2
      IF(M.LT.NWIRE) GO TO 408
      GO TO 410
  408 M=M+1.0
```

```
      GO TO 490
  410 VCOOP(I,J)=VW*NUM/DENOM
      ECX(I,J)=-(PI*VW/2./SX/DENOM)*FXSUM
      ECY(I,J)=-(PI*VW/2./SX/DENOM)*FYSUM
  430 CONTINUE
  402 CONTINUE
  404 CONTINUE
      ECX(1,1)=-(PI*VW/2./SX/DENOM)*FX0
      ECY(1,1)=-(PI*VW/2./SX/DENOM)*FY0
      RETURN
      END
```

```
      SUBROUTINE EFLD3 (UEQ,AC,VO,SX,SY,NX,NY,AEPLT,TDK,P,RF,
     1START,DSTART,CSTART,IFINAL,VSTART,VW,ACONTY,NWIRE,NEC,EBD,JI1,JI2)
C  EVALUATION OF FIELDS, SPACE CHARGE DENSITY, POTENTIAL , AND
C  CURRENT DENSITY FOR A WIRE-PLATE PRECIPITATOR
      REAL NWIRE,MAXS,MOBILT(15,15)
      LOGICAL LTEST
      DIMENSION RHO(15,15),EX(15,15),OLDRO(15,15),OLDV(15,15),
     1CONSTY(15,15),V(15,15),EY(15,15),EAVGS(30),CHFIDS(30),ECOLLS(30)
      COMMON/BLK8/EAVG(30),CHFID(30)
      COMMON/BLK9/ECOLL(30)
      COMMON /BLK13/VCOOP(15,15),NVIT
      COMMON/BLK17/NREAD,NPRNT
      COMMON/BLK21/ECX(15,15),ECY(15,15),X1(15),Y1(15),AX(15),AY(15)
      COMMON /BLK22/ LTEST,RHO,V,EX,EY
      DATA OLDRO/225*0./,OLDV/225*0./,CONSTY/225*0./,MOBILT/225*0./
      COSH(Z)=(EXP(Z)+EXP(-Z))/2.
      SINH(Z)=(EXP(Z)-EXP(-Z))/2.
      VO=-1.*VO
      VW=-1.*VSTART
      RO=AC
      RELD=(293./TDK)*(P/1.)
      ROC=100.*RO
      EORO=ROC*RF*(30.*RELD+9.*SQRT(RELD/ROC))*1.E+03
      DO 550 I=1,NX
      DO 550 J=1,NY
      MOBILT(I,J)=UEQ
  550 CONTINUE
      PI=3.1416
      EPSO=8.854E-12
      SSTART=START
      MAXS=0.
      NX1=NX-1
      NY1=NY-1
      R=0.975
      IVCK=0
      RC=AC
      DO 1001 II=1,IFINAL
      IF(II.EQ.JI1) START=DSTART
      IF(II.GE.JI2) START=CSTART
      MAXS=MAXS+START
 1526 CONTINUE
      IF((.NOT.LTEST).AND.(NVII.EQ.2))ACONTY=MAXS
      A1=PI/2./SX
      B1=2.*ACONTY/EPSO/MOBILT(NX1,1)
      B1R=SQRT(ABS(B1))
      C1=B1*SY/PI
      R1=R*SX
      VWIR=0.
      EXWIR=0.
      EYWIR=0.
      E1=0.
      E2=0.
      E3=0.
      F1=0.
      F2=0.
      NW=NWIRE
      SUM1=0.
      SIG1=0.
      DO 3601 I=1,NW
      RM=I
```

```
      CH=COSH(RM*PI*SY/SX)
      SIG1=SIG1+CH/(CH*CH-COS(A1*AC)*COS(A1*AC))
      SUM1=SUM1+ALOG(ABS((CH-COS(A1*AC))/(CH+COS(A1*AC))))
 3601 CONTINUE
      SUMW=2.*SUM1
      POT1=1./(1./SIN(A1*AC)/SIN(A1*AC)+2.*SIG1)
      SUM1=2.*SUM1+ALOG(ABS((1.-COS(A1*AC))/(1.+COS(A1*AC))))
      IF(R1.GT.SX)R1=SX
      SQON=R1*R1+4.*SX*(SX-R1)
      SQOP=R1*R1+4.*SX*(SX+R1)
      RNN=R1*(2.*SX-R1)
      RNP=R1*(2.*SX+R1)
      ARGR=PI*R1/SX/2.
      FAC1=1.
      IF(R1.LE.SY) GO TO 60
      CALL ARCCOS(SY,R1,ACOS)
      DUM=-ACOS+SY*SQRT(ABS(R1*R1-SY*SY))/R1/R1
      FAC1=(1.+2.*DUM/PI)
      ICOUNT=0
   60 CONTINUE
      EO=EORO/AC
      RLAM=SX*EO*POT1*SUM1/PI/SIN(A1*AC)
      RAD=SQRT(ABS(1.-C1/EO/EO))
      RASX=SQRT(ABS(1.+C1*(SX*SX-AC*AC)/EORO/EORO))
      RAR1=SQRT(ABS(1.+C1*(R1*R1-AC*AC)/EORO/EORO))
      RONSP=R1/(2.*B1*SY/PI/EORO/RAR1+(RAR1-1.)*EORO*(1./SQON+1./SQOP))
     1/(2.*R1*SY/PI/EORO/RAR1+(RAR1-1.)*EORO*(1./SQON+1./SQOP))
      CLAM=EORO*SX*SIN(PI*R1/2./SX)*(2.+R1*(2.*SX-R1)/(R1*R1
     1+4.*SX*(SX-R1))-R1*(2.*SX+R1)/(R1*R1+4.*SX*(SX+R1)))/PI/R1/2.
     2  *(RAR1-1.)
      WLAM=CLAM*FAC1
      VNAUT=CLAM*ALOG(ABS((1.-COS(A1*R1))/(1.+COS(A1*R1))))
     1 -2.*R1R*(SX-R1)*SQRT(ABS(SX-R1))/3.
      VT=VNAUT-EORO*(RAR1-1.  +(RAD-1.)*ALOG(R1/AC)+RAD*ALOG((RAD+1.)/
     1 (RAD+RAR1))+.25*(RAR1-1.)*(ALOG(ABS((AC*AC+4.*SX*(SX-AC))/SQON))
     2 +ALOG(ABS((AC*AC+4.*SX*(SX+AC))/SQOP))))+RLAM+WLAM*SUMW
      IF(NVIT.EQ.1)GO TO 10
      GO TO 30
   10 CONTINUE
      F=VT-VO
      IF(F.EQ.0.)GO TO 30
      IF(ABS(F).LT.1.0E-04*ABS(VO)) GO TO 30
      E3=EORO+0.10*EORO*F/ABS(F)
      IF(F.LT.0.)F1=F
      IF(F.LT.0.)E1=EORO
      IF(F.GT.0.)F2=F
      IF(F.GT.0.)E2=EORO
      IF(F1*F2.LT.0.)E3=(E1*F2-E2*F1)/(F2-F1)
      EORO=E3
      ICOUNT=ICOUNT+1
      IF(ICOUNT.EQ.100)WRITE(NPRNT,  31)
   31 FORMAT(10X,'THE APPLIED POTENTIAL COULD NOT BE MATCHED IN
     1 '100 ITERATIONS'/)
      IF(ICOUNT.GT.100)GO TO 30
      GO TO 60
   30 CONTINUE
      V(1,1)=VT
      CALL CMAN(RLAM,NX,NY,SX,SY,PI,AC,NWIRE)
      X=0.
      DO 3100 I11=1,NX
```

```
      IF(NVII.EQ.1)I11=NX
      Y=0.
      DO 3800 I12=1,NY
      IF(LTEST)X=X1(I11)
      IF(LTEST)Y=Y1(I12)
      IF(NVII.EQ.1)X=SX
      X1(I11)=X
      Y1(I12)=Y
      B1=2.*ACDNTY/EPSO/MOBILT(I11,I12)
      B1R=SQRT(ABS(B1))
      C1=B1*SY/PI
      IF((I11.EQ.1).AND.(I12.EQ.1))X=AC
      SQRN=SQDN+Y*Y
      SQRP=SQDP+Y*Y
      SQXN=X*X+Y*Y+4.*SX*(SX-X)
      SQXP=X*X+Y*Y+4.*SX*(SX+X)
      ARGX=PI*X/SX/2.
      ARGY=PI*Y/SX/2.
      RAXY=SQRT(ABS(1.+C1*(X*X+Y*Y-AC*AC)/EORO/EORO))
      RASXY=SQRT(ABS(1.+C1*(SX*SX+Y*Y-AC*AC)/EORO/EORO))
      RAR1Y=SQRT(ABS(1.+C1*(R1*R1+Y*Y-AC*AC)/EORO/EORO))
      COSHY=COSH(A1*Y)
      SINHY=SINH(A1*Y)
      CX=COS(A1*X)
      IF(X.GT.1.00001 *R1) GO TO 3860
      VXYJ=-EORO*(RAR1Y-RAXY+(RAD-1.)*ALOG(SQRT(ABS((R1*R1+Y*Y)/
     1(X*X+Y*Y))))+RAD*ALOG(ABS((RAD+RAXY)/(RAD+RAR1Y)))+(RAR1Y-1.)*
     2 (ALOG(ABS(SQXN/SQRN))+ALOG(ABS(SQXP/SQRP)))/4.)+VNAUT
      EXJ=-EORO*((RAXY-1.)*X/(X*X+Y*Y)-(RAR1 -1.)*((X-2.*SX)/SQXN
     1 +(X+2.*SX)/SQXP)/2.)
      EYJ=-EORO*((RAXY -1.)*Y/(X*X+Y*Y)-(RAR1Y-1.)*Y/(R1*R1+Y*Y)
     1 -(RAR1 -1.)*(Y/SQXN+Y/SQXP-Y/SQRN-Y/SQRP)/2.)
      RHOJ=-EPSO*C1/EORO/RAXY
     1  *1./(1.+((Y+1.E-09)/SY)**9*2.20)/(1.+.162*Y/SY)
     2 -EPSO*EORO*(RAXY-1.)/2.*((SQDN-Y*Y)/SQRN/SQRN+(SQDP-Y*Y)/
     3   SQRP/SQRP)*0.9
      GO TO 3861
 3860 CONTINUE
      VXYJ=CLAM*ALOG(ABS((COSHY-CX)/(COSHY+CX)))
     1+2.*B1P*((X-R1)*SQRT(ABS(X-R1))-(SX-R1)*SQRT(ABS(SX-R1)))/3.
      EXJ=-CLAM*PI*SIN(A1*X)*COSHY/SX/(COSHY*COSHY-CX*CX)
     1 -B1R*SQRT(ABS(X-R1))
      EYJ=-CLAM*PI*CX*SINHY/SX/(COSHY*COSHY-CX*CX)
      RHOJ=-EPSO*B1R/2./SQRT(ABS(X-R1+RONSP))
     1  *1./(1.+((Y+1.E-09)/SY)**9*2.33)/(1.+0.75*Y/SY)
 3861 CONTINUE
      SUMV=0.
      SUMEX=0.
      SUMEY=0.
      COSX=COS(PI*X/2./SX)
      SINX=SIN(PI*X/2./SX)
      DO 100 I=1,NW
      RI=I
      COSHN=COSH(PI*(Y-2.*RI*SY)/2./SX)
      COSHP=COSH(PI*(Y+2.*RI*SY)/2./SX)
      SINHN=SINH(PI*(Y-2.*RI*SY)/2./SX)
      SINHP=SINH(PI*(Y+2.*RI*SY)/2./SX)
      DENON=COSHN*COSHN-COSX*COSX
      DENOP=COSHP*COSHP-COSX*COSX
      TERMV=ALOG(ABS((COSHN-COSX)/(COSHN+COSX)))
```

```
     1 +ALOG(ABS((COSHP-COSX)/(COSHP+COSX)))
      SUMV=SUMV+TERMV
      TEREX=COSHN/DENON+COSHP/DENOP
      SUMEX=SUMEX+TEREX
      TEREY=SINHN/DENON+SINHP/DENOP
      SUMEY=SUMEY+TEREY
  100 CONTINUE
      VWIR=WLAM*SUMV
      EXWIR=-PI*WLAM*SINX*SUMEX/SX
      EYWIR=-PI*WLAM*COSX*SUMEY/SX
      VXYJ=VXYJ+VWIR
      EXJ=EXJ+EXWIR
      EYJ=EYJ+EYWIR
      V(I11,I12)=VXYJ+VCOOP(I11,I12)
      EX(I11,I12)=EXJ+ECX(I11,I12)
      EY(I11,I12)=EYJ+ECY(I11,I12)
      RHO(I11,I12)=RHOJ
      IF((I11.EQ.1).AND.(I12.EQ.1))X=0.
      Y=Y+SY/FLOAT(NY1)
 3800 CONTINUE
      X=X+SX/FLOAT(NX1)
 3100 CONTINUE
 3150 CONTINUE
      VW=V(1,1)
      EPLT=0.
      DO 1200 J=2,NY
      IF(LTEST)EPLT=EPLT+(EX(NX,J)+EX(NX,J-1))*AY(J-1)/2.
      IF(.NOT.LTEST) EPLT=
     1     EPLT+(EX(NX,J)+EX(NX,J-1))*SY/FLOAT(NX1)/2.
 1200 CONTINUE
      AEPLT=EPLT/SY
      IF(NVII.EQ.2)WRITE(NPRNT,8888) VW,ACONTY,AEPLT
 8888 FORMAT(3X,'VW = ',1PE11.4,2X,'ACONTY = ',1PE11.4,2X,'AEPLT = ',1P
     1E11.4//)
      IF(ABS(EX(NX,1)).LT.EBD) GO TO 1480
      WRITE(NPRNT,1481) VW,ACONTY
 1481 FORMAT(' THE BREAKDOWN FIELD NEAR THE PLATE IS EXCEEDED AT VW =',E
     111.4,1X,'AND ACONTY =',E11.4)
      GO TO 1525
 1480 CONTINUE
      IF(IVCK.EQ.1) GO TO 1525
      IF(ABS(VW).EQ.ABS(VO)) GO TO 1525
      IF(ABS(VW).GT.ABS(VO)) GO TO 1523
      OLDVW=VW
      OLDCO=ACONTY
      GO TO 1524
 1523 CONTINUE
      MAXS=ACONTY-((ACONTY-OLDCO)/(VW-OLDVW))*(VW-VO)
      VW=OLDVW
      IVCK=1
      GO TO 1526
 1524 CONTINUE
 1001 CONTINUE
 1525 CONTINUE
      IF(NFC.NE.0) GO TO 3000
      K=1
      DO 3001 J=1,NY1
      RSUM=0.
      ESUM=0.
      DO 3002 I=1,NX
```

```
      IF(J.EQ.1) GO TO 3005
      ESUM=ESUM+(SQRT(EX(I,J)**2+EY(I,J)**2)+SQRT(EX(I,J+1)**2+
     1EY(I,J+1)**2))/(2.*NX)
      GO TO 3006
 3005 CONTINUE
      ESUM=ESUM+SQRT(EX(I,J+1)**2+EY(I,J+1)**2)/(2.*NX)
      IF(I.EQ.NX) ESUM=ESUM-VO/(2.*SX)
 3006 CONTINUE
      RSUM=RSUM-(RHO(I,J)+RHO(I,J+1))/(2.*1.6E-19*NX)
 3002 CONTINUE
      EAVGS(K)=ESUM
      CHFIDS(K)=RSUM
      K=K+1
 3001 CONTINUE
      NYY=NY1
      DO 3003 L=1,NY1
      EAVG(L)=EAVGS(NYY)
      CHFID(L)=CHFIDS(NYY)
      NYY=NYY-1
 3003 CONTINUE
      KK=1
      M1=NY1+1
      M2=2*NY1
      DO 3004 M=M1,M2
      EAVG(M)=EAVGS(KK)
      CHFID(M)=CHFIDS(KK)
      KK=KK+1
 3004 CONTINUE
 3000 CONTINUE
      LL=1
      DO 3007 NN=1,NY1
      ECOLLS(LL)=-(EX(NX,NN)+EX(NX,NN+1))/2.
      LL=LL+1
 3007 CONTINUE
      L1=NY1
      DO 3008 L=1,NY1
      ECOLL(L)=ECOLLS(L1)
      L1=L1-1
 3008 CONTINUE
      L2=1
      I1=NY1+1
      I2=2*NY1
      DO 3009 I=I1,I2
      ECOLL(I)=ECOLLS(L2)
      L2=L2+1
 3009 CONTINUE
      VO=-1.*VO
      START=SSTART
      RETURN
      END
 PROG > 4K
```

APPENDIX G

OUTPUT DATA FOR EXAMPLE 1 (REVISION 2)

```
*************************************
*                                   *
*          E.P.A. FSP MODEL         *
*                                   *
*     I.E.R.L.-R.T.P. AND SO.R.T.   *
*                                   *
*        REVISION II, AUG., 1979    *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 16 NDATA = 1

DATA ON CARD NUMBER 2

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

DATA ON CARD NUMBER 3

NEST = 1 NDIST = 1 NVI = 3 NX = 10 NY = 10 NITER = 3 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 5 NUMINC = 3

DATA ON CARD NUMBER 5

DL = 0.01500 GRN/ACF PL = 10.0000 FT ETAO = 99.00000 % DD = 1000.00 KG/M**3 EPS = 5.100E+00
VRATIO = 1.0300 US = 0.000165 M**2/V-SEC FPATH = 1.0000 EBD = 1500000. V/M RHOCGS = 1.00E+09 OHM-CM

DATA ON CARD NUMBER 6

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 4.0
ASNUCK(2) = 0.10 AZIGGY(2) = 0.10 AZNUMS(2) = 4.0

DATA ON CARD NUMBER 7

```
ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   8

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER   9

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0002 %   PRCU( 3) =   0.4002 %   PRCU( 4) =   1.0002 %   PRCU( 5) =   2.6672 %
PRCU( 6) =   7.6672 %   PRCU( 7) =  12.6002 %   PRCU( 8) =  17.6002 %   PRCU( 9) =  21.3332 %   PRCU(10) =  29.3332 %

DATA ON CARD NUMBER  10

PRCU(11) =  36.0002 %   PRCU(12) =  46.6672 %   PRCU(13) =  57.3342 %   PRCU(14) =  68.6672 %   PRCU(15) =  80.6672 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  11

NUMSEC =  3    LSECT( 1) =  3  LSECT( 2) =  3  LSECT( 3) =  6

DATA ON CARD NUMBER  12

AS( 1) =  6.2500E+00 FT**2  VDS( 1) =  4.6000E+04 V  TCS( 1) =  1.5000E-04 A  WLS( 1) =  6.2500E+00 FT
ACS( 1) =  4.6875E-02 IN  BS( 1) =  5.0000E+00 IN  NWS( 1) =  5.0000E+00

DATA ON CARD NUMBER  13

SVS( 1) =  2.5000E+00 IN  VGS( 1) =  2.0000E+02 FT**3/MIN  VGASS( 1) =  3.2000E+00 FT/SEC  TEMPS( 1) =  7.6800E+01 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  1.8000E-05 KG/M-SEC  LINCS( 1) =  8.3333E-01 FT

DATA ON CARD NUMBER  14

AS( 2) =  6.2500E+00 FT**2  VDS( 2) =  4.5800E+04 V  TCS( 2) =  1.5000E-04 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00
```

```
DATA ON CARD NUMBER  15

SVS( 2) =  2.5000E+00 IN  VGS( 2) =  2.0000E+02 FT**3/MIN  VGASS( 2) =  3.2000E+00 FT/SEC  TEMPS( 2) =  7.6800E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  8.3333E-01 FT

DATA ON CARD NUMBER  16

AS( 3) =  1.2500E+01 FT**2  VOS( 3) =  4.4400E+04 V  TCS( 3) =  3.0000E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  17

SVS( 3) =  2.5000E+00 IN  VGS( 3) =  2.0000E+02 FT**3/MIN  VGASS( 3) =  3.2000E+00 FT/SEC  TEMPS( 3) =  7.6800E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  8.3333E-01 FT
```

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E+01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.600E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0860	3.622E+05	2.6176E+05	2.2804E+13	25.8	6.88E-06	1.009E-05	2.957E-04	4.83E-08	2.58E-04	1
1.0505	3.622E+05	2.5984E+05	2.3576E+13	25.8	4.14E-06	6.349E-06	1.860E-04	5.76E-08	2.58E-04	2
1.0292	3.622E+05	2.5867E+05	2.4062E+13	25.8	2.97E-06	4.068E-06	1.192E-04	5.15E-08	2.58E-04	3

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.580E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0169	3.606E+05	2.5737E+05	2.4460E+13	25.8	2.41E-06	2.833E-06	8.299E-05	4.50E-08	2.58E-04	4
1.0099	3.606E+05	2.5737E+05	2.4630E+13	25.8	2.10E-06	2.101E-06	6.156E-05	3.93E-08	2.58E-04	5
1.0058	3.606E+05	2.5737E+05	2.4731E+13	25.8	1.86E-06	1.615E-06	4.731E-05	3.43E-08	2.58E-04	6

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.440E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 3.000E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0033	3.496E+05	2.5222E+05	2.5574E+13	25.8	1.66E-06	1.244E-06	3.645E-05	2.92E-08	2.58E-04	7
1.0020	3.496E+05	2.5222E+05	2.5609E+13	25.8	1.54E-06	9.971E-07	2.921E-05	2.55E-08	2.58E-04	8
1.0012	3.496E+05	2.5222E+05	2.5629E+13	25.8	1.45E-06	8.089E-07	2.370E-05	2.23E-08	2.58E-04	9

1.0007	3.496E+05	2.5222E+05	2.5641E+13	25.8	1.38E-06	6.627E-07	1.941E-05	1.96E-08	2.58E-04	10
1.0004	3.496E+05	2.5222E+05	2.5648E+13	25.8	1.31E-06	5.471E-07	1.603E-05	1.71E-08	2.58E-04	11
1.0002	3.496E+05	2.5222E+05	2.5652E+13	25.8	1.24E-06	4.546E-07	1.332E-05	1.51E-08	2.58E-04	12

EST. EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 92.50

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2	APPLIED VOLTAGE = 4.600E+04 VOLTS	TOTAL CURRENT = 1.500E-04 AMPS
WIRE TO PLATE = 1.270E-01 M	CORONA WIRE RADIUS = 1.191E-03 M	CORONA WIRE LENGTH = 1.906E+00 M
CURRENT/M = 7.869E-05 AMP/M	CURRENT DENSITY = 2.581E-04 AMP/M2	DEPOSIT E FIELD = 2.581E+03 VOLT/M
1/2 WIRE TO WIRE = 6.350E-02 M	GAS FLOW RATE = 9.460E-02 M3/SEC	GAS VELOCITY = 9.760E-01 M/SEC
TEMPERATURE = 297.667 K	PRESSURE = 1.000 ATM	VISCOSITY = 1.800E-05 KG/M-SEC
ION MOBILITY = 1.798E-04 M2/VOLT-SEC	MEAN THERMAL SPEED = 4.439E+02 M/SEC	PART. PATH PARAM. = 5.708E-08 M
DUST WEIGHT = 3.250E-06 KG/SEC	LENGTH INCR. =0.25416565 M	INPUT EFF./INCR. = 19.41

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0524	3.622E+05	2.5995E+05	2.3533E+13	25.8	6.89E-06	1.004E-05	2.942E-04	4.80E-08	2.58E-04	1
1.0364	3.622E+05	2.5906E+05	2.3896E+13	25.8	4.15E-06	6.359E-06	1.863E-04	5.77E-08	2.58E-04	2
1.0249	3.622E+05	2.5844E+05	2.4163E+13	25.8	2.97E-06	4.081E-06	1.195E-04	5.16E-08	2.58E-04	3

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2	APPLIED VOLTAGE = 4.580E+04 VOLTS	TOTAL CURRENT = 1.500E-04 AMPS
WIRE TO PLATE = 1.270E-01 M	CORONA WIRE RADIUS = 1.191E-03 M	CORONA WIRE LENGTH = 1.906E+00 M
CURRENT/M = 7.869E-05 AMP/M	CURRENT DENSITY = 2.581E-04 AMP/M2	DEPOSIT E FIELD = 2.581E+03 VOLT/M
1/2 WIRE TO WIRE = 6.350E-02 M	GAS FLOW RATE = 9.460E-02 M3/SEC	GAS VELOCITY = 9.760E-01 M/SEC
TEMPERATURE = 297.667 K	PRESSURE = 1.000 ATM	VISCOSITY = 1.800E-05 KG/M-SEC
ION MOBILITY = 1.798E-04 M2/VOLT-SEC	MEAN THERMAL SPEED = 4.439E+02 M/SEC	PART. PATH PARAM. = 5.708E-08 M
DUST WEIGHT = 3.250E-06 KG/SEC	LENGTH INCR. =0.25416565 M	INPUT EFF./INCR. = 19.41

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0171	3.606E+05	2.5738E+05	2.4456E+13	25.8	2.41E-06	2.842E-06	8.326E-05	4.51E-08	2.58E-04	4
1.0118	3.606E+05	2.5738E+05	2.4584E+13	25.8	2.10E-06	2.107E-06	6.171E-05	3.94E-08	2.58E-04	5
1.0082	3.606E+05	2.5738E+05	2.4672E+13	25.8	1.86E-06	1.618E-06	4.741E-05	3.44E-08	2.58E-04	6

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2	APPLIED VOLTAGE = 4.440E+04 VOLTS	TOTAL CURRENT = 3.000E-04 AMPS
WIRE TO PLATE = 1.270E-01 M	CORONA WIRE RADIUS = 1.191E-03 M	CORONA WIRE LENGTH = 3.812E+00 M
CURRENT/M = 7.869E-05 AMP/M	CURRENT DENSITY = 2.581E-04 AMP/M2	DEPOSIT E FIELD = 2.581E+03 VOLT/M
1/2 WIRE TO WIRE = 6.350E-02 M	GAS FLOW RATE = 9.460E-02 M3/SEC	GAS VELOCITY = 9.760E-01 M/SEC
TEMPERATURE = 297.667 K	PRESSURE = 1.000 ATM	VISCOSITY = 1.800E-05 KG/M-SEC
ION MOBILITY = 1.798E-04 M2/VOLT-SEC	MEAN THERMAL SPEED = 4.439E+02 M/SEC	PART. PATH PARAM. = 5.708E-08 M
DUST WEIGHT = 3.250E-06 KG/SEC	LENGTH INCR. =0.25416565 M	INPUT EFF./INCR. = 19.41

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.

1.0055	3.496E+05	2.5235E+05	2.5518E+13	25.8	1.66E-06	1.247E-06	3.653E-05	2.93E-08	2.58E-04	7
1.0039	3.496E+05	2.5235E+05	2.5560E+13	25.8	1.54E-06	9.985E-07	2.925E-05	2.56E-08	2.58E-04	8
1.0027	3.496E+05	2.5235E+05	2.5589E+13	25.8	1.45E-06	8.100E-07	2.373E-05	2.24E-08	2.58E-04	9
1.0019	3.496E+05	2.5235E+05	2.5610E+13	25.8	1.38E-06	6.636E-07	1.944E-05	1.96E-08	2.58E-04	10
1.0013	3.496E+05	2.5235E+05	2.5624E+13	25.8	1.31E-06	5.477E-07	1.605E-05	1.72E-08	2.58E-04	11
1.0009	3.496E+05	2.5235E+05	2.5635E+13	25.8	1.24E-06	4.550E-07	1.333E-05	1.51E-08	2.58E-04	12

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360
2	1.6777	1.6491	1.6048	1.5613	1.5044	1.4447	1.3993	1.3643
3	1.8871	1.8326	1.7664	1.7056	1.6295	1.5522	1.4947	1.4509
4	2.0124	1.9405	1.8605	1.7890	1.7013	1.6134	1.5488	1.4997
5	2.1020	2.0172	1.9271	1.8480	1.7520	1.6567	1.5870	1.5342
6	2.1715	2.0764	1.9785	1.8935	1.7911	1.6901	1.6164	1.5608
7	2.2249	2.1208	2.0161	1.9262	1.8183	1.7125	1.6356	1.5776
8	2.2703	2.1586	2.0483	1.9541	1.8417	1.7318	1.6522	1.5921
9	2.3098	2.1915	2.0762	1.9784	1.8622	1.7488	1.6668	1.6050
10	2.3446	2.2205	2.1010	2.0000	1.8804	1.7639	1.6798	1.6165
11	2.3758	2.2466	2.1232	2.0194	1.8967	1.7776	1.6915	1.6269
12	2.4040	2.2701	2.1433	2.0370	1.9115	1.7899	1.7022	1.6363

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360
2	1.3251	1.2889	1.2540	1.2226	1.1918	1.1569	1.1178
3	1.4022	1.3571	1.3129	1.2717	1.2303	1.1844	1.1352
4	1.4454	1.3949	1.3450	1.2979	1.2504	1.1982	1.1435
5	1.4758	1.4215	1.3675	1.3162	1.2644	1.2080	1.1494
6	1.4992	1.4419	1.3847	1.3302	1.2752	1.2155	1.1541
7	1.5134	1.4536	1.3939	1.3369	1.2796	1.2178	1.1541
8	1.5257	1.4638	1.4019	1.3369	1.2796	1.2178	1.1541
9	1.5366	1.4729	1.4091	1.3369	1.2796	1.2178	1.1541
10	1.5464	1.4811	1.4157	1.3369	1.2796	1.2178	1.1541
11	1.5553	1.4886	1.4157	1.3369	1.2796	1.2178	1.1541
12	1.5634	1.4886	1.4157	1.3369	1.2796	1.2178	1.1541

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.18895E-17	0.33413E-17	0.52363E-17	0.75764E-17	0.11922E-16	0.19280E-16	0.28423E-16	0.39355E-16
2	0.30598E-17	0.53183E-17	0.81110E-17	0.11417E-16	0.17313E-16	0.26885E-16	0.38391E-16	0.51823E-16
3	0.34418E-17	0.59103E-17	0.89279E-17	0.12473E-16	0.18752E-16	0.28884E-16	0.41007E-16	0.55113E-16
4	0.36703E-17	0.62583E-17	0.94032E-17	0.13083E-16	0.19578E-16	0.30024E-16	0.42490E-16	0.56969E-16
5	0.38336E-17	0.65055E-17	0.97398E-17	0.13514E-16	0.20161E-16	0.30829E-16	0.43539E-16	0.58280E-16
6	0.39604E-17	0.66967E-17	0.99997E-17	0.13847E-16	0.20612E-16	0.31450E-16	0.44346E-16	0.59289E-16
7	0.40579E-17	0.68398E-17	0.10190E-16	0.14086E-16	0.20925E-16	0.31868E-16	0.44872E-16	0.59926E-16
8	0.41407E-17	0.69617E-17	0.10352E-16	0.14290E-16	0.21194E-16	0.32228E-16	0.45327E-16	0.60479E-16
9	0.42126E-17	0.70677E-17	0.10494E-16	0.14468E-16	0.21430E-16	0.32544E-16	0.45727E-16	0.60967E-16
10	0.42762E-17	0.71614E-17	0.10619E-16	0.14626E-16	0.21639E-16	0.32825E-16	0.46085E-16	0.61403E-16
11	0.43331E-17	0.72453E-17	0.10731E-16	0.14768E-16	0.21827E-16	0.33078E-16	0.46407E-16	0.61798E-16
12	0.43845E-17	0.73213E-17	0.10833E-16	0.14896E-16	0.21997E-16	0.33309E-16	0.46701E-16	0.62158E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.59103E-16	0.91693E-16	0.15399E-15	0.27760E-15	0.56409E-15	0.14388E-14	0.50445E-14
2	0.75592E-16	0.11407E-15	0.18639E-15	0.32759E-15	0.64889E-15	0.16067E-14	0.54428E-14
3	0.79991E-16	0.12011E-15	0.19514E-15	0.34076E-15	0.66989E-15	0.16449E-14	0.55276E-14
4	0.82454E-16	0.12345E-15	0.19991E-15	0.34776E-15	0.68079E-15	0.16641E-14	0.55677E-14
5	0.84191E-16	0.12581E-15	0.20325E-15	0.35267E-15	0.68844E-15	0.16777E-14	0.55967E-14
6	0.85527E-16	0.12761E-15	0.20581E-15	0.35643E-15	0.69431E-15	0.16881E-14	0.56193E-14
7	0.86334E-16	0.12865E-15	0.20717E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14
8	0.87038E-16	0.12955E-15	0.20837E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14
9	0.87662E-16	0.13036E-15	0.20944E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14
10	0.88221E-16	0.13109E-15	0.21041E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14
11	0.88727E-16	0.13174E-15	0.21041E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14
12	0.89189E-16	0.13174E-15	0.21041E-15	0.35822E-15	0.69668E-15	0.16913E-14	0.56193E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.590	0.000	0.0009	0.0005	87.2518	8.381	12.7482	87.2518	8.381	12.7482
3.500E-07	1.414	0.400	1.7859	1.1202	87.3555	8.414	12.6445	86.8819	8.264	13.1181
4.500E-07	1.320	0.600	2.5381	1.6050	88.0199	8.634	11.9801	87.4690	8.451	12.5310
5.500E-07	1.261	1.667	6.4831	4.0240	88.9860	8.976	11.0140	88.6923	8.869	11.3077
7.000E-07	1.205	5.000	17.2301	10.7313	90.2408	9.468	9.7592	89.9461	9.347	10.0539
9.000E-07	1.159	4.933	14.2047	9.0357	91.8451	10.199	8.1549	91.4197	9.992	8.5803
1.100E-06	1.130	5.000	12.1443	7.9052	93.1214	10.891	6.8786	92.5937	10.590	7.4063
1.300E-06	1.110	3.733	7.6527	5.2837	94.1943	11.581	5.8057	93.3696	11.041	6.6304
1.600E-06	1.090	8.000	13.0744	9.4199	95.3716	12.503	4.6284	94.4841	11.790	5.5159
2.000E-06	1.072	6.667	8.1804	6.6204	96.5251	13.670	3.4749	95.3483	12.483	4.6517
2.600E-06	1.055	10.667	8.7944	8.7947	97.6651	15.287	2.3349	96.1378	13.240	3.8622
3.500E-06	1.041	10.667	5.4164	7.4037	98.5620	17.259	1.4380	96.7487	13.940	3.2513
5.000E-06	1.029	11.333	2.3183	8.1639	99.4207	20.959	0.5793	96.6255	13.789	3.3745
8.000E-06	1.018	12.000	0.1755	8.4692	99.9586	31.694	0.0414	96.6939	13.872	3.3061
1.500E-05	1.010	19.333	0.0007	11.4226	99.9999	56.257	0.0001	97.2323	14.595	2.7677

EFFICIENCY - STATED = 92.50 COMPUTED = 92.4959 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 97.1680
MMD OF INLET SIZE DISTRIBUTION = 3.300E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.164E+00
LOG-NORMAL GOODNESS OF FIT = 0.934
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.296E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.628E+00
LOG-NORMAL GOODNESS OF FIT = 0.961
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 14.502

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 95.3156
CORRECTED MMD OF EFFLUENT = 2.354E+00
CORRECTED SIGMAP OF EFFLUENT = 2.154E+00
LOG-NORMAL GOODNESS OF FIT = 0.915
CORRECTED PRECIPITATION RATE PARAMETER = 12.45

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
3.605E+00	5.877E+01	5.433E-05	1.722E-03	1.776E-03	4.360E-02	2.500E-07
3.877E+00	6.144E+01	1.519E-01	5.690E-03	1.576E-01	1.022E-01	3.500E-07
4.212E+00	6.448E+01	2.783E-01	1.280E-02	2.911E-01	1.784E-01	4.500E-07
4.568E+00	6.746E+01	8.701E-01	2.320E-02	8.933E-01	2.642E-01	5.500E-07
5.118E+00	7.157E+01	1.466E+00	4.427E-02	1.510E+00	7.953E-01	7.000E-07
5.861E+00	7.632E+01	1.558E+00	8.127E-02	1.639E+00	1.132E+00	9.000E-07
6.609E+00	8.029E+01	1.630E+00	1.251E-01	1.755E+00	1.424E+00	1.100E-06
7.358E+00	8.361E+01	1.215E+00	1.726E-01	1.387E+00	1.661E+00	1.300E-06
8.483E+00	8.757E+01	1.273E+00	2.441E-01	1.517E+00	3.831E+00	1.600E-06
9.978E+00	9.139E+01	9.975E-01	3.378E-01	1.335E+00	4.234E+00	2.000E-06
1.221E+01	9.503E+01	6.939E-01	4.539E-01	1.148E+00	8.791E+00	2.600E-06
1.548E+01	9.777E+01	4.607E-01	5.810E-01	1.042E+00	1.044E+01	3.500E-06
2.096E+01	9.942E+01	1.399E-01	6.750E-01	8.150E-01	1.709E+01	5.000E-06
3.169E+01	9.996E+01	8.405E-03	6.627E-01	6.711E-01	2.114E+01	8.000E-06
5.626E+01	1.000E+02	2.390E-05	6.670E-01	6.670E-01	2.887E+01	1.500E-05

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SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  95.3156 %     SCA =  2.458E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.515E+04 V
                           AVG. CURRENT DENSITY =   25.81 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.300E+00 UM     INLET SIGMAP = - 2.164E+00
                        OUTLET MMD =  2.354E+00 UM     OUTLET SIGMAP =  2.154E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
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PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.590	0.000	0.0007	0.0005	83.5792	7.351	16.4208	83.5792	7.351	16.4208
3.500E-07	1.414	0.400	1.4492	1.0109	83.6436	7.367	16.3564	83.0869	7.231	16.9131
4.500E-07	1.320	0.600	2.0818	1.4625	84.3356	7.543	15.6644	83.6881	7.378	16.3119
5.500E-07	1.261	1.667	5.3981	3.7277	85.3804	7.824	14.6196	85.0353	7.729	14.9647
7.000E-07	1.205	5.000	14.6749	10.1592	86.7494	8.224	13.2506	86.4029	8.119	13.5971
9.000E-07	1.159	4.933	12.5146	8.8115	88.5465	8.817	11.4535	88.0464	8.643	11.9536
1.100E-06	1.130	5.000	11.0687	7.9308	90.0056	9.371	9.9944	89.3853	9.126	10.6147
1.300E-06	1.110	3.733	7.2247	5.4148	91.2624	9.918	8.7376	90.2931	9.490	9.7069
1.600E-06	1.090	8.000	12.9907	10.0111	92.6688	10.632	7.3312	91.6256	10.091	8.3744
2.000E-06	1.072	6.667	8.7171	7.2589	94.0970	11.514	5.9030	92.7138	10.657	7.2862
2.600E-06	1.055	10.667	10.4449	9.9081	95.5793	12.690	4.4207	93.7840	11.303	6.2160
3.500E-06	1.041	10.667	7.5515	8.4919	96.8039	14.010	3.1961	94.6725	11.931	5.3275
5.000E-06	1.029	11.333	4.5396	8.6265	98.1916	16.327	1.8084	94.9061	12.113	5.0939
8.000E-06	1.018	12.000	1.0716	7.6040	99.5968	22.434	0.4032	95.7595	12.859	4.2405
1.500E-05	1.010	19.333	0.2721	9.5816	99.9364	29.951	0.0636	96.6833	13.859	3.3167

EFFICIENCY - STATED = 92.50 COMPUTED = 92.4959 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 95.4853
MMD OF INLET SIZE DISTRIBUTION = 3.300E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.164E+00
LOG-NORMAL GOODNESS OF FIT = 0.934
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.486E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.719E+00
LOG-NORMAL GOODNESS OF FIT = 0.961
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 12.604

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 93.3079
CORRECTED MMD OF EFFLUENT = 2.315E+00
CORRECTED SIGMAP OF EFFLUENT = 2.099E+00
LOG-NORMAL GOODNESS OF FIT = 0.925
CORRECTED PRECIPITATION RATE PARAMETER = 11.00

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
3.605E+00	5.877E+01	6.999E-05	2.024E-03	2.094E-03	4.360E-02	2.500E-07
3.877E+00	6.144E+01	1.965E-01	6.688E-03	2.032E-01	1.022E-01	3.500E-07
4.212E+00	6.448E+01	3.639E-01	1.504E-02	3.790E-01	1.784E-01	4.500E-07
4.568E+00	6.746E+01	1.155E+00	2.727E-02	1.182E+00	2.642E-01	5.500E-07
5.118E+00	7.157E+01	1.990E+00	5.203E-02	2.042E+00	7.953E-01	7.000E-07
5.861E+00	7.632E+01	2.188E+00	9.552E-02	2.283E+00	1.132E+00	9.000E-07
6.609E+00	8.029E+01	2.368E+00	1.470E-01	2.515E+00	1.424E+00	1.100E-06
7.358E+00	8.361E+01	1.828E+00	2.028E-01	2.031E+00	1.661E+00	1.300E-06
8.483E+00	8.757E+01	2.016E+00	2.869E-01	2.303E+00	3.831E+00	1.600E-06
9.978E+00	9.139E+01	1.695E+00	3.971E-01	2.092E+00	4.234E+00	2.000E-06
1.221E+01	9.503E+01	1.314E+00	5.335E-01	1.847E+00	8.791E+00	2.600E-06
1.548E+01	9.777E+01	1.024E+00	6.829E-01	1.707E+00	1.044E+01	3.500E-06
2.096E+01	9.942E+01	4.368E-01	7.935E-01	1.230E+00	1.709E+01	5.000E-06
3.169E+01	9.996E+01	8.184E-02	7.789E-01	8.607E-01	2.114E+01	8.000E-06
5.626E+01	1.000E+02	1.532E-02	7.840E-01	7.993E-01	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

DATA SET NUMBER   2

ESP PERFORMANCE:     EFFICIENCY =  93.3079 %     SCA =  2.458E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.515E+04 V
                           AVG. CURRENT DENSITY =   25.81 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.300E+00 UM     INLET SIGMAP =  2.164E+00
                        OUTLET MMD =  2.315E+00 UM     OUTLET SIGMAP =  2.099E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00

STOP  011111
```

APPENDIX H

OUTPUT DATA FOR EXAMPLE 1 (REVISION 1)

```
*************************************
*                                   *
*          E.P.A. ESP MODEL         *
*                                   *
*     I.E.R.L.-R.T.P. AND SO.R.I.   *
*                                   *
*       REVISION I,JAN. 1, 1978     *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 16 NDATA = 1

DATA ON CARD NUMBER 2

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

DATA ON CARD NUMBER 3

NEST = 1 NDIST = 1 NVI = 1 NX = 10 NY = 10 NITER = 3 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 10 NUMINC = 20

DATA ON CARD NUMBER 5

DL = 0.01500 GRN/ACF PL = 10.0000 FT ETAO = 99.00000 % DD = 1000.00 KG/M**3 EPS = 5.100E+00
VRATIO = 1.0300 US = 0.000165 M**2/V-SEC FPATH = 1.0000 EBD = 1500000. V/M RHOCGS = 1.00E+09 OHM-CM

DATA ON CARD NUMBER 6

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 4.0
ASNUCK(2) = 0.10 AZIGGY(2) = 0.10 AZNUMS(2) = 4.0

DATA ON CARD NUMBER 7

```
ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   8

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER   9

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0002 %   PRCU( 3) =   0.4002 %   PRCU( 4) =   1.0002 %   PRCU( 5) =   2.6672 %
PRCU( 6) =   7.6672 %   PRCU( 7) =  12.6002 %   PRCU( 8) =  17.6002 %   PRCU( 9) =  21.3332 %   PRCU(10) =  29.3332 %

DATA ON CARD NUMBER  10

PRCU(11) =  36.0002 %   PRCU(12) =  46.6672 %   PRCU(13) =  57.3342 %   PRCU(14) =  68.6672 %   PRCU(15) =  80.6672 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  11

NUMSEC =  3    LSECT( 1) =  3  LSECT( 2) =  3  LSECT( 3) =  6

DATA ON CARD NUMBER  12

AS( 1) =  6.2500E+00 FT**2  VOS( 1) =  4.6000E+04 V  TCS( 1) =  1.5000E-04 A  WLS( 1) =  6.2500E+00 FT
ACS( 1) =  4.6875E-02 IN  BS( 1) =  5.0000E+00 IN  NWS( 1) =  5.0000E+00

DATA ON CARD NUMBER  13

SYS( 1) =  2.5000E+00 IN  VGS( 1) =  2.0000E+02 FT**3/MIN  VGASS( 1) =  3.2000E+00 FT/SEC  TEMPS( 1) =  7.6800E+01 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  1.8000E-05 KG/M-SEC  LINCS( 1) =  8.3333E-01 FT

DATA ON CARD NUMBER  14

AS( 2) =  6.2500E+00 FT**2  VOS( 2) =  4.5800E+04 V  TCS( 2) =  1.5000E-04 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00
```

```
DATA ON CARD NUMBER  15

SYS( 2) =  2.5000E+00 IN  VGS( 2) =  2.0000E+02 FT**3/MIN  VGASS( 2) =  3.2000E+00 FT/SEC  TEMPS( 2) =  7.6800E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  8.3333E-01 FT

DATA ON CARD NUMBER  16

AS( 3) =  1.2500E+01 FT**2  VDS( 3) =  4.4400E+04 V  TCS( 3) =  3.0000E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  17

SYS( 3) =  2.5000E+00 IN  VGS( 3) =  2.0000E+02 FT**3/MIN  VGASS( 3) =  3.2000E+00 FT/SEC  TEMPS( 3) =  7.6800E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  8.3333E-01 FT
```

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.600E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0860	3.622E+05	2.7624E+05	2.2804E+13	25.8	6.69E-06	1.033E-05	3.027E-04	5.00E-08	2.58E-04	1
1.0501	3.622E+05	2.7455E+05	2.3583E+13	25.8	4.07E-06	6.545E-06	1.917E-04	6.06E-08	2.58E-04	2
1.0288	3.622E+05	2.7356E+05	2.4073E+13	25.8	2.89E-06	4.124E-06	1.208E-04	5.37E-08	2.58E-04	3

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.580E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0165	3.606E+05	2.7206E+05	2.4470E+13	25.8	2.35E-06	2.836E-06	8.310E-05	4.64E-08	2.58E-04	4
1.0096	3.606E+05	2.7206E+05	2.4638E+13	25.8	2.04E-06	2.085E-06	6.107E-05	4.03E-08	2.58E-04	5
1.0056	3.606E+05	2.7206E+05	2.4736E+13	25.8	1.80E-06	1.589E-06	4.655E-05	3.49E-08	2.58E-04	6

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.440E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 3.000E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 31.87

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0031	3.496E+05	2.6452E+05	2.5578E+13	25.8	1.60E-06	1.206E-06	3.533E-05	2.93E-08	2.58E-04	7
1.0018	3.496E+05	2.6452E+05	2.5611E+13	25.8	1.50E-06	9.603E-07	2.813E-05	2.54E-08	2.58E-04	8
1.0011	3.496E+05	2.6452E+05	2.5631E+13	25.8	1.42E-06	7.745E-07	2.269E-05	2.21E-08	2.58E-04	9

1.0006	3.496E+05	2.6452E+05	2.5642E+13	25.8	1.35E-06	6.304E-07	1.847E-05	1.92E-08	2.58E-04	10
1.0004	3.496E+05	2.6452E+05	2.5649E+13	25.8	1.27E-06	5.174E-07	1.516E-05	1.68E-08	2.58E-04	11
1.0002	3.496E+05	2.6452E+05	2.5653E+13	25.8	1.20E-06	4.272E-07	1.252E-05	1.46E-08	2.58E-04	12

EST. EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 93.24

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=125FT2/1000ACFM;J=24.0UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.600E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 20.11

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0543	3.622E+05	2.7479E+05	2.3490E+13	25.8	6.71E-06	1.032E-05	3.022E-04	4.98E-08	2.58E-04	1
1.0371	3.622E+05	2.7395E+05	2.3879E+13	25.8	4.07E-06	6.541E-06	1.916E-04	6.06E-08	2.58E-04	2
1.0250	3.622E+05	2.7338E+05	2.4162E+13	25.8	2.89E-06	4.130E-06	1.210E-04	5.38E-08	2.58E-04	3

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.580E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 1.500E-04 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 20.11

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0168	3.606E+05	2.7208E+05	2.4463E+13	25.8	2.35E-06	2.842E-06	8.326E-05	4.65E-08	2.58E-04	4
1.0114	3.606E+05	2.7208E+05	2.4593E+13	25.8	2.04E-06	2.088E-06	6.117E-05	4.03E-08	2.58E-04	5
1.0078	3.606E+05	2.7208E+05	2.4682E+13	25.8	1.80E-06	1.591E-06	4.662E-05	3.49E-08	2.58E-04	6

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 7.869E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.667 K
ION MOBILITY = 1.798E-04 M2/VOLT-SEC
DUST WEIGHT = 3.250E-06 KG/SEC

APPLIED VOLTAGE = 4.440E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 2.581E-04 AMP/M2
GAS FLOW RATE = 9.460E-02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.439E+02 M/SEC
LENGTH INCR. =0.25416565 M

TOTAL CURRENT = 3.000E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 2.581E+03 VOLT/M
GAS VELOCITY = 9.760E-01 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.708E-08 M
INPUT EFF./INCR. = 20.11

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.

1.0052	3.496E+05	2.6461E+05	2.5527E+13	25.8	1.60E-06	1.208E-06	3.538E-05	2.93E-08	2.58E-04	7
1.0036	3.496E+05	2.6461E+05	2.5568E+13	25.8	1.50E-06	9.615E-07	2.817E-05	2.54E-08	2.58E-04	8
1.0025	3.496E+05	2.6461E+05	2.5596E+13	25.8	1.42E-06	7.753E-07	2.271E-05	2.21E-08	2.58E-04	9
1.0017	3.496E+05	2.6461E+05	2.5615E+13	25.8	1.35E-06	6.310E-07	1.849E-05	1.92E-08	2.58E-04	10
1.0012	3.496E+05	2.6461E+05	2.5629E+13	25.8	1.27E-06	5.178E-07	1.517E-05	1.68E-08	2.58E-04	11
1.0008	3.496F+05	2.6461E+05	2.5638E+13	25.8	1.20E-06	4.275E-07	1.253E-05	1.46E-08	2.58E-04	12

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360
2	1.6765	1.6491	1.6069	1.5659	1.5128	1.4572	1.4146	1.3809
3	1.8868	1.8344	1.7709	1.7129	1.6406	1.5667	1.5110	1.4676
4	2.0127	1.9433	1.8663	1.7977	1.7136	1.6287	1.5653	1.5140
5	2.1027	2.0207	1.9338	1.8577	1.7651	1.6724	1.6034	1.5501
6	2.1726	2.0805	1.9859	1.9039	1.8047	1.7060	1.6328	1.5762
7	2.2263	2.1253	2.0239	1.9369	1.8322	1.7285	1.6517	1.5926
8	2.2719	2.1634	2.0564	1.9651	1.8558	1.7478	1.6682	1.6069
9	2.3116	2.1966	2.0847	1.9897	1.8765	1.7648	1.6826	1.6195
10	2.3466	2.2259	2.1097	2.0116	1.8948	1.7800	1.6955	1.6307
11	2.3779	2.2521	2.1322	2.0312	1.9113	1.7936	1.7071	1.6409
12	2.4063	2.2759	2.1525	2.0489	1.9262	1.8059	1.7177	1.6501

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	1.0360	1.0360	1.0360	1.0360	1.0360	1.0360	0.9805
2	1.3419	1.3037	1.2638	1.2246	1.1852	1.1440	1.0975
3	1.4177	1.3692	1.3189	1.2699	1.2210	1.1704	1.1185
4	1.4596	1.4052	1.3488	1.2942	1.2399	1.1839	1.1279
5	1.4892	1.4305	1.3699	1.3113	1.2533	1.1935	1.1345
6	1.5119	1.4499	1.3861	1.3245	1.2636	1.2009	1.1396
7	1.5255	1.4609	1.3946	1.3307	1.2677	1.2032	1.1396
8	1.5374	1.4706	1.4022	1.3307	1.2677	1.2032	1.1396
9	1.5479	1.4793	1.4089	1.3307	1.2677	1.2032	1.1396
10	1.5573	1.4870	1.4089	1.3307	1.2677	1.2032	1.1396
11	1.5659	1.4941	1.4089	1.3307	1.2677	1.2032	1.1396
12	1.5737	1.4941	1.4089	1.3307	1.2677	1.2032	1.1396

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.18895E-17	0.33413E-17	0.52363E-17	0.75764E-17	0.11922E-16	0.19280E-16	0.28423E-16	0.39355E-16
2	0.30576E-17	0.53184E-17	0.81218E-17	0.11451E-16	0.17409E-16	0.27117E-16	0.38808E-16	0.52455E-16
3	0.34412E-17	0.59159E-17	0.89506E-17	0.12526E-16	0.18879E-16	0.29155E-16	0.41455E-16	0.55747E-16
4	0.36708E-17	0.62673E-17	0.94325E-17	0.13147E-16	0.19720E-16	0.30309E-16	0.42942E-16	0.57586E-16
5	0.38350E-17	0.65169E-17	0.97737E-17	0.13585E-16	0.20312E-16	0.31122E-16	0.43990E-16	0.58880E-16
6	0.39624E-17	0.67099E-17	0.10037E-16	0.13923E-16	0.20768E-16	0.31747E-16	0.44795E-16	0.59875E-16
7	0.40603E-17	0.68543E-17	0.10229E-16	0.14164E-16	0.21085E-16	0.32165E-16	0.45315E-16	0.60498E-16
8	0.41436E-17	0.69772E-17	0.10393E-16	0.14370E-16	0.21356E-16	0.32526E-16	0.45766E-16	0.61039E-16
9	0.42159E-17	0.70841E-17	0.10536E-16	0.14551E-16	0.21594E-16	0.32842E-16	0.46162E-16	0.61517E-16
10	0.42797E-17	0.71786E-17	0.10663E-16	0.14710E-16	0.21805E-16	0.33123E-16	0.46516E-16	0.61944E-16
11	0.43369E-17	0.72633E-17	0.10776E-16	0.14853E-16	0.21994E-16	0.33376E-16	0.46835E-16	0.62330E-16
12	0.43886E-17	0.73399E-17	0.10879E-16	0.14983E-16	0.22166E-16	0.33607E-16	0.47125E-16	0.62682E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.59103E-16	0.91693E-16	0.15399E-15	0.27760E-15	0.56409E-15	0.14388E-14	0.47743E-14
2	0.76553E-16	0.11538E-15	0.18783E-15	0.32811E-15	0.64529E-15	0.15888E-14	0.53438E-14
3	0.80874E-16	0.12118E-15	0.19602E-15	0.34026E-15	0.66482E-15	0.16255E-14	0.54458E-14
4	0.83269E-16	0.12436E-15	0.20047E-15	0.34677E-15	0.67509E-15	0.16442E-14	0.54918E-14
5	0.84954E-16	0.12660E-15	0.20361E-15	0.35136E-15	0.68237E-15	0.16575E-14	0.55241E-14
6	0.86249E-16	0.12832E-15	0.20602E-15	0.35490E-15	0.68798E-15	0.16678E-14	0.55489E-14
7	0.87025E-16	0.12930E-15	0.20728E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14
8	0.87702E-16	0.13016E-15	0.20841E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14
9	0.88302E-16	0.13092E-15	0.20941E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14
10	0.88841E-16	0.13161E-15	0.20941E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14
11	0.89329E-16	0.13223E-15	0.20941E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14
12	0.89775E-16	0.13223E-15	0.20941E-15	0.35657E-15	0.69025E-15	0.16710E-14	0.55489E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.590	0.000	0.0010	0.0006	88.5687	8.824	11.4313	88.5687	8.824	11.4313
3.500E-07	1.414	0.400	1.8884	1.1360	88.7009	8.872	11.2991	88.2556	8.715	11.7444
4.500E-07	1.320	0.600	2.6661	1.6182	89.3651	9.118	10.6349	88.8470	8.925	11.1530
5.500E-07	1.261	1.667	6.7526	4.0195	90.3050	9.495	9.6950	90.0288	9.381	9.9712
7.000E-07	1.205	5.000	17.7324	10.5981	91.5119	10.036	8.4881	91.2347	9.905	8.7653
9.000E-07	1.159	4.933	14.3956	8.8090	93.0155	10.829	6.9845	92.6155	10.602	7.3845
1.100E-06	1.130	5.000	12.1546	7.6348	94.1818	11.572	5.8182	93.6856	11.239	6.3144
1.300E-06	1.110	3.733	7.5813	5.0878	95.1393	12.304	4.8607	94.3638	11.702	5.6362
1.600E-06	1.090	8.000	12.8201	9.0344	96.1645	13.268	3.8355	95.3300	12.467	4.6700
2.000E-06	1.072	6.667	7.9521	6.3865	97.1453	14.469	2.8547	96.0386	13.137	3.9614
2.600E-06	1.055	10.667	8.5246	8.6386	98.0873	16.099	1.9127	96.6510	13.820	3.3490
3.500E-06	1.041	10.667	5.1979	7.4069	98.8337	18.112	1.1663	97.1285	14.446	2.8715
5.000E-06	1.029	11.333	2.1822	8.4664	99.5391	21.890	0.4609	96.9107	14.148	3.0893
8.000E-06	1.018	12.000	0.1505	8.9957	99.9700	33.002	0.0300	96.9000	14.134	3.1000
1.500E-05	1.010	19.333	0.0008	12.1675	99.9999	58.252	0.0001	97.3973	14.886	2.6027

EFFICIENCY = STATED = 93.24 COMPUTED = 93.2425 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 97.6066
MMD OF INLET SIZE DISTRIBUTION = 3.300E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.164E+00
LOG-NORMAL GOODNESS OF FIT = 0.934
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.279E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.626E+00
LOG-NORMAL GOODNESS OF FIT = 0.961
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 15.187

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 95.8647
CORRECTED MMD OF EFFLUENT = 2.487E+00
CORRECTED SIGMAP OF EFFLUENT = 2.177E+00
LOG-NORMAL GOODNESS OF FIT = 0.913
CORRECTED PRECIPITATION RATE PARAMETER = 12.96

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
3.795E+00	6.066E+01	4.872E-05	1.619E-03	1.668E-03	4.360E-02	2.500E-07
4.088E+00	6.339E+01	1.357E-01	5.350E-03	1.411E-01	1.022E-01	3.500E-07
4.448E+00	6.649E+01	2.471E-01	1.204E-02	2.591E-01	1.784E-01	4.500E-07
4.832E+00	6.950E+01	7.659E-01	2.182E-02	7.878E-01	2.642E-01	5.500E-07
5.425E+00	7.364E+01	1.275E+00	4.163E-02	1.316E+00	7.953E-01	7.000E-07
6.224E+00	7.834E+01	1.334E+00	7.642E-02	1.411E+00	1.132E+00	9.000E-07
7.022E+00	8.220E+01	1.379E+00	1.176E-01	1.496E+00	1.424E+00	1.100E-06
7.817E+00	8.536E+01	1.017E+00	1.623E-01	1.179E+00	1.661E+00	1.300E-06
9.001E+00	8.905E+01	1.055E+00	2.295E-01	1.285E+00	3.831E+00	1.600E-06
1.056E+01	9.254E+01	8.195E-01	3.177E-01	1.137E+00	4.234E+00	2.000E-06
1.286E+01	9.576E+01	5.684E-01	4.268E-01	9.952E-01	8.791E+00	2.600E-06
1.624E+01	9.815E+01	3.737E-01	5.463E-01	9.200E-01	1.044E+01	3.500E-06
2.189E+01	9.954E+01	1.113E-01	6.348E-01	7.461E-01	1.709E+01	5.000E-06
3.300E+01	9.997E+01	6.094E-03	6.231E-01	6.292E-01	2.114E+01	8.000E-06
5.825E+01	1.000E+02	2.390E-05	6.272E-01	6.272E-01	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

                DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  95.8647 %     SCA =  2.458E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.515E+04 V
                           AVG. CURRENT DENSITY =   25.81 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.300E+00 UM     INLET SIGMAP =  2.164E+00
                        OUTLET MMD =  2.407E+00 UM     OUTLET SIGMAP =  2.177E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.590	0.000	0.0008	0.0005	85.0413	7.730	14.9587	85.0413	7.730	14.9587
3.500E-07	1.414	0.400	1.5105	1.0237	85.1390	7.757	14.8610	84.6075	7.614	15.3925
4.500E-07	1.320	0.600	2.1586	1.4741	85.8414	7.954	14.1586	85.2230	7.780	14.7770
5.500E-07	1.261	1.667	5.5601	3.7294	86.8737	8.262	13.1263	86.5441	8.161	13.4559
7.000E-07	1.205	5.000	14.9759	10.0738	88.2127	8.700	11.7873	87.8819	8.587	12.1181
9.000E-07	1.159	4.933	12.6233	8.6511	89.9295	9.340	10.0705	89.4519	9.152	10.5481
1.100E-06	1.130	5.000	11.0645	7.7320	91.2913	9.931	8.7087	90.6989	9.664	9.3011
1.300E-06	1.110	3.733	7.1718	5.2670	92.4393	10.507	7.5607	91.5136	10.037	8.4864
1.600E-06	1.090	8.000	12.8182	9.7120	93.6944	11.245	6.3056	92.6982	10.648	7.3018
2.000E-06	1.072	6.667	8.5701	7.0716	94.9412	12.142	5.0588	93.6203	11.198	6.3797
2.600E-06	1.055	10.667	10.2993	9.7794	96.2002	13.306	3.7998	94.4858	11.791	5.5142
3.500E-06	1.041	10.667	7.4536	8.4866	97.2501	14.622	2.7499	95.2147	12.368	4.7853
5.000E-06	1.029	11.333	4.4961	8.8535	98.4387	16.925	1.5613	95.3013	12.442	4.6987
8.000E-06	1.018	12.000	1.0551	8.0015	99.6540	23.056	0.3460	95.9895	13.086	4.0105
1.500E-05	1.010	19.333	0.2420	10.1438	99.9507	30.987	0.0493	96.8441	14.061	3.1559

EFFICIENCY = STATED = 93.24 COMPUTED = 93.2425 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 96.0646
MMD OF INLET SIZE DISTRIBUTION = 3.300E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.164E+00
LOG-NORMAL GOODNESS OF FIT = 0.934
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.475E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.720E+00
LOG-NORMAL GOODNESS OF FIT = 0.960
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 13.163

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 93.9853
CORRECTED MMD OF EFFLUENT = 2.354E+00
CORRECTED SIGMAP OF EFFLUENT = 2.116E+00
LOG-NORMAL GOODNESS OF FIT = 0.923
CORRECTED PRECIPITATION RATE PARAMETER = 11.44

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
3.795E+00	6.066E+01	6.375E-05	1.933E-03	1.996E-03	4.360E-02	2.500E-07
4.088E+00	6.339E+01	1.785E-01	6.386E-03	1.849E-01	1.022E-01	3.500E-07
4.448E+00	6.649E+01	3.290E-01	1.437E-02	3.433E-01	1.784E-01	4.500E-07
4.832E+00	6.950E+01	1.037E+00	2.604E-02	1.063E+00	2.642E-01	5.500E-07
5.425E+00	7.364E+01	1.770E+00	4.969E-02	1.820E+00	7.953E-01	7.000E-07
6.224E+00	7.834E+01	1.924E+00	9.122E-02	2.015E+00	1.132E+00	9.000E-07
7.022E+00	8.220E+01	2.064E+00	1.404E-01	2.204E+00	1.424E+00	1.100E-06
7.817E+00	8.536E+01	1.582E+00	1.937E-01	1.776E+00	1.661E+00	1.300E-06
9.001E+00	8.905E+01	1.734E+00	2.740E-01	2.008E+00	3.831E+00	1.600E-06
1.056E+01	9.254E+01	1.452E+00	3.792E-01	1.831E+00	4.234E+00	2.000E-06
1.286E+01	9.576E+01	1.129E+00	5.095E-01	1.639E+00	8.791E+00	2.600E-06
1.624E+01	9.815E+01	8.810E-01	6.521E-01	1.533E+00	1.044E+01	3.500E-06
2.189E+01	9.954E+01	3.771E-01	7.577E-01	1.135E+00	1.709E+01	5.000E-06
3.300E+01	9.997E+01	7.024E-02	7.438E-01	8.140E-01	2.114E+01	8.000E-06
5.825E+01	1.000E+02	1.187E-02	7.487E-01	7.605E-01	2.887E+01	1.500E-05

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SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

DATA SET NUMBER   2

ESP PERFORMANCE:     EFFICIENCY =  93.9853 %     SCA =  2.458E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.515E+04 V
                           AVG. CURRENT DENSITY =   25.81 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.300E+00 UM     INLET SIGMAP =  2.164E+00
                        OUTLET MMD =  2.354E+00 UM     OUTLET SIGMAP =  2.116E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

STOP 011111

APPENDIX I

OUTPUT DATA FOR EXAMPLE 2 (REVISION 2)

```
*************************************
*                                   *
*          E.P.A. ESP MODEL         *
*                                   *
*     I.F.R.L.-R.T.P. AND SO.R.I.   *
*                                   *
*        REVISION II, AUG., 1979    *
*                                   *
*************************************

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER  1


DATA ON CARD NUMBER   1

NENDPT = 16   NDATA =  1

DATA ON CARD NUMBER   2

LAB ESP; SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

DATA ON CARD NUMBER   3

NEST =  1  NDIST =  1  NVI =  4  NX = 15  NY = 15  NITER =  1  NCALC =  0  NRAPD =  1  NEFF =  1  NTEMP =  1  NONID =  2

DATA ON CARD NUMBER   4

NN =  5  NUMINC =  3

DATA ON CARD NUMBER   5

IFINAL = 20  JI1 =  2  JI2 = 21  VISKIP = 1  VISAME =  2

DATA ON CARD NUMBER   6

DL =  0.06500 GRN/ACF  PL =  10.0000 FT  ETAD = 99.00000 %  DD =  1000.00 KG/M**3  EPS =  5.100E+00
VRATIO =   1.0300  US = 0.000165 M**2/V-SEC  FPATH =   1.0000  FBD = 1500000. V/M  RHOCGS =  1.00E+09 OHM-CM

DATA ON CARD NUMBER   7

ASNUCK( 1) = 0.00  AZIGGY( 1) = 0.00  AZNUMS( 1) =  4.0
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```
ASHUCK( 2) = 0.10  AZIGGY( 2) = 0.10  AZNUMS( 2) =  4.0

DATA ON CARD NUMBER   8

ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   9

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER  10

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0076 %   PRCU( 3) =   0.0563 %   PRCU( 4) =   0.2682 %   PRCU( 5) =   0.8652 %
PRCU( 6) =   2.9845 %   PRCU( 7) =   5.9695 %   PRCU( 8) =   9.5515 %   PRCU( 9) =  12.8350 %   PRCU(10) =  19.7004 %

DATA ON CARD NUMBER  11

PRCU(11) =  26.8643 %   PRCU(12) =  38.8042 %   PRCU(13) =  49.2516 %   PRCU(14) =  64.1765 %   PRCU(15) =  79.1014 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  12

NUMSEC =  3    LSECT( 1) =  6  LSECT( 2) =  6  LSECT( 3) = 12

DATA ON CARD NUMBER  13

AB( 1) =  6.2500E+00 FT**2  VOB( 1) =  4.0800E+04 V  TCB( 1) =  6.2500E-05 A  HLB( 1) =  6.2500E+00 FT
ACB( 1) =  4.6875E-02 IN  BB( 1) =  5.0000E+00 IN  NWB( 1) =  5.0000E+00

DATA ON CARD NUMBER  14

BYB( 1) =  2.5000E+00 IN  VGB( 1) =  3.0533E+02 FT**3/MIN  VGABB( 1) =  4.8853E+00 FT/SEC  TEMPB( 1) =  7.6000E+01 F
PB( 1) =  1.0000E+00 ATM  VISB( 1) =  1.8000E-05 KG/M-SEC  LINCB( 1) =  4.1667E-01 FT
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DATA ON CARD NUMBER  15

RFS( 1) =  9.0000E-01  START1( 1) =  6.0000E-05 A/M**2  START2( 1) =  2.0000E-05 A/M**2
START3( 1) =  2.0000E-05 A/M**2  VSTAR( 1) =  3.8000E+04 V

DATA ON CARD NUMBER  16

AS( 2) =  6.2500E+00 FT**2  VOS( 2) =  4.0800E+04 V  TCS( 2) =  6.2500E-05 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00

DATA ON CARD NUMBER  17

SYS( 2) =  2.5000E+00 IN  VGS( 2) =  3.0533E+02 FT**3/MIN  VGASS( 2) =  4.8853E+00 FT/SEC  TEMPS( 2) =  7.6000E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  4.1667E-01 FT

DATA ON CARD NUMBER  18

RFS( 2) =  9.0000E-01  START1( 2) =  6.0000E-05 A/M**2  START2( 2) =  2.0000E-05 A/M**2
START3( 2) =  2.0000E-05 A/M**2  VSTAR( 2) =  3.8000E+04 V

DATA ON CARD NUMBER  19

AS( 3) =  1.2500E+01 FT**2  VOS( 3) =  3.9600E+04 V  TCS( 3) =  1.2500E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  20

SYS( 3) =  2.5000E+00 IN  VGS( 3) =  3.0533E+02 FT**3/MIN  VGASS( 3) =  4.8853E+00 FT/SEC  TEMPS( 3) =  7.6000E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  4.1667E-01 FT

DATA ON CARD NUMBER  21

RFS( 3) =  9.0000E-01  START1( 3) =  6.0000E-05 A/M**2  START2( 3) =  2.0000E-05 A/M**2
START3( 3) =  2.0000E-05 A/M**2  VSTAR( 3) =  3.8000E+04 V
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CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 1

VW = -3.7698E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7773E+05

VW = -3.8347E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8647E+05

VW = -3.8965E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9469E+05

VW = -3.9557E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0248E+05

VW = -4.0125E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0988E+05

VW = -4.0673E+04 ACDNTY = 1.6000E-04 AEPLT = -2.1697E+05

VW = -4.1204E+04 ACDNTY = 1.8000E-04 AEPLT = -2.2376E+05

VW = -4.0802E+04 ACDNTY = 1.6478E-04 AEPLT = -2.1861E+05

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 5.024E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.648E-04 AMP/M2
GAS FLOW RATE = 1.464E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.578E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.648E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.6198	2.056E+05	2.1861E+05	1.1808E+13	13.5	7.30E-06	5.885E-06	5.264E-04	3.53E-08	1.65E-04	1
0.6314	2.056E+05	2.1861E+05	1.1824E+13	11.7	4.42E-06	9.761E-06	8.731E-04	8.79E-08	1.65E-04	2
0.6684	2.056E+05	2.1861E+05	1.1826E+13	11.3	2.97E-06	1.010E-05	9.030E-04	1.11E-07	1.65E-04	3
0.6814	2.056E+05	2.1861E+05	1.1826E+13	11.2	2.28E-06	9.660E-06	8.640E-04	1.21E-07	1.65E-04	4
0.6804	2.056E+05	2.1861E+05	1.1826E+13	11.2	1.92E-06	8.978E-06	8.030E-04	1.24E-07	1.65E-04	5
0.6824	2.056E+05	2.1861E+05	1.1827E+13	11.2	1.63E-06	8.217E-06	7.350E-04	1.25E-07	1.65E-04	6

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 2

VW = -3.7698E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7773E+05

VW = -3.8347E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8647E+05

VW = -3.8965E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9469E+05

VW = -3.9557E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0248E+05

VW = -4.0125E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0988E+05

VW = -4.0673E+04 ACDNTY = 1.6000E-04 AEPLT = -2.1697E+05

VW = -4.1204E+04 ACDNTY = 1.8000E-04 AEPLT = -2.2376E+05

VW = -4.0802E+04 ACDNTY = 1.6478E-04 AEPLT = -2.1861E+05

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 5.024E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.705E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.648E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.578E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.668E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.6862	2.056E+05	2.1861E+05	1.1827E+13	11.3	1.45E-06	7.460E-06	6.673E-04	1.23E-07	1.65E-04	7
0.6910	2.056E+05	2.1861E+05	1.1827E+13	11.4	1.32E-06	6.747E-06	6.039E-04	1.20E-07	1.65E-04	8
0.6965	2.056E+05	2.1861E+05	1.1827E+13	11.5	1.19E-06	6.093E-06	5.450E-04	1.17E-07	1.65E-04	9
0.7024	2.056E+05	2.1861E+05	1.1827E+13	11.6	1.08E-06	5.497E-06	4.917E-04	1.13E-07	1.65E-04	10
0.7085	2.056E+05	2.1861E+05	1.1827E+13	11.7	9.97E-07	4.962E-06	4.438E-04	1.09E-07	1.65E-04	11
0.7148	2.056E+05	2.1861E+05	1.1827E+13	11.8	9.31E-07	4.486E-06	4.013E-04	1.05E-07	1.65E-04	12

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 3

VW = -3.7701E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7777E+05

VW = -3.8350E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8651E+05

VW = -3.8968E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9473E+05

VW = -3.9560E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0252E+05

VW = -4.0128E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0993E+05

VW = -3.9601E+04 ACDNTY = 1.2142E-04 AEPLT = -2.0306E+05

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 3.702E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION-MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 3.960E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.214E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 1.412E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 1.214E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.6684	1.963E+05	2.0306E+05	9.2745E+12	8.1	8.51E-07	3.784E-06	3.385E-04	9.33E-08	1.21E-04	13
0.6756	1.963E+05	2.0306E+05	9.2745E+12	8.2	8.03E-07	3.449E-06	3.085E-04	8.93E-08	1.21E-04	14
0.6829	1.963E+05	2.0306E+05	9.2745E+12	8.3	7.63E-07	3.156E-06	2.817E-04	8.52E-08	1.21E-04	15
0.6902	1.963E+05	2.0306E+05	9.2745E+12	8.4	7.31E-07	2.886E-06	2.581E-04	8.14E-08	1.21E-04	16
0.6975	1.963E+05	2.0306E+05	9.2745E+12	8.5	7.04E-07	2.652E-06	2.372E-04	7.77E-08	1.21E-04	17
0.7047	1.963E+05	2.0306E+05	9.2746E+12	8.6	6.78E-07	2.445E-06	2.187E-04	7.43E-08	1.21E-04	18
0.7118	1.963E+05	2.0306E+05	9.2746E+12	8.6	6.56E-07	2.260E-06	2.022E-04	7.10E-08	1.21E-04	19
0.7188	1.963E+05	2.0306E+05	9.2746E+12	8.7	6.38E-07	2.095E-06	1.874E-04	6.79E-08	1.21E-04	20
0.7257	1.963E+05	2.0306E+05	9.2746E+12	8.8	6.22E-07	1.947E-06	1.742E-04	6.50E-08	1.21E-04	21
0.7325	1.963E+05	2.0306E+05	9.2746E+12	8.9	6.09E-07	1.814E-06	1.622E-04	6.22E-08	1.21E-04	22
0.7391	1.963E+05	2.0306E+05	9.2746E+12	9.0	5.97E-07	1.693E-06	1.514E-04	5.96E-08	1.21E-04	23
0.7456	1.963E+05	2.0306E+05	9.2746E+12	9.1	5.87E-07	1.584E-06	1.416E-04	5.71E-08	1.21E-04	24

DESIGN EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 79.01

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.0663	1.0390	0.9995	0.9613	0.9116	0.8615	0.8220	0.7916
2	1.3532	1.3082	1.2569	1.2112	1.1555	1.0976	1.0486	1.0102
3	1.5070	1.4468	1.3840	1.3296	1.2644	1.1990	1.1481	1.1093
4	1.6119	1.5398	1.4680	1.4068	1.3341	1.2625	1.2086	1.1680
5	1.6913	1.6096	1.5305	1.4639	1.3852	1.3085	1.2517	1.2092
6	1.7551	1.6654	1.5802	1.5090	1.4254	1.3443	1.2851	1.2410
7	1.8084	1.7118	1.6214	1.5463	1.4584	1.3737	1.3123	1.2666
8	1.8541	1.7515	1.6566	1.5780	1.4865	1.3986	1.3352	1.2882
9	1.8941	1.7861	1.6871	1.6056	1.5108	1.4201	1.3549	1.3067
10	1.9296	1.8168	1.7142	1.6300	1.5322	1.4390	1.3722	1.3229
11	1.9616	1.8444	1.7385	1.6518	1.5514	1.4559	1.3876	1.3373
12	1.9906	1.8694	1.7605	1.6716	1.5688	1.4711	1.4015	1.3502
13	2.0095	1.8853	1.7742	1.6837	1.5792	1.4800	1.4094	1.3575
14	2.0274	1.9003	1.7872	1.6951	1.5890	1.4884	1.4169	1.3643
15	2.0443	1.9145	1.7995	1.7059	1.5983	1.4964	1.4240	1.3708
16	2.0603	1.9280	1.8111	1.7162	1.6072	1.5039	1.4240	1.3708
17	2.0756	1.9409	1.8222	1.7260	1.6156	1.5111	1.4240	1.3708
18	2.0901	1.9531	1.8328	1.7354	1.6236	1.5111	1.4240	1.3708
19	2.1040	1.9648	1.8429	1.7443	1.6236	1.5111	1.4240	1.3708
20	2.1173	1.9760	1.8525	1.7528	1.6236	1.5111	1.4240	1.3708
21	2.1300	1.9867	1.8618	1.7528	1.6236	1.5111	1.4240	1.3708
22	2.1423	1.9970	1.8618	1.7528	1.6236	1.5111	1.4240	1.3708
23	2.1540	2.0070	1.8618	1.7528	1.6236	1.5111	1.4240	1.3708
24	2.1654	2.0070	1.8618	1.7528	1.6236	1.5111	1.4240	1.3708

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.7564	0.7216	0.6866	0.6534	0.6227	0.5910	0.5508
2	0.9665	0.9233	0.8795	0.8392	0.8019	0.7571	0.6984
3	1.0651	1.0195	0.9729	0.9302	0.8872	0.8368	0.7690
4	1.1226	1.0780	1.0341	0.9917	0.9489	0.8916	0.8173
5	1.1623	1.1175	1.0741	1.0362	0.9944	0.9377	0.8523
6	1.1925	1.1471	1.1035	1.0660	1.0305	0.9751	0.8798
7	1.2168	1.1706	1.1266	1.0891	1.0549	1.0055	0.9047
8	1.2370	1.1899	1.1455	1.1077	1.0740	1.0316	0.9293
9	1.2543	1.2064	1.1613	1.1232	1.0895	1.0501	0.9537
10	1.2694	1.2207	1.1750	1.1363	1.1024	1.0646	0.9740
11	1.2828	1.2333	1.1869	1.1477	1.1133	1.0762	0.9912
12	1.2948	1.2446	1.1975	1.1577	1.1228	1.0859	1.0069
13	1.3013	1.2505	1.2029	1.1624	1.1269	1.0894	1.0160
14	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0235
15	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0297
16	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0351
17	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
18	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
19	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
20	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
21	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397

22	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
23	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397
24	1.3075	1.2505	1.2029	1.1624	1.1269	1.0894	1.0397

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.17422E-17	0.30023E-17	0.45269E-17	0.63002E-17	0.94017E-17	0.14369E-16	0.20212E-16	0.26950E-16
2	0.22111E-17	0.37803E-17	0.56927E-17	0.79380E-17	0.11917E-16	0.18306E-16	0.25784E-16	0.34393E-16
3	0.24623E-17	0.41808E-17	0.62682E-17	0.87137E-17	0.13040E-16	0.19998E-16	0.28232E-16	0.37769E-16
4	0.26336E-17	0.44497E-17	0.66487E-17	0.92196E-17	0.13759E-16	0.21057E-16	0.29718E-16	0.39765E-16
5	0.27634E-17	0.46514E-17	0.69320E-17	0.95935E-17	0.14286E-16	0.21823E-16	0.30779E-16	0.41171E-16
6	0.28676E-17	0.48126E-17	0.71572E-17	0.98893E-17	0.14700E-16	0.22422E-16	0.31600E-16	0.42251E-16
7	0.29547E-17	0.49467E-17	0.73437E-17	0.10134E-16	0.15041E-16	0.22912E-16	0.32268E-16	0.43125E-16
8	0.30294E-17	0.50613E-17	0.75028E-17	0.10342E-16	0.15331E-16	0.23326E-16	0.32831E-16	0.43858E-16
9	0.30947E-17	0.51614E-17	0.76418E-17	0.10522E-16	0.15582E-16	0.23684E-16	0.33316E-16	0.44488E-16
10	0.31528E-17	0.52501E-17	0.77641E-17	0.10682E-16	0.15803E-16	0.24000E-16	0.33742E-16	0.45040E-16
11	0.32050E-17	0.53298E-17	0.78740E-17	0.10825E-16	0.16001E-16	0.24282E-16	0.34121E-16	0.45530E-16
12	0.32525E-17	0.54020E-17	0.79737E-17	0.10955E-16	0.16180E-16	0.24536E-16	0.34463E-16	0.45971E-16
13	0.32834E-17	0.54481E-17	0.80359E-17	0.11034E-16	0.16287E-16	0.24684E-16	0.34657E-16	0.46217E-16
14	0.33126E-17	0.54915E-17	0.80946E-17	0.11109E-16	0.16388E-16	0.24824E-16	0.34841E-16	0.46450E-16
15	0.33402E-17	0.55325E-17	0.81501E-17	0.11180E-16	0.16484E-16	0.24957E-16	0.35016E-16	0.46671E-16
16	0.33664E-17	0.55715E-17	0.82029E-17	0.11247E-16	0.16575E-16	0.25083E-16	0.35016E-16	0.46671E-16
17	0.33913E-17	0.56086E-17	0.82530E-17	0.11312E-16	0.16662E-16	0.25203E-16	0.35016E-16	0.46671E-16
18	0.34150E-17	0.56440E-17	0.83009E-17	0.11373E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
19	0.34377E-17	0.56778E-17	0.83466E-17	0.11431E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
20	0.34594E-17	0.57101E-17	0.83904E-17	0.11487E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
21	0.34802E-17	0.57412E-17	0.84325E-17	0.11487E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
22	0.35002E-17	0.57710E-17	0.84325E-17	0.11487E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
23	0.35195E-17	0.57996E-17	0.84325E-17	0.11487E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16
24	0.35380E-17	0.57996E-17	0.84325E-17	0.11487E-16	0.16745E-16	0.25203E-16	0.35016E-16	0.46671E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.38675E-16	0.57246E-16	0.91469E-16	0.15693E-15	0.30391E-15	0.73569E-15	0.24038E-14
2	0.49418E-16	0.73240E-16	0.11718E-15	0.20155E-15	0.39134E-15	0.94250E-15	0.30481E-14
3	0.54462E-16	0.80878E-16	0.12962E-15	0.22342E-15	0.43298E-15	0.10417E-14	0.33561E-14
4	0.57399E-16	0.85518E-16	0.13777E-15	0.23818E-15	0.46311E-15	0.11099E-14	0.35672E-14
5	0.59432E-16	0.88652E-16	0.14310E-15	0.24886E-15	0.48530E-15	0.11673E-14	0.37197E-14
6	0.60977E-16	0.90996E-16	0.14702E-15	0.25603E-15	0.50292E-15	0.12138E-14	0.38398E-14
7	0.62218E-16	0.92857E-16	0.15009E-15	0.26158E-15	0.51882E-15	0.12517E-14	0.39484E-14
8	0.63252E-16	0.94396E-16	0.15260E-15	0.26604E-15	0.52416E-15	0.12842E-14	0.40560E-14
9	0.64137E-16	0.95703E-16	0.15471E-15	0.26975E-15	0.53173E-15	0.13072E-14	0.41625E-14
10	0.64909E-16	0.96837E-16	0.15653E-15	0.27291E-15	0.53801E-15	0.13252E-14	0.42512E-14
11	0.65593E-16	0.97837E-16	0.15813E-15	0.27564E-15	0.54336E-15	0.13397E-14	0.43261E-14
12	0.66207E-16	0.98730E-16	0.15954E-15	0.27804E-15	0.54798E-15	0.13517E-14	0.43947E-14
13	0.66540E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.44345E-14
14	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.44670E-14
15	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.44942E-14
16	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45174E-14
17	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
18	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
19	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
20	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
21	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
22	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
23	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14
24	0.66855E-16	0.99200E-16	0.16025E-15	0.27919E-15	0.54998E-15	0.13562E-14	0.45376E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0201	0.0235	59.1650	5.563	40.8350	44.1728	3.621	55.8272
3.500E-07	1.414	0.049	0.1299	0.1259	58.7095	5.494	41.2905	53.2243	4.720	46.7757
4.500E-07	1.320	0.212	0.5586	0.5037	59.1955	5.568	40.8045	56.9958	5.242	43.0042
5.500E-07	1.261	0.597	1.5320	1.3489	60.2813	5.736	39.7187	59.1249	5.557	40.8751
7.000E-07	1.205	2.119	5.2257	4.5857	61.8360	5.984	38.1640	60.8553	5.826	39.1447
9.000E-07	1.159	2.985	6.8981	6.0652	64.2328	6.386	35.7672	63.2414	6.217	36.7586
1.100E-06	1.130	3.582	7.7967	6.8762	66.3110	6.758	33.6890	65.2722	6.570	34.7278
1.300E-06	1.110	3.283	6.7014	5.9733	68.4115	7.158	31.5885	67.0893	6.903	32.9107
1.600E-06	1.090	6.865	12.8769	11.5702	70.9701	7.683	29.0299	69.5117	7.378	30.4883
2.000E-06	1.072	7.164	12.0580	10.9277	73.9489	8.355	26.0511	72.4045	7.998	27.5955
2.600E-06	1.055	11.940	17.1710	15.9605	77.7415	9.333	22.2585	75.8173	8.818	24.1827
3.500E-06	1.041	10.447	12.2611	11.9976	81.8356	10.595	18.1644	79.2248	9.761	20.7752
5.000E-06	1.029	14.925	12.0579	12.7853	87.4957	12.915	12.5043	84.5027	11.582	15.4973
8.000E-06	1.018	14.925	4.1302	6.5873	95.7169	19.570	4.2831	92.0154	15.701	7.9846
1.500E-05	1.010	20.899	0.5822	4.6689	99.5688	33.831	0.4312	95.9584	19.930	4.0416

EFFICIENCY = STATED = 99.00 COMPUTED = 79.0054 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 84.5225
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.083E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.804E+00
LOG-NORMAL GOODNESS OF FIT = 0.996
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 11.590

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 81.9092
CORRECTED MMD OF EFFLUENT = 2.485E+00
CORRECTED SIGMAP OF EFFLUENT = 1.962E+00
LOG-NORMAL GOODNESS OF FIT = 0.991
CORRECTED PRECIPITATION RATE PARAMETER = 10.62

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.393E+00	3.197E+01	2.862E-02	1.051E-02	3.912E-02	4.360E-02	2.500E-07
2.532E+00	3.348E+01	2.613E-01	3.472E-02	2.960E-01	1.022E-01	3.500E-07
2.716E+00	3.542E+01	1.449E+00	7.809E-02	1.527E+00	1.784E-01	4.500E-07
2.919E+00	3.749E+01	4.862E+00	1.416E-01	5.004E+00	2.642E-01	5.500E-07
3.234E+00	4.059E+01	1.051E+01	2.701E-01	1.078E+01	7.953E-01	7.000E-07
3.670E+00	4.462E+01	1.789E+01	4.959E-01	1.838E+01	1.132E+00	9.000E-07
4.101E+00	4.832E+01	2.474E+01	7.630E-01	2.551E+01	1.424E+00	1.100E-06
4.548E+00	5.191E+01	2.516E+01	1.053E+00	2.621E+01	1.661E+00	1.300E-06
5.212E+00	5.679E+01	2.965E+01	1.489E+00	3.114E+01	3.831E+00	1.600E-06
6.099E+00	6.254E+01	3.477E+01	2.061E+00	3.683E+01	4.234E+00	2.000E-06
7.454E+00	6.988E+01	3.203E+01	2.769E+00	3.480E+01	8.791E+00	2.600E-06
9.502E+00	7.834E+01	2.466E+01	3.545E+00	2.821E+01	1.044E+01	3.500E-06
1.291E+01	8.750E+01	1.721E+01	4.119E+00	2.133E+01	1.709E+01	5.000E-06
1.957E+01	9.572E+01	4.678E+00	4.043E+00	8.722E+00	2.114E+01	8.000E-06
3.383E+01	9.957E+01	4.861E-01	4.070E+00	4.556E+00	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  81.9092 %     SCA =  1.610E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.020E+04 V
                           AVG. CURRENT DENSITY =   10.11 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00
                        OUTLET MMD =  2.485E+00 UM     OUTLET SIGMAP =  1.962E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0179	0.0210	54.9130	4.948	45.0870	39.4952	3.121	60.5048
3.500E-07	1.414	0.049	0.1157	0.1141	54.4426	4.884	45.5574	48.8017	4.158	51.1983
4.500E-07	1.320	0.212	0.4986	0.4593	54.8886	4.945	45.1114	52.6265	4.641	47.3735
5.500E-07	1.261	0.597	1.3727	1.2364	55.9224	5.089	44.0776	54.7332	4.923	45.2668
7.000E-07	1.205	2.119	4.7090	4.2278	57.4040	5.301	42.5960	56.3954	5.156	43.6046
9.000E-07	1.159	2.985	6.2735	5.6414	59.7104	5.647	40.2896	58.6907	5.492	41.3093
1.100E-06	1.130	3.582	7.1533	6.4488	61.7165	5.964	38.2835	60.6482	5.793	39.3518
1.300E-06	1.110	3.283	6.2075	5.6485	63.7581	6.305	36.2419	62.3985	6.076	37.6015
1.600E-06	1.090	6.865	12.0867	11.0716	66.2502	6.747	33.7498	64.7504	6.477	35.2496
2.000E-06	1.072	7.164	11.5199	10.6240	69.1731	7.310	30.8269	67.5849	6.998	32.4151
2.600E-06	1.055	11.940	16.8568	15.8651	72.9351	8.118	27.0649	70.9563	7.680	29.0437
3.500E-06	1.041	10.447	12.5155	12.2600	77.0347	9.138	22.9653	74.3497	8.452	25.6503
5.000E-06	1.029	14.925	13.2853	13.7535	82.9356	10.983	17.0644	79.8576	9.953	20.1424
8.000E-06	1.018	14.925	5.7558	7.6473	92.6069	16.179	7.3931	88.8003	13.599	11.1997
1.500E-05	1.010	20.899	1.6318	4.9811	98.5031	26.100	1.4969	94.7902	18.353	5.2098

EFFICIENCY - STATED = 99.00 COMPUTED = 79.0054 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 80.8296
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.292E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.871E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.260

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 78.1421
CORRECTED MMD OF EFFLUENT = 2.579E+00
CORRECTED SIGMAP OF EFFLUENT = 1.971E+00
LOG-NORMAL GOODNESS OF FIT = 0.991
CORRECTED PRECIPITATION RATE PARAMETER = 9.45

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2,393E+00	3,197E+01	3,159E-02	1,080E-02	4,240E-02	4,360E-02	2,500E-07
2,532E+00	3,348E+01	2,883E-01	3,570E-02	3,240E-01	1,022E-01	3,500E-07
2,716E+00	3,542E+01	1,602E+00	8,031E-02	1,682E+00	1,784E-01	4,500E-07
2,919E+00	3,749E+01	5,396E+00	1,456E-01	5,541E+00	2,642E-01	5,500E-07
3,234E+00	4,059E+01	1,173E+01	2,778E-01	1,201E+01	7,953E-01	7,000E-07
3,670E+00	4,462E+01	2,015E+01	5,099E-01	2,066E+01	1,132E+00	9,000E-07
4,101E+00	4,832E+01	2,812E+01	7,847E-01	2,890E+01	1,424E+00	1,100E-06
4,548E+00	5,191E+01	2,886E+01	1,083E+00	2,994E+01	1,661E+00	1,300E-06
5,212E+00	5,679E+01	3,447E+01	1,532E+00	3,600E+01	3,831E+00	1,600E-06
6,099E+00	6,254E+01	4,114E+01	2,120E+00	4,326E+01	4,234E+00	2,000E-06
7,454E+00	6,988E+01	3,895E+01	2,848E+00	4,180E+01	8,791E+00	2,600E-06
9,502E+00	7,834E+01	3,118E+01	3,645E+00	3,483E+01	1,044E+01	3,500E-06
1,291E+01	8,750E+01	2,348E+01	4,236E+00	2,772E+01	1,709E+01	5,000E-06
1,957E+01	9,572E+01	8,076E+00	4,158E+00	1,223E+01	2,114E+01	8,000E-06
3,383E+01	9,957E+01	1,687E+00	4,185E+00	5,872E+00	2,887E+01	1,500E-05

```
*****************************************************************************************************
*                                                                                                   *
*                                  SUMMARY TABLE OF ESP OPERATING                                   *
*                                    PARAMETERS AND PERFORMANCE                                     *
*                                                                                                   *
*                                                                                                   *
*                                                                                                   *
*                                        DATA SET NUMBER   2                                        *
*                                                                                                   *
*                                                                                                   *
*          ESP PERFORMANCE:     EFFICIENCY =  78.1421 %     SCA =  1.610E+01 M**2/(M**3/SEC)       *
*                                                                                                   *
*          ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.020E+04 V                           *
*                                     AVG. CURRENT DENSITY =   10.11 NA/CM**2                       *
*                                     RESISTIVITY =  1.000E+09 OHM-CM                               *
*                                                                                                   *
*          SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00          *
*                                  OUTLET MMD =  2.579E+00 UM     OUTLET SIGMAP =  1.971E+00         *
*                                                                                                   *
*          NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10 *
*                                   RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00      *
*                                                                                                   *
*****************************************************************************************************
STOP  011111
```

APPENDIX J

OUTPUT DATA FOR EXAMPLE 2 (REVISION 1)

```
*************************************
*                                   *
*        E.P.A. ESP MODEL           *
*                                   *
*    I.E.R.L.-R.T.P. AND SO.R.I.    *
*                                   *
*      REVISION I,JAN. 1, 1978      *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 16 NDATA = 1

DATA ON CARD NUMBER 2

LAB ESP; SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

DATA ON CARD NUMBER 3

NEST = 1 NDIST = 1 NVI = 2 NX = 15 NY = 15 NITER = 1 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 10 NUMINC = 20

DATA ON CARD NUMBER 5

IFINAL = 20 JI1 = 2 JI2 = 21 VISKIP = 1 VISAME = 2

DATA ON CARD NUMBER 6

DL = 0.06500 GRN/ACF PL = 10.0000 FT ETAO = 99.00000 % DD = 1000.00 KG/M**3 EPS = 5.100E+00
VRATIO = 1.0300 US = 0.000165 M**2/V-SEC FPATH = 1.0000 EBD = 1500000. V/M RHOCGS = 1.00E+09 OHM-CM

DATA ON CARD NUMBER 7

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 4.0

```
ASNUCK( 2) = 0.10  AZIGGY( 2) = 0.10  AZNUMS( 2) =  4.0

DATA ON CARD NUMBER   8

ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   9

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER  10

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0076 %   PRCU( 3) =   0.0563 %   PRCU( 4) =   0.2682 %   PRCU( 5) =   0.8652 %
PRCU( 6) =   2.9849 %   PRCU( 7) =   5.9695 %   PRCU( 8) =   9.5515 %   PRCU( 9) =  12.8350 %   PRCU(10) =  19.7004 %

DATA ON CARD NUMBER  11

PRCU(11) =  26.8643 %   PRCU(12) =  38.8042 %   PRCU(13) =  49.2516 %   PRCU(14) =  64.1765 %   PRCU(15) =  79.1014 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  12

NUMSEC =  3    LSECT( 1) =  6  LSECT( 2) =  6  LSECT( 3) = 12

DATA ON CARD NUMBER  13

AS( 1) =  6.2500E+00 FT**2  VOS( 1) =  4.0800E+04 V  TCS( 1) =  6.2500E-05 A  WLS( 1) =  6.2500E+00 FT
ACS( 1) =  4.6875E-02 IN  BS( 1) =  5.0000E+00 IN  NWS( 1) =  5.0000E+00

DATA ON CARD NUMBER  14

SYS( 1) =  2.5000E+00 IN  VGS( 1) =  3.0533E+02 FT**3/MIN  VGASS( 1) =  4.8853E+00 FT/SEC  TEMPS( 1) =  7.6000E+01 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  1.8000E-05 KG/M-SEC  LINCS( 1) =  4.1667E-01 FT
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DATA ON CARD NUMBER  15

RFS( 1) =  9.0000E-01  START1( 1) =  6.0000E-05 A/M**2  START2( 1) =  2.0000E-05 A/M**2
START3( 1) =  2.0000E-05 A/M**2  VSTAR( 1) =  3.8000E+04 V

DATA ON CARD NUMBER  16

AS( 2) =  6.2500E+00 FT**2  VOS( 2) =  4.0800E+04 V  TCS( 2) =  6.2500E-05 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00

DATA ON CARD NUMBER  17

SYS( 2) =  2.5000E+00 IN  VGS( 2) =  3.0533E+02 FT**3/MIN  VGASS( 2) =  4.8853E+00 FT/SEC  TEMPS( 2) =  7.6000E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  4.1667E-01 FT

DATA ON CARD NUMBER  18

RFS( 2) =  9.0000E-01  START1( 2) =  6.0000E-05 A/M**2  START2( 2) =  2.0000E-05 A/M**2
START3( 2) =  2.0000E-05 A/M**2  VSTAR( 2) =  3.8000E+04 V

DATA ON CARD NUMBER  19

AS( 3) =  1.2500E+01 FT**2  VOS( 3) =  3.9600E+04 V  TCS( 3) =  1.2500E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  20

SYS( 3) =  2.5000E+00 IN  VGS( 3) =  3.0533E+02 FT**3/MIN  VGASS( 3) =  4.8853E+00 FT/SEC  TEMPS( 3) =  7.6000E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  4.1667E-01 FT

DATA ON CARD NUMBER  21

RFS( 3) =  9.0000E-01  START1( 3) =  6.0000E-05 A/M**2  START2( 3) =  2.0000E-05 A/M**2
START3( 3) =  2.0000E-05 A/M**2  VSTAR( 3) =  3.8000E+04 V
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CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 1

VW = -3.8000E+04 ACDNTY = 6.0276E-05 AEPLT = -1.7902E+05

VW = -3.8206E+04 ACDNTY = 7.9337E-05 AEPLT = -1.8597E+05

VW = -3.8896E+04 ACDNTY = 9.9193E-05 AEPLT = -1.9435E+05

VW = -3.9513E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3890E-04 AEPLT = -2.0993E+05

VW = -4.0656E+04 ACDNTY = 1.5874E-04 AEPLT = -2.1722E+05

VW = -4.1193E+04 ACDNTY = 1.7859E-04 AEPLT = -2.2424E+05

VW = -4.0711E+04 ACDNTY = 1.6251E-04 AEPLT = -2.1842E+05

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 4.955E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.625E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.446E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.625E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.8267	2.085E+05	2.1842E+05	2.1564E+13	13.4	7.30E-06	6.228E-06	5.570E-04	3.88E-08	1.62E-04	1
0.7338	2.085E+05	2.1842E+05	2.1580E+13	11.9	4.34E-06	9.904E-06	8.859E-04	9.22E-08	1.62E-04	2
0.7114	2.085E+05	2.1842E+05	2.1582E+13	11.6	2.92E-06	1.026E-05	9.180E-04	1.16E-07	1.62E-04	3
0.7040	2.085E+05	2.1842E+05	2.1582E+13	11.4	2.26E-06	9.832E-06	8.794E-04	1.28E-07	1.62E-04	4
0.7027	2.085E+05	2.1842E+05	2.1583E+13	11.4	1.90E-06	9.138E-06	8.174E-04	1.33E-07	1.62E-04	5
0.7047	2.085E+05	2.1842E+05	2.1583E+13	11.5	1.62E-06	8.361E-06	7.479E-04	1.34E-07	1.62E-04	6

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 2

VW = -3.8000E+04 ACDNTY = 6.0276E-05 AEPLT = -1.7902E+05

VW = -3.8206E+04 ACDNTY = 7.9337E-05 AEPLT = -1.8597E+05

VW = -3.8896E+04 ACDNTY = 9.9193E-05 AEPLT = -1.9435E+05

VW = -3.9513E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3890E-04 AEPLT = -2.0993E+05

VW = -4.0656E+04 ACDNTY = 1.5874E-04 AEPLT = -2.1722E+05

VW = -4.1193E+04 ACDNTY = 1.7859E-04 AEPLT = -2.2424E+05

VW = -4.0711E+04 ACDNTY = 1.6251E-04 AEPLT = -2.1842E+05

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 4.955E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.625E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.446E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.625E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.7085	2.085E+05	2.1842E+05	2.1583E+13	11.5	1.44E-06	7.585E-06	6.784E-04	1.32E-07	1.62E-04	7
0.7134	2.085E+05	2.1842E+05	2.1583E+13	11.6	1.32E-06	6.849E-06	6.126E-04	1.29E-07	1.62E-04	8
0.7190	2.085E+05	2.1842E+05	2.1583E+13	11.7	1.18E-06	6.170E-06	5.519E-04	1.25E-07	1.62E-04	9
0.7250	2.085E+05	2.1842E+05	2.1583E+13	11.8	1.07E-06	5.556E-06	4.970E-04	1.21E-07	1.62E-04	10
0.7313	2.085E+05	2.1842E+05	2.1583E+13	11.9	9.69E-07	5.006E-06	4.478E-04	1.16E-07	1.62E-04	11
0.7377	2.085E+05	2.1842E+05	2.1583E+13	12.0	9.25E-07	4.517E-06	4.040E-04	1.12E-07	1.62E-04	12

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 3

VW = -3.8000E+04 ACDNTY = 6.0277E-05 AEPLT = -1.7902E+05

VW = -3.8205E+04 ACDNTY = 7.9332E-05 AEPLT = -1.8596E+05

VW = -3.8896E+04 ACDNTY = 9.9192E-05 AEPLT = -1.9435E+05

VW = -3.9512E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3889E-04 AEPLT = -2.0993E+05

VW = -3.9514E+04 ACDNTY = 1.2081E-04 AEPLT = -2.0279E+05

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 3.684E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 3.960E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.208E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 1.404E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 1.208E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-06 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.6947	2.001E+05	2.0279E+05	1.7774E+13	8.4	8.44E-07	3.800E-06	3.399E-04	9.93E-08	1.21E-04	13
0.7020	2.001E+05	2.0279E+05	1.7774E+13	8.5	7.96E-07	3.456E-06	3.091E-04	9.48E-08	1.21E-04	14
0.7094	2.001E+05	2.0279E+05	1.7774E+13	8.6	7.57E-07	3.150E-06	2.818E-04	9.04E-08	1.21E-04	15
0.7167	2.001E+05	2.0279E+05	1.7774E+13	8.7	7.25E-07	2.881E-06	2.577E-04	8.62E-08	1.21E-04	16
0.7240	2.001E+05	2.0279E+05	1.7774E+13	8.8	6.99E-07	2.648E-06	2.369E-04	8.22E-08	1.21E-04	17
0.7312	2.001E+05	2.0279E+05	1.7774E+13	8.8	6.73E-07	2.433E-06	2.176E-04	7.85E-08	1.21E-04	18
0.7382	2.001E+05	2.0279E+05	1.7774E+13	8.9	6.52E-07	2.246E-06	2.009E-04	7.49E-08	1.21E-04	19
0.7451	2.001E+05	2.0279E+05	1.7774E+13	9.0	6.34E-07	2.079E-06	1.859E-04	7.15E-08	1.21E-04	20
0.7520	2.001E+05	2.0279E+05	1.7774E+13	9.1	6.18E-07	1.929E-06	1.725E-04	6.84E-08	1.21E-04	21
0.7587	2.001E+05	2.0279E+05	1.7774E+13	9.2	6.05E-07	1.794E-06	1.605E-04	6.53E-08	1.21E-04	22
0.7652	2.001E+05	2.0279E+05	1.7774E+13	9.2	5.94E-07	1.672E-06	1.496E-04	6.25E-08	1.21E-04	23
0.7716	2.001E+05	2.0279E+05	1.7774E+13	9.3	5.84E-07	1.562E-06	1.397E-04	5.98E-08	1.21E-04	24

DESIGN EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 79.98

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.0603	1.0325	0.9918	0.9523	0.9013	0.8506	0.8118	0.7815
2	1.3302	1.2853	1.2346	1.1900	1.1363	1.0790	1.0324	0.9955
3	1.4762	1.4174	1.3567	1.3049	1.2438	1.1825	1.1364	1.1015
4	1.5763	1.5066	1.4380	1.3803	1.3130	1.2472	1.1991	1.1633
5	1.6522	1.5738	1.4987	1.4362	1.3638	1.2940	1.2436	1.2064
6	1.7134	1.6276	1.5470	1.4805	1.4038	1.3304	1.2779	1.2392
7	1.7645	1.6723	1.5871	1.5172	1.4368	1.3602	1.3057	1.2656
8	1.8083	1.7107	1.6214	1.5484	1.4647	1.3853	1.3290	1.2876
9	1.8467	1.7441	1.6512	1.5755	1.4889	1.4070	1.3491	1.3064
10	1.8809	1.7738	1.6776	1.5995	1.5103	1.4261	1.3666	1.3229
11	1.9116	1.8005	1.7013	1.6210	1.5294	1.4431	1.3822	1.3374
12	1.9395	1.8248	1.7228	1.6405	1.5467	1.4584	1.3963	1.3505
13	1.9579	1.8403	1.7364	1.6526	1.5571	1.4675	1.4043	1.3578
14	1.9752	1.8550	1.7492	1.6639	1.5670	1.4760	1.4120	1.3647
15	1.9916	1.8689	1.7612	1.6747	1.5763	1.4841	1.4192	1.3713
16	2.0072	1.8821	1.7727	1.6849	1.5852	1.4918	1.4260	1.3713
17	2.0219	1.8946	1.7836	1.6946	1.5937	1.4990	1.4260	1.3713
18	2.0360	1.9066	1.7940	1.7039	1.6017	1.4990	1.4260	1.3713
19	2.0495	1.9180	1.8040	1.7128	1.6094	1.4990	1.4260	1.3713
20	2.0624	1.9289	1.8135	1.7213	1.6094	1.4990	1.4260	1.3713
21	2.0747	1.9394	1.8226	1.7213	1.6094	1.4990	1.4260	1.3713
22	2.0866	1.9495	1.8314	1.7213	1.6094	1.4990	1.4260	1.3713
23	2.0980	1.9592	1.8314	1.7213	1.6094	1.4990	1.4260	1.3713
24	2.1089	1.9592	1.8314	1.7213	1.6094	1.4990	1.4260	1.3713

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.7479	0.7141	0.6800	0.6459	0.6124	0.5762	0.5399
2	0.9532	0.9108	0.8690	0.8260	0.7808	0.7332	0.6825
3	1.0611	1.0142	0.9651	0.9159	0.8656	0.8132	0.7558
4	1.1232	1.0811	1.0352	0.9818	0.9242	0.8678	0.8062
5	1.1653	1.1241	1.0814	1.0335	0.9730	0.9088	0.8449
6	1.1967	1.1553	1.1133	1.0694	1.0141	0.9440	0.8749
7	1.2217	1.1795	1.1373	1.0949	1.0461	0.9766	0.8999
8	1.2423	1.1992	1.1564	1.1143	1.0686	1.0048	0.9224
9	1.2598	1.2158	1.1721	1.1298	1.0855	1.0280	0.9434
10	1.2750	1.2300	1.1855	1.1427	1.0988	1.0461	0.9633
11	1.2885	1.2425	1.1971	1.1537	1.1098	1.0596	0.9822
12	1.3004	1.2536	1.2073	1.1632	1.1191	1.0702	0.9983
13	1.3070	1.2594	1.2123	1.1676	1.1230	1.0740	1.0064
14	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0130
15	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0185
16	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
17	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
18	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
19	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
20	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
21	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233

22	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
23	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233
24	1.3132	1.2594	1.2123	1.1676	1.1230	1.0740	1.0233

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.18113E-17	0.31194E-17	0.46963E-17	0.65249E-17	0.97189E-17	0.14833E-16	0.20870E-16	0.27819E-16
2	0.22722E-17	0.38832E-17	0.58463E-17	0.81534E-17	0.12252E-16	0.18815E-16	0.26541E-16	0.35435E-16
3	0.25218E-17	0.42824E-17	0.64245E-17	0.89407E-17	0.13411E-16	0.20620E-16	0.29214E-16	0.39209E-16
4	0.26927E-17	0.45519E-17	0.68092E-17	0.94575E-17	0.14158E-16	0.21749E-16	0.30828E-16	0.41410E-16
5	0.28224E-17	0.47548E-17	0.70966E-17	0.98407E-17	0.14706E-16	0.22564E-16	0.31978E-16	0.42944E-16
6	0.29268E-17	0.49173E-17	0.73255E-17	0.10144E-16	0.15137E-16	0.23199E-16	0.32853E-16	0.44111E-16
7	0.30141E-17	0.50525E-17	0.75154E-17	0.10395E-16	0.15492E-16	0.23718E-16	0.33568E-16	0.45051E-16
8	0.30891E-17	0.51683E-17	0.76776E-17	0.10609E-16	0.15793E-16	0.24156E-16	0.34167E-16	0.45833E-16
9	0.31547E-17	0.52695E-17	0.78189E-17	0.10795E-16	0.16055E-16	0.24535E-16	0.34683E-16	0.46504E-16
10	0.32130E-17	0.53593E-17	0.79440E-17	0.10960E-16	0.16285E-16	0.24867E-16	0.35134E-16	0.47088E-16
11	0.32655E-17	0.54399E-17	0.80563E-17	0.11107E-16	0.16491E-16	0.25164E-16	0.35535E-16	0.47606E-16
12	0.33132E-17	0.55131E-17	0.81581E-17	0.11240E-16	0.16678E-16	0.25431E-16	0.35896E-16	0.48071E-16
13	0.33446E-17	0.55601E-17	0.82222E-17	0.11323E-16	0.16790E-16	0.25589E-16	0.36103E-16	0.48333E-16
14	0.33742E-17	0.56045E-17	0.82827E-17	0.11401E-16	0.16897E-16	0.25738E-16	0.36290E-16	0.48579E-16
15	0.34022E-17	0.56465E-17	0.83399E-17	0.11475E-16	0.16997E-16	0.25879E-16	0.36484E-16	0.48813E-16
16	0.34288E-17	0.56863E-17	0.83943E-17	0.11545E-16	0.17093E-16	0.26012E-16	0.36660E-16	0.48813E-16
17	0.34540E-17	0.57242E-17	0.84460E-17	0.11611E-16	0.17184E-16	0.26140E-16	0.36660E-16	0.48813E-16
18	0.34781E-17	0.57603E-17	0.84952E-17	0.11675E-16	0.17271E-16	0.26140E-16	0.36660E-16	0.48813E-16
19	0.35010E-17	0.57948E-17	0.85423E-17	0.11736E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16
20	0.35230E-17	0.58278E-17	0.85874E-17	0.11794E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16
21	0.35441E-17	0.58594E-17	0.86306E-17	0.11794E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16
22	0.35644E-17	0.58899E-17	0.86722E-17	0.11794E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16
23	0.35838E-17	0.59191E-17	0.86722E-17	0.11794E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16
24	0.36026E-17	0.59191E-17	0.86722E-17	0.11794E-16	0.17354E-16	0.26140E-16	0.36660E-16	0.48813E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.39980E-16	0.59228E-16	0.94712E-16	0.16218E-15	0.31245E-15	0.74992E-15	0.24636E-14
2	0.50958E-16	0.75536E-16	0.12104E-15	0.20741E-15	0.39842E-15	0.95430E-15	0.31143E-14
3	0.56727E-16	0.84119E-16	0.13443E-15	0.22998E-15	0.44164E-15	0.10584E-14	0.34489E-14
4	0.60047E-16	0.89667E-16	0.14418E-15	0.24654E-15	0.47158E-15	0.11295E-14	0.36789E-14
5	0.62294E-16	0.93232E-16	0.15063E-15	0.25950E-15	0.49646E-15	0.11828E-14	0.38553E-14
6	0.63975E-16	0.95816E-16	0.15507E-15	0.26854E-15	0.51746E-15	0.12286E-14	0.39920E-14
7	0.65310E-16	0.97826E-16	0.15841E-15	0.27492E-15	0.53379E-15	0.12710E-14	0.41064E-14
8	0.66413E-16	0.99461E-16	0.16107E-15	0.27979E-15	0.54524E-15	0.13078E-14	0.42091E-14
9	0.67350E-16	0.10084E-15	0.16326E-15	0.28369E-15	0.55385E-15	0.13379E-14	0.43048E-14
10	0.68163E-16	0.10202E-15	0.16512E-15	0.28693E-15	0.56067E-15	0.13615E-14	0.43958E-14
11	0.68880E-16	0.10305E-15	0.16673E-15	0.28968E-15	0.56629E-15	0.13790E-14	0.44819E-14
12	0.69521E-16	0.10397E-15	0.16815E-15	0.29208E-15	0.57103E-15	0.13929E-14	0.45554E-14
13	0.69871E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.45922E-14
14	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46223E-14
15	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46475E-14
16	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
17	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
18	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
19	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
20	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
21	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
22	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
23	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14
24	0.70201E-16	0.10445E-15	0.16886E-15	0.29319E-15	0.57303E-15	0.13978E-14	0.46692E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0210	0.0244	59.8767	5.673	40.1233	45.0424	3.718	54.9576
3.500E-07	1.414	0.049	0.1359	0.1308	59.4811	5.612	40.5189	54.0537	4.831	45.9463
4.500E-07	1.320	0.212	0.5826	0.5215	60.0682	5.702	39.9318	57.8917	5.373	42.1083
5.500E-07	1.261	0.597	1.5937	1.3928	61.2279	5.885	38.7721	60.0837	5.705	39.9163
7.000E-07	1.205	2.119	5.4026	4.7063	62.9750	6.172	37.0250	62.0046	6.011	37.9954
9.000E-07	1.159	2.985	7.0896	6.1893	65.5043	6.611	34.4957	64.5233	6.437	35.4767
1.100E-06	1.130	3.582	7.9404	6.9556	67.8036	7.040	32.1964	66.7758	6.845	33.2242
1.300E-06	1.110	3.283	6.7915	6.0162	69.9588	7.470	30.0412	68.6506	7.205	31.3494
1.600E-06	1.090	6.865	12.9352	11.5594	72.6349	8.050	27.3651	71.1920	7.731	28.8080
2.000E-06	1.072	7.164	12.0059	10.8313	75.6592	8.777	24.3408	74.1311	8.399	25.8689
2.600E-06	1.055	11.940	16.9421	15.7103	79.3911	9.811	20.6089	77.4871	9.262	22.5129
3.500E-06	1.041	10.447	12.0625	11.8169	83.2307	11.092	16.7693	80.6474	10.202	19.3526
5.000E-06	1.029	14.925	11.9052	12.6892	88.4146	13.389	11.5854	85.4531	11.975	14.5469
8.000E-06	1.018	14.925	4.0698	6.6496	96.0395	20.056	3.9605	92.3770	15.989	7.6230
1.500E-05	1.010	20.899	0.5220	4.8066	99.6372	34.904	0.3628	96.0648	20.096	3.9352

EFFICIENCY = STATED = 99.00 COMPUTED = 79.9829 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 85.4759
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.063E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.804E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 11.985

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 82.8902
CORRECTED MMD OF EFFLUENT = 2.481E+00
CORRECTED SIGMAP OF EFFLUENT = 1.969E+00
LOG-NORMAL GOODNESS OF FIT = 0.990
CORRECTED PRECIPITATION RATE PARAMETER = 10.97

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.440E+00	3.248E+01	2.812E-02	1.040E-02	3.851E-02	4.360E-02	2.500E-07
2.586E+00	3.405E+01	2.564E-01	3.435E-02	2.908E-01	1.022E-01	3.500E-07
2.782E+00	3.610E+01	1.418E+00	7.727E-02	1.495E+00	1.784E-01	4.500E-07
2.995E+00	3.826E+01	4.746E+00	1.401E-01	4.886E+00	2.642E-01	5.500E-07
3.336E+00	4.155E+01	1.020E+01	2.673E-01	1.046E+01	7.953E-01	7.000E-07
3.800E+00	4.576E+01	1.725E+01	4.906E-01	1.774E+01	1.132E+00	9.000E-07
4.272E+00	4.973E+01	2.365E+01	7.550E-01	2.440E+01	1.424E+00	1.100E-06
4.746E+00	5.342E+01	2.392E+01	1.042E+00	2.496E+01	1.661E+00	1.300E-06
5.461E+00	5.849E+01	2.795E+01	1.474E+00	2.942E+01	3.831E+00	1.600E-06
6.407E+00	6.435E+01	3.249E+01	2.040E+00	3.453E+01	4.234E+00	2.000E-06
7.836E+00	7.168E+01	2.966E+01	2.740E+00	3.240E+01	8.791E+00	2.600E-06
9.948E+00	7.984E+01	2.277E+01	3.507E+00	2.627E+01	1.044E+01	3.500E-06
1.339E+01	8.841E+01	1.594E+01	4.075E+00	2.002E+01	1.709E+01	5.000E-06
2.006E+01	9.604E+01	4.326E+00	4.001E+00	8.327E+00	2.114E+01	8.000E-06
3.490E+01	9.964E+01	4.089E-01	4.027E+00	4.436E+00	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

                DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  82.8902 %     SCA =  1.610E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.011E+04 V
                           AVG. CURRENT DENSITY =   10.34 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00
                        OUTLET MMD =  2.481E+00 UM     OUTLET SIGMAP =  1.969E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0186	0.0218	55.6046	5.044	44.3954	40.2773	3.202	59.7227
3.500E-07	1.414	0.049	0.1202	0.1179	55.1910	4.986	44.8090	49.5831	4.254	50.4169
4.500E-07	1.320	0.212	0.5166	0.4732	55.7356	5.062	44.2644	53.4867	4.755	46.5133
5.500E-07	1.261	0.597	1.4190	1.2708	56.8430	5.220	43.1570	55.6608	5.052	44.3392
7.000E-07	1.205	2.119	4.8421	4.3230	58.5153	5.465	41.4847	57.5127	5.317	42.4873
9.000E-07	1.159	2.985	6.4184	5.7404	60.9581	5.842	39.0419	59.9444	5.683	40.0556
1.100E-06	1.130	3.582	7.2618	6.5130	63.1894	6.208	36.8106	62.1274	6.031	37.8726
1.300E-06	1.110	3.283	6.2760	5.6841	65.2944	6.574	34.7056	63.9427	6.336	36.0573
1.600E-06	1.090	6.865	12.1309	11.0663	67.9168	7.062	32.0832	66.4259	6.779	33.5741
2.000E-06	1.072	7.164	11.4797	10.5502	70.9042	7.669	29.0958	69.3253	7.341	30.6747
2.600E-06	1.055	11.940	16.6809	15.6689	74.6330	8.521	25.3670	72.6658	8.057	27.3342
3.500E-06	1.041	10.447	12.3687	12.1210	78.5035	9.549	21.4965	75.8344	8.822	24.1656
5.000E-06	1.029	14.925	13.1924	13.6928	83.9504	11.364	16.0496	80.8905	10.280	19.1095
8.000E-06	1.018	14.925	5.7287	7.7055	93.0306	16.546	6.9694	89.2463	13.852	10.7537
1.500E-05	1.010	20.899	1.5461	5.0512	98.6567	26.773	1.3433	94.9656	18.566	5.0344

EFFICIENCY = STATED = 99.00 COMPUTED = 79.9829 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 81.8427
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.273E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.871E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.598

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 79.1710
CORRECTED MMD OF EFFLUENT = 2.573E+00
CORRECTED SIGMAP OF EFFLUENT = 1.976E+00
LOG-NORMAL GOODNESS OF FIT = 0.991
CORRECTED PRECIPITATION RATE PARAMETER = 9.74

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.440E+00	3.248E+01	3.111E-02	1.074E-02	4.185E-02	4.360E-02	2.500E-07
2.586E+00	3.405E+01	2.836E-01	3.549E-02	3.191E-01	1.022E-01	3.500E-07
2.782E+00	3.610E+01	1.571E+00	7.984E-02	1.651E+00	1.784E-01	4.500E-07
2.995E+00	3.826E+01	5.283E+00	1.447E-01	5.428E+00	2.642E-01	5.500E-07
3.336E+00	4.155E+01	1.143E+01	2.761E-01	1.170E+01	7.953E-01	7.000E-07
3.800E+00	4.576E+01	1.953E+01	5.069E-01	2.003E+01	1.132E+00	9.000E-07
4.272E+00	4.973E+01	2.704E+01	7.801E-01	2.782E+01	1.424E+00	1.100E-06
4.746E+00	5.342E+01	2.764E+01	1.076E+00	2.871E+01	1.661E+00	1.300E-06
5.461E+00	5.849E+01	3.277E+01	1.523E+00	3.429E+01	3.831E+00	1.600E-06
6.407E+00	6.435E+01	3.883E+01	2.107E+00	4.094E+01	4.234E+00	2.000E-06
7.836E+00	7.168E+01	3.651E+01	2.831E+00	3.934E+01	8.791E+00	2.600E-06
9.948E+00	7.984E+01	2.919E+01	3.624E+00	3.281E+01	1.044E+01	3.500E-06
1.339E+01	8.841E+01	2.209E+01	4.211E+00	2.630E+01	1.709E+01	5.000E-06
2.006E+01	9.604E+01	7.613E+00	4.134E+00	1.175E+01	2.118E+01	8.000E-06
3.490E+01	9.964E+01	1.514E+00	4.161E+00	5.675E+00	2.887E+01	1.500E-05

```
*****************************************************************************************************
*                                                                                                   *
*                                  SUMMARY TABLE OF ESP OPERATING                                   *
*                                    PARAMETERS AND PERFORMANCE                                     *
*                                                                                                   *
*                                                                                                   *
*                                        DATA SET NUMBER   2                                        *
*                                                                                                   *
*          ESP PERFORMANCE:     EFFICIENCY =  79.1710 %     SCA =  1.610E+01 M**2/(M**3/SEC)        *
*                                                                                                   *
*          ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.011E+04 V                           *
*                                     AVG. CURRENT DENSITY =   10.34 NA/CM**2                       *
*                                     RESISTIVITY =  1.000E+09 OHM-CM                               *
*                                                                                                   *
*          SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00          *
*                                  OUTLET MMD =  2.573E+00 UM     OUTLET SIGMAP =  1.976E+00         *
*                                                                                                   *
*          NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10 *
*                                   RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00      *
*                                                                                                   *
*****************************************************************************************************
STOP  011111
```

APPENDIX K

OUTPUT DATA FOR EXAMPLE 3 (REVISION 2)

```
*************************************
*                                   *
*        E.P.A. ESP MODEL           *
*                                   *
*   T.E.R.L.-R.T.P. AND SO.R.I.     *
*                                   *
*      REVISION II, AUG., 1979      *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 16 NDATA = 1

DATA ON CARD NUMBER 2

LAB ESP; SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

DATA ON CARD NUMBER 3

NEST = 2 NDIST = 1 NVI = 4 NX = 15 NY = 15 NITER = 1 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 5 NUMINC = 3

DATA ON CARD NUMBER 5

IFINAL = 20 JI1 = 2 JI2 = 21 VISKIP = 1 VISAME = 2

DATA ON CARD NUMBER 6

DL = 0.06500 GRN/ACF PL = 10.0000 FT ETAO = 99.00000 % DD = 1000.00 KG/M**3 EPS = 5.100E+00
VRATIO = 1.0300 US = 0.000165 M**2/V-SEC FPATH = 1.0000 EBD = 1500000. V/M RHOCGS = 1.00E+09 OHM-CM

DATA ON CARD NUMBER 7

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 4.0

```
ABNUCK( 2) = 0.10  AZIGGY( 2) = 0.10  AZNUMS( 2) =  4.0

DATA ON CARD NUMBER   8

ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   9

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER  10

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0076 %   PRCU( 3) =   0.0563 %   PRCU( 4) =   0.2682 %   PRCU( 5) =   0.8652 %
PRCU( 6) =   2.9845 %   PRCU( 7) =   5.9695 %   PRCU( 8) =   9.5515 %   PRCU( 9) =  12.8350 %   PRCU(10) =  19.7004 %

DATA ON CARD NUMBER  11

PRCU(11) =  26.8643 %   PRCU(12) =  38.8042 %   PRCU(13) =  49.2516 %   PRCU(14) =  64.1765 %   PRCU(15) =  79.1014 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  12

NUMBEC =  3    LBECT( 1) =  6  LBECT( 2) =  6  LBECT( 3) = 12

DATA ON CARD NUMBER  13

AB( 1) =  6.2500E+00 FT**2  VDS( 1) =  4.0000E+04 V  TCS( 1) =  6.2500E-05 A  WLS( 1) =  6.2500E+00 FT
ACS( 1) =  4.6875E-02 IN  BS( 1) =  5.0000E+00 IN  NWS( 1) =  5.0000E+00

DATA ON CARD NUMBER  14

BYS( 1) =  2.5000E+00 IN  VGS( 1) =  3.0533E+02 FT**3/MIN  VGASS( 1) =  4.8853E+00 FT/SEC  TEMPS( 1) =  7.6000E+01 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  1.8000E-05 KG/M-SEC  LINCS( 1) =  4.1667E-01 FT
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DATA ON CARD NUMBER  15

RFS( 1) =  9.0000E-01  START1( 1) =  6.0000E-05 A/M**2  START2( 1) =  2.0000E-05 A/M**2
START3( 1) =  2.0000E-05 A/M**2  VSTAR( 1) =  3.8000E+04 V

DATA ON CARD NUMBER  16

AS( 2) =  6.2500E+00 FT**2  VOS( 2) =  4.0800E+08 V  TCS( 2) =  6.2500E-05 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00

DATA ON CARD NUMBER  17

SYS( 2) =  2.5000E+00 IN  VGS( 2) =  3.0533E+02 FT**3/MIN  VGASS( 2) =  4.8853E+00 FT/SEC  TEMPS( 2) =  7.6000E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  4.1667E-01 FT

DATA ON CARD NUMBER  18

RFS( 2) =  9.0000E-01  START1( 2) =  6.0000E-05 A/M**2  START2( 2) =  2.0000E-05 A/M**2
START3( 2) =  2.0000E-05 A/M**2  VSTAR( 2) =  3.8000E+04 V

DATA ON CARD NUMBER  19

AS( 3) =  1.2500E+01 FT**2  VOS( 3) =  3.9600E+04 V  TCS( 3) =  1.2500E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  20

SYS( 3) =  2.5000E+00 IN  VGS( 3) =  3.0533E+02 FT**3/MIN  VGASS( 3) =  8.8853E+00 FT/SEC  TEMPS( 3) =  7.6000E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  4.1667E-01 FT

DATA ON CARD NUMBER  21

RFS( 3) =  9.0000E-01  START1( 3) =  6.0000E-05 A/M**2  START2( 3) =  2.0000E-05 A/M**2
START3( 3) =  2.0000E-05 A/M**2  VSTAR( 3) =  3.8000E+04 V
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CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 1

VW = -3.7698E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7773E+05

VW = -3.8347E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8647E+05

VW = -3.8965E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9469E+05

VW = -3.9557E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0248E+05

VW = -4.0125E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0988E+05

VW = -4.0673E+04 ACDNTY = 1.6000E-04 AEPLT = -2.1697E+05

VW = -4.1204E+04 ACDNTY = 1.8000E-04 AEPLT = -2.2376E+05

VW = -4.0802E+04 ACDNTY = 1.6478E-04 AEPLT = -2.1861E+05

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP; SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 5.024E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.648E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.578E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.648E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.8184	2.056E+05	2.1861E+05	1.1816E+13	13.5	7.28E-06	5.695E-06	5.094E-04	3.27E-08	1.65E-04	1
0.7343	2.056E+05	2.1861E+05	1.1822E+13	12.1	4.31E-06	8.586E-06	7.680E-04	6.77E-08	1.65E-04	2
0.7147	2.056E+05	2.1861E+05	1.1824E+13	11.8	2.94E-06	8.928E-06	7.986E-04	8.37E-08	1.65E-04	3
0.7067	2.056E+05	2.1861E+05	1.1825E+13	11.6	2.29E-06	8.655E-06	7.742E-04	9.19E-08	1.65E-04	4
0.7038	2.056E+05	2.1861E+05	1.1825E+13	11.6	1.94E-06	8.152E-06	7.292E-04	9.60E-08	1.65E-04	5
0.7038	2.056E+05	2.1861E+05	1.1826E+13	11.6	1.65E-06	7.566E-06	6.768E-04	9.77E-08	1.65E-04	6

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 2

VW = -3.7698E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7773E+05

VW = -3.8347E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8647E+05

VW = -3.8965E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9469E+05

VW = -3.9557E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0248E+05

VW = -4.0125E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0988E+05

VW = -4.0673E+04 ACDNTY = 1.6000E-04 AEPLT = -2.1697E+05

VW = -4.1204E+04 ACDNTY = 1.8000E-04 AEPLT = -2.2376E+05

VW = -4.0802E+04 ACDNTY = 1.6478E-04 AEPLT = -2.1861E+05

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 5.024E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.648E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.578E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.648E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.7054	2.056E+05	2.1861E+05	1.1826E+13	11.6	1.47E-06	6.967E-06	6.232E-04	9.79E-08	1.65E-04	7
0.7082	2.056E+05	2.1861E+05	1.1826E+13	11.7	1.34E-06	6.388E-06	5.714E-04	9.71E-08	1.65E-04	8
0.7117	2.056E+05	2.1861E+05	1.1826E+13	11.7	1.22E-06	5.846E-06	5.229E-04	9.56E-08	1.65E-04	9
0.7159	2.056E+05	2.1861E+05	1.1826E+13	11.8	1.11E-06	5.347E-06	4.783E-04	9.37E-08	1.65E-04	10
0.7204	2.056E+05	2.1861E+05	1.1826E+13	11.9	1.02E-06	4.894E-06	4.377E-04	9.15E-08	1.65E-04	11
0.7252	2.056E+05	2.1861E+05	1.1826E+13	12.0	9.55E-07	4.484E-06	4.011E-04	8.91E-08	1.65E-04	12

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 3

VW = -3.7701E+04 ACDNTY = 6.0000E-05 AEPLT = -1.7777E+05

VW = -3.8350E+04 ACDNTY = 8.0000E-05 AEPLT = -1.8651E+05

VW = -3.8968E+04 ACDNTY = 1.0000E-04 AEPLT = -1.9473E+05

VW = -3.9560E+04 ACDNTY = 1.2000E-04 AEPLT = -2.0252E+05

VW = -4.0128E+04 ACDNTY = 1.4000E-04 AEPLT = -2.0993E+05

VW = -3.9601E+04 ACDNTY = 1.2142E-04 AEPLT = -2.0306E+05

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 3.702E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION-MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 3.960E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.214E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 1.412E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 1.214E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.6785	1.963E+05	2.0306E+05	9.2742E+12	8.2	8.78E-07	3.827E-06	3.423E-04	8.02E-08	1.21E-04	13
0.6844	1.963E+05	2.0306E+05	9.2742E+12	8.3	8.28E-07	3.529E-06	3.157E-04	7.76E-08	1.21E-04	14
0.6903	1.963E+05	2.0306E+05	9.2742E+12	8.4	7.87E-07	3.262E-06	2.918E-04	7.50E-08	1.21E-04	15
0.6962	1.963E+05	2.0306E+05	9.2743E+12	8.5	7.53E-07	3.023E-06	2.704E-04	7.25E-08	1.21E-04	16
0.7021	1.963E+05	2.0306E+05	9.2743E+12	8.5	7.25E-07	2.804E-06	2.508E-04	7.01E-08	1.21E-04	17
0.7081	1.963E+05	2.0306E+05	9.2744E+12	8.6	7.00E-07	2.603E-06	2.329E-04	6.76E-08	1.21E-04	18
0.7143	1.963E+05	2.0306E+05	9.2744E+12	8.7	6.77E-07	2.420E-06	2.165E-04	6.51E-08	1.21E-04	19
0.7206	1.963E+05	2.0306E+05	9.2745E+12	8.8	6.56E-07	2.254E-06	2.016E-04	6.25E-08	1.21E-04	20
0.7269	1.963E+05	2.0306E+05	9.2745E+12	8.8	6.39E-07	2.104E-06	1.882E-04	6.01E-08	1.21E-04	21
0.7331	1.963E+05	2.0306E+05	9.2746E+12	8.9	6.24E-07	1.967E-06	1.760E-04	5.77E-08	1.21E-04	22
0.7393	1.963E+05	2.0306E+05	9.2746E+12	9.0	6.11E-07	1.843E-06	1.649E-04	5.55E-08	1.21E-04	23
0.7454	1.963E+05	2.0306E+05	9.2746E+12	9.1	6.00E-07	1.730E-06	1.547E-04	5.34E-08	1.21E-04	24

DESIGN EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 75.83

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SUM OF CLASSICAL FIELD AND DIFFUSIONAL CHARGES USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.1602	1.0713	0.9970	0.9378	0.8703	0.8062	0.7605	0.7262
2	1.4208	1.3024	1.2075	1.1335	1.0506	0.9731	0.9184	0.8777
3	1.5699	1.4336	1.3265	1.2438	1.1517	1.0662	1.0062	0.9618
4	1.6741	1.5251	1.4092	1.3203	1.2216	1.1305	1.0668	1.0196
5	1.7538	1.5949	1.4721	1.3784	1.2747	1.1792	1.1125	1.0633
6	1.8182	1.6511	1.5227	1.4250	1.3172	1.2181	1.1490	1.0981
7	1.8720	1.6980	1.5649	1.4638	1.3524	1.2503	1.1792	1.1269
8	1.9180	1.7380	1.6008	1.4968	1.3824	1.2776	1.2048	1.1512
9	1.9582	1.7729	1.6321	1.5255	1.4084	1.3013	1.2269	1.1722
10	1.9937	1.8037	1.6596	1.5507	1.4313	1.3221	1.2463	1.1907
11	2.0256	1.8313	1.6843	1.5733	1.4516	1.3406	1.2636	1.2070
12	2.0545	1.8562	1.7065	1.5936	1.4700	1.3572	1.2790	1.2217
13	2.0730	1.8719	1.7203	1.6060	1.4809	1.3669	1.2879	1.2300
14	2.0903	1.8866	1.7332	1.6176	1.4912	1.3760	1.2963	1.2378
15	2.1067	1.9005	1.7453	1.6285	1.5009	1.3846	1.3041	1.2451
16	2.1222	1.9135	1.7568	1.6389	1.5100	1.3927	1.3115	1.2520
17	2.1368	1.9260	1.7676	1.6486	1.5186	1.4003	1.3185	1.2585
18	2.1507	1.9377	1.7779	1.6579	1.5268	1.4075	1.3251	1.2647
19	2.1640	1.9489	1.7878	1.6667	1.5346	1.4144	1.3251	1.2647
20	2.1767	1.9596	1.7971	1.6751	1.5420	1.4144	1.3251	1.2647
21	2.1888	1.9698	1.8060	1.6831	1.5420	1.4144	1.3251	1.2647
22	2.2003	1.9796	1.8060	1.6831	1.5420	1.4144	1.3251	1.2647
23	2.2114	1.9796	1.8060	1.6831	1.5420	1.4144	1.3251	1.2647
24	2.2221	1.9796	1.8060	1.6831	1.5420	1.4144	1.3251	1.2647

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.6882	0.6528	0.6175	0.5850	0.5545	0.5253	0.5002
2	0.8329	0.7915	0.7507	0.7133	0.6785	0.6456	0.6176
3	0.9131	0.8682	0.8241	0.7839	0.7466	0.7115	0.6817
4	0.9681	0.9208	0.8743	0.8321	0.7930	0.7563	0.7253
5	1.0096	0.9603	0.9121	0.8682	0.8278	0.7899	0.7580
6	1.0426	0.9918	0.9421	0.8969	0.8554	0.8165	0.7838
7	1.0699	1.0177	0.9667	0.9205	0.8780	0.8383	0.8049
8	1.0929	1.0396	0.9875	0.9404	0.8971	0.8566	0.8226
9	1.1128	1.0584	1.0054	0.9574	0.9134	0.8723	0.8378
10	1.1302	1.0749	1.0210	0.9723	0.9276	0.8860	0.8510
11	1.1456	1.0895	1.0349	0.9855	0.9402	0.8980	0.8627
12	1.1594	1.1025	1.0472	0.9972	0.9514	0.9087	0.8731
13	1.1671	1.1097	1.0539	1.0034	0.9572	0.9142	0.8783
14	1.1743	1.1164	1.0601	1.0092	0.9627	0.9194	0.8832
15	1.1811	1.1227	1.0660	1.0147	0.9678	0.9242	0.8877
16	1.1875	1.1286	1.0715	1.0198	0.9726	0.9287	0.8920
17	1.1935	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
18	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
19	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
20	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
21	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920

22	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
23	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920
24	1.1992	1.1342	1.0766	1.0247	0.9726	0.9287	0.8920

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.18957E-17	0.30959E-17	0.45155E-17	0.61461E-17	0.89755E-17	0.13447E-16	0.18700E-16	0.24724E-16
2	0.23215E-17	0.37635E-17	0.54688E-17	0.74288E-17	0.10835E-16	0.16229E-16	0.22582E-16	0.29881E-16
3	0.25650E-17	0.41429E-17	0.60078E-17	0.81514E-17	0.11878E-16	0.17783E-16	0.24743E-16	0.32746E-16
4	0.27353E-17	0.44071E-17	0.63823E-17	0.86524E-17	0.12599E-16	0.18855E-16	0.26231E-16	0.34715E-16
5	0.28656E-17	0.46089E-17	0.66676E-17	0.90333E-17	0.13146E-16	0.19667E-16	0.27356E-16	0.36202E-16
6	0.29707E-17	0.47713E-17	0.68968E-17	0.93390E-17	0.13585E-16	0.20316E-16	0.28254E-16	0.37387E-16
7	0.30586E-17	0.49067E-17	0.70876E-17	0.95930E-17	0.13948E-16	0.20853E-16	0.28996E-16	0.38366E-16
8	0.31338E-17	0.50225E-17	0.72504E-17	0.98094E-17	0.14258E-16	0.21309E-16	0.29625E-16	0.39195E-16
9	0.31995E-17	0.51232E-17	0.73919E-17	0.99973E-17	0.14526E-16	0.21703E-16	0.30169E-16	0.39911E-16
10	0.32576E-17	0.52123E-17	0.75168E-17	0.10163E-16	0.14761E-16	0.22050E-16	0.30646E-16	0.40538E-16
11	0.33097E-17	0.52920E-17	0.76284E-17	0.10311E-16	0.14972E-16	0.22359E-16	0.31070E-16	0.41095E-16
12	0.33568E-17	0.53640E-17	0.77292E-17	0.10444E-16	0.15161E-16	0.22636E-16	0.31451E-16	0.41595E-16
13	0.33870E-17	0.54093E-17	0.77914E-17	0.10525E-16	0.15274E-16	0.22798E-16	0.31670E-16	0.41878E-16
14	0.34154E-17	0.54518E-17	0.78498E-17	0.10601E-16	0.15380E-16	0.22950E-16	0.31875E-16	0.42143E-16
15	0.34421E-17	0.54919E-17	0.79048E-17	0.10673E-16	0.15479E-16	0.23093E-16	0.32067E-16	0.42392E-16
16	0.34674E-17	0.55297E-17	0.79568E-17	0.10740E-16	0.15573E-16	0.23227E-16	0.32249E-16	0.42627E-16
17	0.34914E-17	0.55656E-17	0.80059E-17	0.10804E-16	0.15662E-16	0.23355E-16	0.32421E-16	0.42849E-16
18	0.35141E-17	0.55996E-17	0.80526E-17	0.10865E-16	0.15747E-16	0.23476E-16	0.32583E-16	0.43059E-16
19	0.35358E-17	0.56320E-17	0.80971E-17	0.10923E-16	0.15827E-16	0.23590E-16	0.32583E-16	0.43059E-16
20	0.35565E-17	0.56629E-17	0.81394E-17	0.10978E-16	0.15903E-16	0.23590E-16	0.32583E-16	0.43059E-16
21	0.35762E-17	0.56924E-17	0.81798E-17	0.11030E-16	0.15903E-16	0.23590E-16	0.32583E-16	0.43059E-16
22	0.35951E-17	0.57206E-17	0.81798E-17	0.11030E-16	0.15903E-16	0.23590E-16	0.32583E-16	0.43059E-16
23	0.36133E-17	0.57206E-17	0.81798E-17	0.11030E-16	0.15903E-16	0.23590E-16	0.32583E-16	0.43059E-16
24	0.36307E-17	0.57206E-17	0.81798E-17	0.11030E-16	0.15903E-16	0.23590E-16	0.32583E-16	0.43059E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.35189E-16	0.51782E-16	0.82271E-16	0.14050E-15	0.27061E-15	0.65395E-15	0.21832E-14
2	0.42590E-16	0.62791E-16	0.10001E-15	0.17132E-15	0.33116E-15	0.80371E-15	0.26954E-14
3	0.46689E-16	0.68873E-16	0.10979E-15	0.18826E-15	0.36437E-15	0.88568E-15	0.29752E-14
4	0.49503E-16	0.73041E-16	0.11648E-15	0.19984E-15	0.38703E-15	0.94153E-15	0.31657E-14
5	0.51624E-16	0.76180E-16	0.12151E-15	0.20853E-15	0.40401E-15	0.98334E-15	0.33081E-14
6	0.53313E-16	0.78674E-16	0.12550E-15	0.21542E-15	0.41746E-15	0.10164E-14	0.34207E-14
7	0.54706E-16	0.80730E-16	0.12879E-15	0.22108E-15	0.42851E-15	0.10435E-14	0.35129E-14
8	0.55884E-16	0.82466E-16	0.13156E-15	0.22585E-15	0.43780E-15	0.10663E-14	0.35904E-14
9	0.56900E-16	0.83961E-16	0.13395E-15	0.22995E-15	0.44577E-15	0.10859E-14	0.36567E-14
10	0.57789E-16	0.85268E-16	0.13603E-15	0.23352E-15	0.45271E-15	0.11029E-14	0.37143E-14
11	0.58578E-16	0.86426E-16	0.13787E-15	0.23668E-15	0.45885E-15	0.11179E-14	0.37651E-14
12	0.59284E-16	0.87462E-16	0.13952E-15	0.23950E-15	0.46432E-15	0.11312E-14	0.38104E-14
13	0.59678E-16	0.88030E-16	0.14040E-15	0.24100E-15	0.46716E-15	0.11381E-14	0.38332E-14
14	0.60047E-16	0.88562E-16	0.14123E-15	0.24239E-15	0.46982E-15	0.11445E-14	0.38549E-14
15	0.60393E-16	0.89061E-16	0.14201E-15	0.24370E-15	0.47232E-15	0.11504E-14	0.38744E-14
16	0.60719E-16	0.89531E-16	0.14274E-15	0.24493E-15	0.47466E-15	0.11561E-14	0.38932E-14
17	0.61027E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
18	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
19	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
20	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
21	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
22	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
23	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14
24	0.61319E-16	0.89975E-16	0.14343E-15	0.24609E-15	0.47466E-15	0.11561E-14	0.38932E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0162	0.0196	60.4177	5.757	39.5823	45.0462	3.719	54.9538
3.500E-07	1.414	0.049	0.1085	0.1077	58.4853	5.461	41.5147	52.8613	4.672	47.1387
4.500E-07	1.320	0.212	0.4771	0.4395	58.0627	5.398	41.9373	55.8074	5.073	44.1926
5.500E-07	1.261	0.597	1.3291	1.1952	58.5306	5.468	41.4694	57.3450	5.292	42.6550
7.000E-07	1.205	2.119	4.6137	4.1335	59.4501	5.607	40.5499	58.4446	5.455	41.5554
9.000E-07	1.159	2.985	6.2119	5.5731	61.2373	5.887	38.7627	60.2208	5.726	39.7792
1.100E-06	1.130	3.582	7.1198	6.4035	62.9766	6.172	37.0234	61.9115	5.996	38.0885
1.300E-06	1.110	3.283	6.2122	5.6399	64.7594	6.479	35.2406	63.4039	6.244	36.5961
1.600E-06	1.090	6.865	12.1510	11.1047	67.0329	6.893	32.9671	65.5377	6.617	34.4623
2.000E-06	1.072	7.164	11.6408	10.7093	69.7332	7.424	30.2668	68.1497	7.107	31.8503
2.600E-06	1.055	11.940	17.1454	16.0948	73.2526	8.192	26.7474	71.2798	7.749	28.7202
3.500E-06	1.041	10.447	12.8117	12.5131	77.1581	9.172	22.8419	74.4812	8.484	25.5188
5.000E-06	1.029	14.925	13.6244	14.0606	82.9965	11.005	17.0035	79.9277	9.975	20.0723
8.000E-06	1.018	14.925	5.5649	7.5235	93.0549	16.567	6.9451	89.2598	13.859	10.7402
1.500E-05	1.010	20.899	0.9735	4.4820	99.1324	29.488	0.8676	95.4306	19.168	4.5694

EFFICIENCY = STATED = 99.00 COMPUTED = 75.8299 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 81.3734
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.218E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.825E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.439

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 78.6939
CORRECTED MMD OF EFFLUENT = 2.565E+00
CORRECTED SIGMAP OF EFFLUENT = 1.955E+00
LOG-NORMAL GOODNESS OF FIT = 0.992
CORRECTED PRECIPITATION RATE PARAMETER = 9.60

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.476E+00	3.288E+01	2.774E-02	1.077E-02	3.851E-02	4.360E-02	2.500E-07
2.517E+00	3.331E+01	2.627E-01	3.559E-02	2.983E-01	1.022E-01	3.500E-07
2.633E+00	3.455E+01	1.489E+00	8.007E-02	1.569E+00	1.784E-01	4.500E-07
2.782E+00	3.611E+01	5.077E+00	1.451E-01	5.222E+00	2.642E-01	5.500E-07
3.031E+00	3.861E+01	1.117E+01	2.769E-01	1.144E+01	7.953E-01	7.000E-07
3.383E+00	4.200E+01	1.939E+01	5.084E-01	1.989E+01	1.132E+00	9.000E-07
3.745E+00	4.528E+01	2.719E+01	7.823E-01	2.798E+01	1.424E+00	1.100E-06
4.116E+00	4.845E+01	2.806E+01	1.080E+00	2.914E+01	1.661E+00	1.300E-06
4.676E+00	5.290E+01	3.367E+01	1.527E+00	3.520E+01	3.831E+00	1.600E-06
5.419E+00	5.820E+01	4.040E+01	2.113E+00	4.251E+01	4.234E+00	2.000E-06
6.543E+00	6.512E+01	3.850E+01	2.839E+00	4.133E+01	8.791E+00	2.600E-06
8.226E+00	7.340E+01	3.101E+01	3.634E+00	3.465E+01	1.044E+01	3.500E-06
1.101E+01	8.300E+01	2.340E+01	4.223E+00	2.762E+01	1.709E+01	5.000E-06
1.657E+01	9.305E+01	7.586E+00	4.146E+00	1.173E+01	2.114E+01	8.000E-06
2.949E+01	9.913E+01	9.780E-01	4.173E+00	5.151E+00	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  78.6939 %     SCA =  1.610E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.020E+04 V
                           AVG. CURRENT DENSITY =   10.28 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00
                        OUTLET MMD =  2.565E+00 UM     OUTLET SIGMAP =  1.955E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0148	0.0179	56.1311	5.118	43.8689	40.5296	3.228	59.4704
3.500E-07	1.414	0.049	0.0988	0.0991	54.2253	4.854	45.7747	48.5172	4.124	51.4828
4.500E-07	1.320	0.212	0.4338	0.4064	53.7920	4.796	46.2080	51.5029	4.495	48.4971
5.500E-07	1.261	0.597	1.2108	1.1090	54.2255	4.854	45.7745	53.0221	4.693	46.9779
7.000E-07	1.205	2.119	4.2174	3.8494	55.0865	4.972	44.9135	54.0660	4.832	45.9340
9.000E-07	1.159	2.985	5.7151	5.2223	56.7880	5.212	43.2120	55.7562	5.065	44.2438
1.100E-06	1.130	3.582	6.5944	6.0384	58.4494	5.455	41.5506	57.3684	5.296	42.6316
1.300E-06	1.110	3.283	5.7957	5.3511	60.1622	5.717	39.8378	58.7863	5.506	41.2137
1.600E-06	1.090	6.865	11.4532	10.6336	62.3479	6.067	37.6521	60.8303	5.822	39.1697
2.000E-06	1.072	7.164	11.1228	10.3820	64.9577	6.514	35.0423	63.3506	6.235	36.6494
2.600E-06	1.055	11.940	16.7251	15.8719	68.3849	7.153	31.6151	66.3825	6.771	33.6175
3.500E-06	1.041	10.447	12.8663	12.6051	72.2046	7.953	27.7954	69.4877	7.373	30.5123
5.000E-06	1.029	14.925	14.4817	14.7625	78.1006	9.434	21.8994	74.9859	8.608	25.0141
8.000E-06	1.018	14.925	7.0835	8.5951	89.2881	13.876	10.7119	85.4362	11.968	14.5638
1.500E-05	1.010	20.899	2.1866	5.0562	97.6386	23.268	2.3614	93.8815	17.354	6.1185

EFFICIENCY - STATED = 99.00 COMPUTED = 75.8299 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 77.4303
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.423E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.889E+00
LOG-NORMAL GOODNESS OF FIT = 0.994
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 9.246

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 74.7107
CORRECTED MMD OF EFFLUENT = 2.663E+00
CORRECTED SIGMAP OF EFFLUENT = 1.968E+00
LOG-NORMAL GOODNESS OF FIT = 0.992
CORRECTED PRECIPITATION RATE PARAMETER = 8.54

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2,476E+00	3,288E+01	3,074E-02	1,093E-02	4,167E-02	4,360E-02	2,500E-07
2,517E+00	3,331E+01	2,897E-01	3.613E-02	3,258E-01	1,022E-01	3,500E-07
2,633E+00	3,455E+01	1,640E+00	8.127E-02	1.722E+00	1,784E-01	4,500E-07
2,782E+00	3,611E+01	5,604E+00	1,473E-01	5.751E+00	2,642E-01	5,500E-07
3,031E+00	3,861E+01	1,237E+01	2,811E-01	1.265E+01	7,953E-01	7,000E-07
3,383E+00	4,200E+01	2,161E+01	5,160E-01	2,213E+01	1,132E+00	9,000E-07
3,745E+00	4,528E+01	3,052E+01	7,940E-01	3,131E+01	1,424E+00	1,100E-06
4,116E+00	4,845E+01	3,172E+01	1,096E+00	3,282E+01	1,661E+00	1,300E-06
4,676E+00	5.290E+01	3,845E+01	1.550E+00	4,000E+01	3,831E+00	1,600E-06
5,419E+00	5,820E+01	4,677E+01	2,145E+00	4,891E+01	4,234E+00	2,000E-06
6,543E+00	6.512E+01	4,550E+01	2.882E+00	4,838E+01	8,791E+00	2,600E-06
8,226E+00	7,340E+01	3,774E+01	3,689E+00	4,143E+01	1,044E+01	3,500E-06
1,101E+01	8,300E+01	3,014E+01	4.286E+00	3,442E+01	1,709E+01	5,000E-06
1,657E+01	9,305E+01	1,170E+01	4,208E+00	1,591E+01	2,114E+01	8,000E-06
2.949E+01	9.913E+01	2.662E+00	4.235E+00	6.897E+00	2,887E+01	1,500E-05

```
*****************************************************************************************************
*                                                                                                   *
*                                  SUMMARY TABLE OF ESP OPERATING                                   *
*                                    PARAMETERS AND PERFORMANCE                                     *
*                                                                                                   *
*                                                                                                   *
*                                        DATA SET NUMBER   2                                        *
*                                                                                                   *
*          ESP PERFORMANCE:     EFFICIENCY =  74.7107 %     SCA =  1.610E+01 M**2/(M**3/SEC)        *
*                                                                                                   *
*          ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.020E+04 V                           *
*                                     AVG. CURRENT DENSITY =   10.28 NA/CM**2                       *
*                                     RESISTIVITY =  1.000E+09 OHM-CM                               *
*                                                                                                   *
*          SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00          *
*                                  OUTLET MMD =  2.663E+00 UM     OUTLET SIGMAP =  1.968E+00         *
*                                                                                                   *
*          NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10 *
*                                   RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00      *
*                                                                                                   *
*****************************************************************************************************
STOP  011111
```

APPENDIX L

OUTPUT DATA FOR EXAMPLE 3 (REVISION 1)

```
*************************************
*                                   *
*          E.P.A. ESP MODEL         *
*                                   *
*     T.E.R.L.-R.T.P. AND SO.R.I.   *
*                                   *
*        REVISION I,JAN. 1, 1978    *
*                                   *
*************************************

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER  1


DATA ON CARD NUMBER   1

NENDPT = 16   NDATA =  1

DATA ON CARD NUMBER   2

LAB ESP: SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

DATA ON CARD NUMBER   3

NEST =  2  NDIST =  1  NVI =  2  NX = 15  NY = 15  NITER =  1  NCALC =  0  NRAPD =  1  NEFF =  1  NTEMP =  1  NONID =  2

DATA ON CARD NUMBER   4

NN = 10  NUMINC = 20

DATA ON CARD NUMBER   5

IFINAL = 20  JI1 =  2  JI2 = 21  VISKIP = 1  VISAME =  2

DATA ON CARD NUMBER   6

DL =  0.06500 GRN/ACF  PL =  10.0000 FT  ETAO = 99.00000 %  DD =  1000.00 KG/M**3  EPS =  5.100E+00
VRATIO =   1.0300  US = 0.000165 M**2/V-SEC  FPATH =   1.0000  EBD = 1500000. V/M  RHOCGS =  1.00E+09 OHM-CM

DATA ON CARD NUMBER   7

ASNUCK( 1) = 0.00  AZIGGY( 1) = 0.00  AZNUMS( 1) =  4.0
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ABNUCK( 2) = 0.10  AZIGGY( 2) = 0.10  AZNUMS( 2) =  4.0

DATA ON CARD NUMBER   8

ENDPT( 1) =    0.200 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.400 UM   ENDPT( 4) =    0.500 UM   ENDPT( 5) =    0.600 UM
ENDPT( 6) =    0.800 UM   ENDPT( 7) =    1.000 UM   ENDPT( 8) =    1.200 UM   ENDPT( 9) =    1.400 UM   ENDPT(10) =    1.800 UM

DATA ON CARD NUMBER   9

ENDPT(11) =    2.200 UM   ENDPT(12) =    3.000 UM   ENDPT(13) =    4.000 UM   ENDPT(14) =    6.000 UM   ENDPT(15) =   10.000 UM
ENDPT(16) =   20.000 UM

DATA ON CARD NUMBER  10

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0076 %   PRCU( 3) =   0.0563 %   PRCU( 4) =   0.2682 %   PRCU( 5) =   0.8652 %
PRCU( 6) =   2.9845 %   PRCU( 7) =   5.9695 %   PRCU( 8) =   9.5515 %   PRCU( 9) =  12.8350 %   PRCU(10) =  19.7004 %

DATA ON CARD NUMBER  11

PRCU(11) =  26.8643 %   PRCU(12) =  38.8042 %   PRCU(13) =  49.2516 %   PRCU(14) =  64.1765 %   PRCU(15) =  79.1014 %
PRCU(16) = 100.0000 %

DATA ON CARD NUMBER  12

NUMSEC =  3    LSECT( 1) =  6  LSECT( 2) =  6  LSECT( 3) = 12

DATA ON CARD NUMBER  13

AS( 1) =  6.2500E+00 FT**2  VOS( 1) =  4.0800E+04 V  TCS( 1) =  6.2500E-05 A  WLS( 1) =  6.2500E+00 FT
ACS( 1) =  4.6875E-02 IN  BS( 1) =  5.0000E+00 IN  NWB( 1) =  5.0000E+00

DATA ON CARD NUMBER  14

SYS( 1) =  2.5000E+00 IN  VGS( 1) =  3.0533E+02 FT**3/MIN  VGABS( 1) =  4.8853E+00 FT/SEC  TEMPS( 1) =  7.6000E+01 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  1.8000E-05 KG/M-SEC  LINCS( 1) =  4.1667E-01 FT
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DATA ON CARD NUMBER  15

RFS( 1) =  9.0000E-01  START1( 1) =  6.0000E-05 A/M**2  START2( 1) =  2.0000E-05 A/M**2
START3( 1) =  2.0000E-05 A/M**2  VSTAR( 1) =  3.8000E+04 V

DATA ON CARD NUMBER  16

AS( 2) =  6.2500E+00 FT**2  VOS( 2) =  4.0800E+04 V  TCS( 2) =  6.2500E-05 A  WLS( 2) =  6.2500E+00 FT
ACS( 2) =  4.6875E-02 IN  BS( 2) =  5.0000E+00 IN  NWS( 2) =  5.0000E+00

DATA ON CARD NUMBER  17

SYS( 2) =  2.5000E+00 IN  VGS( 2) =  3.0533E+02 FT**3/MIN  VGASS( 2) =  4.8853E+00 FT/SEC  TEMPS( 2) =  7.6000E+01 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  1.8000E-05 KG/M-SEC  LINCS( 2) =  4.1667E-01 FT

DATA ON CARD NUMBER  18

RFS( 2) =  9.0000E-01  START1( 2) =  6.0000E-05 A/M**2  START2( 2) =  2.0000E-05 A/M**2
START3( 2) =  2.0000E-05 A/M**2  VSTAR( 2) =  3.8000E+04 V

DATA ON CARD NUMBER  19

AS( 3) =  1.2500E+01 FT**2  VOS( 3) =  3.9600E+04 V  TCS( 3) =  1.2500E-04 A  WLS( 3) =  1.2500E+01 FT
ACS( 3) =  4.6875E-02 IN  BS( 3) =  5.0000E+00 IN  NWS( 3) =  1.0000E+01

DATA ON CARD NUMBER  20

SYS( 3) =  2.5000E+00 IN  VGS( 3) =  3.0533E+02 FT**3/MIN  VGASS( 3) =  4.8853E+00 FT/SEC  TEMPS( 3) =  7.6000E+01 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  1.8000E-05 KG/M-SEC  LINCS( 3) =  4.1667E-01 FT

DATA ON CARD NUMBER  21

RFS( 3) =  9.0000E-01  START1( 3) =  6.0000E-05 A/M**2  START2( 3) =  2.0000E-05 A/M**2
START3( 3) =  2.0000E-05 A/M**2  VSTAR( 3) =  3.8000E+04 V
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CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 1

VW = -3.8000E+04 ACDNTY = 6.0276E-05 AEPLT = -1.7902E+05

VW = -3.8206E+04 ACDNTY = 7.9337E-05 AEPLT = -1.8597E+05

VW = -3.8896E+04 ACDNTY = 9.9193E-05 AEPLT = -1.9435E+05

VW = -3.9513E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3890E-04 AEPLT = -2.0993E+05

VW = -4.0656E+04 ACDNTY = 1.5874E-04 AEPLT = -2.1722E+05

VW = -4.1193E+04 ACDNTY = 1.7859E-04 AEPLT = -2.2424E+05

VW = -4.0711E+04 ACDNTY = 1.6251E-04 AEPLT = -2.1842E+05

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

LAB ESP: SCA=82FT2/1000ACFM;CALCULATED V-I FOR EACH ELECTRICAL SECTION

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 8.955E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.625E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.446E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.675E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.8270	2.085E+05	2.1842E+05	2.1568E+13	13.4	7.29E-06	6.039E-06	5.402E-04	3.60E-08	1.62E-04	1
0.7546	2.085E+05	2.1842E+05	2.1575E+13	12.3	4.28E-06	8.888E-06	7.950E-04	7.28E-08	1.62E-04	2
0.7356	2.085E+05	2.1842E+05	2.1578E+13	12.0	2.92E-06	9.226E-06	8.252E-04	9.01E-08	1.62E-04	3
0.7278	2.085E+05	2.1842E+05	2.1579E+13	11.8	2.28E-06	8.922E-06	7.981E-04	9.91E-08	1.62E-04	4
0.7251	2.085E+05	2.1842E+05	2.1580E+13	11.8	1.93E-06	8.376E-06	7.492E-04	1.04E-07	1.62E-04	5
0.7292	2.085E+05	2.1842E+05	2.1581E+13	11.8	1.64E-06	7.745E-06	6.927E-04	1.05E-07	1.62E-04	6

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 2

VW = -3.8000E+04 ACDNTY = 6.0276E-05 AEPLT = -1.7902E+05

VW = -3.8206E+04 ACDNTY = 7.9337E-05 AEPLT = -1.8597E+05

VW = -3.8896E+04 ACDNTY = 9.9193E-05 AEPLT = -1.9435E+05

VW = -3.9513E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3890E-04 AEPLT = -2.0993E+05

VW = -4.0656E+04 ACDNTY = 1.5874E-04 AEPLT = -2.1722E+05

VW = -4.1193E+04 ACDNTY = 1.7859E-04 AEPLT = -2.2424E+05

VW = -4.0711E+04 ACDNTY = 1.6251E-04 AEPLT = -2.1842E+05

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 0.7625 M

COLLECTION AREA = 5.812E-01 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 4.955E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 4.080E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.625E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 9.446E-05 AMPS
CORONA WIRE LENGTH = 1.906E+00 M
DEPOSIT E FIELD = 1.625E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.7270	2.085E+05	2.1842E+05	2.1581E+13	11.8	1.46E-06	7.103E-06	6.354E-04	1.05E-07	1.62E-04	7
0.7299	2.085E+05	2.1842E+05	2.1581E+13	11.9	1.33E-06	6.487E-06	5.803E-04	1.04E-07	1.62E-04	8
0.7336	2.085E+05	2.1842E+05	2.1582E+13	11.9	1.20E-06	5.914E-06	5.290E-04	1.03E-07	1.62E-04	9
0.7370	2.085E+05	2.1842E+05	2.1582E+13	12.0	1.09E-06	5.390E-06	4.821E-04	1.00E-07	1.62E-04	10
0.7426	2.085E+05	2.1842E+05	2.1582E+13	12.1	1.01E-06	4.916E-06	4.398E-04	9.78E-08	1.62E-04	11
0.7475	2.085E+05	2.1842E+05	2.1582E+13	12.2	9.44E-07	4.491E-06	4.017E-04	9.50E-08	1.62E-04	12

CLEAN GAS VOLTAGE-CURRENT DENSITY-FIELD AT THE PLATE RELATIONSHIP FOR SECTION NO. 3

VW = -3.8000E+04 ACDNTY = 6.0277E-05 AEPLT = -1.7902E+05

VW = -3.8205E+04 ACDNTY = 7.9332E-05 AEPLT = -1.8596E+05

VW = -3.8896E+04 ACDNTY = 9.9192E-05 AEPLT = -1.9435E+05

VW = -3.9512E+04 ACDNTY = 1.1904E-04 AEPLT = -2.0232E+05

VW = -4.0098E+04 ACDNTY = 1.3889E-04 AEPLT = -2.0993E+05

VW = -3.9514E+04 ACDNTY = 1.2081E-04 AEPLT = -2.0279E+05

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 1.5250 M

COLLECTION AREA = 1.162E+00 M2
WIRE TO PLATE = 1.270E-01 M
CURRENT/M = 3.684E-05 AMP/M
1/2 WIRE TO WIRE = 6.350E-02 M
TEMPERATURE = 297.222 K
ION MOBILITY = 1.795E-04 M2/VOLT-SEC
DUST WEIGHT = 2.150E-05 KG/SEC

APPLIED VOLTAGE = 3.960E+04 VOLTS
CORONA WIRE RADIUS = 1.191E-03 M
CURRENT DENSITY = 1.208E-04 AMP/M2
GAS FLOW RATE = 1.444E-01 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 4.436E+02 M/SEC
LENGTH INCR. =0.12708435 M

TOTAL CURRENT = 1.404E-04 AMPS
CORONA WIRE LENGTH = 3.812E+00 M
DEPOSIT E FIELD = 1.208E+03 VOLT/M
GAS VELOCITY = 1.490E+00 M/SEC
VISCOSITY = 1.800E-05 KG/M-SEC
PART. PATH PARAM. = 5.700E-08 M
INPUT EFF./INCR. = 17.46

RIOVR	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
0.7042	2.001E+05	2.0279E+05	1.7773E+13	8.5	8.66E-07	3.821E-06	3.418E-04	8.54E-08	1.21E-04	13
0.7102	2.001E+05	2.0279E+05	1.7773E+13	8.6	8.17E-07	3.515E-06	3.145E-04	8.25E-08	1.21E-04	14
0.7162	2.001E+05	2.0279E+05	1.7773E+13	8.7	7.77E-07	3.243E-06	2.901E-04	7.96E-08	1.21E-04	15
0.7222	2.001E+05	2.0279E+05	1.7773E+13	8.7	7.44E-07	2.999E-06	2.683E-04	7.69E-08	1.21E-04	16
0.7281	2.001E+05	2.0279E+05	1.7773E+13	8.8	7.17E-07	2.779E-06	2.485E-04	7.42E-08	1.21E-04	17
0.7341	2.001E+05	2.0279E+05	1.7773E+13	8.9	6.92E-07	2.576E-06	2.304E-04	7.15E-08	1.21E-04	18
0.7403	2.001E+05	2.0279E+05	1.7773E+13	8.9	6.69E-07	2.391E-06	2.139E-04	6.87E-08	1.21E-04	19
0.7466	2.001E+05	2.0279E+05	1.7774E+13	9.0	6.50E-07	2.223E-06	1.989E-04	6.59E-08	1.21E-04	20
0.7528	2.001E+05	2.0279E+05	1.7774E+13	9.1	6.33E-07	2.072E-06	1.853E-04	6.33E-08	1.21E-04	21
0.7591	2.001E+05	2.0279E+05	1.7774E+13	9.2	6.18E-07	1.935E-06	1.731E-04	6.07E-08	1.21E-04	22
0.7652	2.001E+05	2.0279E+05	1.7774E+13	9.2	6.06E-07	1.810E-06	1.619E-04	5.82E-08	1.21E-04	23
0.7711	2.001E+05	2.0279E+05	1.7774E+13	9.3	5.95E-07	1.697E-06	1.518E-04	5.59E-08	1.21E-04	24

DESIGN EFFICIENCY = 99.00 UNCORRECTED COMPUTED EFFICIENCY = 76.96

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SUM OF CLASSICAL FIELD AND DIFFUSIONAL CHARGES USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	1.1496	1.0609	0.9872	0.9287	0.8622	0.7992	0.7543	0.7207
2	1.4040	1.2869	1.1934	1.1208	1.0394	0.9636	0.9101	0.8704
3	1.5514	1.4171	1.3119	1.2309	1.1408	1.0574	0.9988	0.9555
4	1.6546	1.5082	1.3946	1.3076	1.2112	1.1224	1.0607	1.0143
5	1.7336	1.5776	1.4575	1.3659	1.2647	1.1716	1.1066	1.0588
6	1.7972	1.6335	1.5080	1.4125	1.3074	1.2108	1.1436	1.0941
7	1.8503	1.6799	1.5499	1.4513	1.3427	1.2433	1.1741	1.1233
8	1.8957	1.7195	1.5856	1.4841	1.3727	1.2707	1.1999	1.1478
9	1.9352	1.7539	1.6165	1.5126	1.3986	1.2944	1.2221	1.1690
10	1.9700	1.7843	1.6437	1.5376	1.4213	1.3151	1.2415	1.1875
11	2.0013	1.8114	1.6680	1.5599	1.4416	1.3336	1.2587	1.2038
12	2.0295	1.8358	1.6899	1.5800	1.4597	1.3501	1.2742	1.2185
13	2.0477	1.8513	1.7035	1.5923	1.4706	1.3598	1.2831	1.2269
14	2.0647	1.8658	1.7163	1.6038	1.4809	1.3689	1.2915	1.2347
15	2.0808	1.8795	1.7283	1.6146	1.4905	1.3775	1.2993	1.2420
16	2.0959	1.8923	1.7396	1.6248	1.4995	1.3855	1.3067	1.2490
17	2.1103	1.9045	1.7503	1.6345	1.5081	1.3931	1.3137	1.2555
18	2.1239	1.9161	1.7604	1.6436	1.5162	1.4003	1.3202	1.2616
19	2.1369	1.9271	1.7701	1.6523	1.5238	1.4071	1.3202	1.2616
20	2.1493	1.9375	1.7793	1.6606	1.5311	1.4071	1.3202	1.2616
21	2.1610	1.9475	1.7880	1.6606	1.5311	1.4071	1.3202	1.2616
22	2.1723	1.9571	1.7880	1.6606	1.5311	1.4071	1.3202	1.2616
23	2.1831	1.9571	1.7880	1.6606	1.5311	1.4071	1.3202	1.2616
24	2.1831	1.9571	1.7880	1.6606	1.5311	1.4071	1.3202	1.2616

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.6835	0.6488	0.6144	0.5827	0.5530	0.5246	0.5002
2	0.8267	0.7863	0.7466	0.7102	0.6764	0.6444	0.6172
3	0.9080	0.8643	0.8215	0.7823	0.7461	0.7121	0.6832
4	0.9642	0.9181	0.8730	0.8320	0.7941	0.7585	0.7285
5	1.0065	0.9586	0.9118	0.8692	0.8300	0.7933	0.7623
6	1.0402	0.9908	0.9425	0.8987	0.8584	0.8208	0.7891
7	1.0679	1.0172	0.9677	0.9229	0.8817	0.8432	0.8109
8	1.0912	1.0394	0.9889	0.9432	0.9012	0.8620	0.8292
9	1.1113	1.0585	1.0071	0.9606	0.9179	0.8781	0.8448
10	1.1288	1.0751	1.0229	0.9756	0.9324	0.8920	0.8582
11	1.1442	1.0898	1.0368	0.9889	0.9451	0.9043	0.8701
12	1.1581	1.1029	1.0493	1.0008	0.9564	0.9151	0.8806
13	1.1658	1.1101	1.0560	1.0071	0.9624	0.9208	0.8860
14	1.1731	1.1169	1.0624	1.0131	0.9680	0.9261	0.8911
15	1.1799	1.1233	1.0683	1.0186	0.9732	0.9310	0.8958
16	1.1864	1.1293	1.0739	1.0238	0.9781	0.9356	0.9002
17	1.1924	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
18	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
19	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
20	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
21	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002

22	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
23	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002
24	1.1981	1.1349	1.0791	1.0287	0.9827	0.9356	0.9002

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2500E-06	0.3500E-06	0.4500E-06	0.5500E-06	0.7000E-06	0.9000E-06	0.1100E-05	0.1300E-05
1	0.19639E-17	0.32052E-17	0.46746E-17	0.63635E-17	0.92966E-17	0.13936E-16	0.19392E-16	0.25654E-16
2	0.23984E-17	0.38879E-17	0.56511E-17	0.76796E-17	0.11208E-16	0.16802E-16	0.23397E-16	0.30981E-16
3	0.26501E-17	0.42815E-17	0.62123E-17	0.84342E-17	0.12301E-16	0.18438E-16	0.25678E-16	0.34011E-16
4	0.28265E-17	0.45565E-17	0.66036E-17	0.89594E-17	0.13061E-16	0.19571E-16	0.27257E-16	0.36106E-16
5	0.29614E-17	0.47664E-17	0.69016E-17	0.93587E-17	0.13637E-16	0.20429E-16	0.28450E-16	0.37688E-16
6	0.30701E-17	0.49351E-17	0.71406E-17	0.96785E-17	0.14097E-16	0.21114E-16	0.29401E-16	0.38946E-16
7	0.31608E-17	0.50755E-17	0.73392E-17	0.99437E-17	0.14478E-16	0.21680E-16	0.30185E-16	0.39983E-16
8	0.32383E-17	0.51951E-17	0.75081E-17	0.10169E-16	0.14802E-16	0.22158E-16	0.30848E-16	0.40859E-16
9	0.33057E-17	0.52991E-17	0.76546E-17	0.10364E-16	0.15081E-16	0.22571E-16	0.31418E-16	0.41611E-16
10	0.33653E-17	0.53908E-17	0.77836E-17	0.10536E-16	0.15326E-16	0.22933E-16	0.31918E-16	0.42269E-16
11	0.34186E-17	0.54727E-17	0.78986E-17	0.10688E-16	0.15544E-16	0.23254E-16	0.32360E-16	0.42852E-16
12	0.34668E-17	0.55465E-17	0.80022E-17	0.10826E-16	0.15740E-16	0.23542E-16	0.32757E-16	0.43373E-16
13	0.34979E-17	0.55933E-17	0.80667E-17	0.10910E-16	0.15858E-16	0.23712E-16	0.32986E-16	0.43671E-16
14	0.35271E-17	0.56371E-17	0.81271E-17	0.10989E-16	0.15968E-16	0.23870E-16	0.33201E-16	0.43950E-16
15	0.35545E-17	0.56783E-17	0.81839E-17	0.11063E-16	0.16071E-16	0.24019E-16	0.33403E-16	0.44212E-16
16	0.35804E-17	0.57173E-17	0.82375E-17	0.11133E-16	0.16169E-16	0.24160E-16	0.33593E-16	0.44458E-16
17	0.36049E-17	0.57541E-17	0.82882E-17	0.11199E-16	0.16261E-16	0.24292E-16	0.33772E-16	0.44690E-16
18	0.36282E-17	0.57890E-17	0.83362E-17	0.11262E-16	0.16349E-16	0.24417E-16	0.33941E-16	0.44909E-16
19	0.36504E-17	0.58222E-17	0.83818E-17	0.11321E-16	0.16431E-16	0.24536E-16	0.33941E-16	0.44909E-16
20	0.36715E-17	0.58538E-17	0.84252E-17	0.11378E-16	0.16510E-16	0.24536E-16	0.33941E-16	0.44909E-16
21	0.36916E-17	0.58840E-17	0.84666E-17	0.11378E-16	0.16510E-16	0.24536E-16	0.33941E-16	0.44909E-16
22	0.37109E-17	0.59128E-17	0.84666E-17	0.11378E-16	0.16510E-16	0.24536E-16	0.33941E-16	0.44909E-16
23	0.37293E-17	0.59128E-17	0.84666E-17	0.11378E-16	0.16510E-16	0.24536E-16	0.33941E-16	0.44909E-16
24	0.37293E-17	0.59128E-17	0.84666E-17	0.11378E-16	0.16510E-16	0.24536E-16	0.33941E-16	0.44909E-16

	0.1600E-05	0.2000E-05	0.2600E-05	0.3500E-05	0.5000E-05	0.8000E-05	0.1500E-04
1	0.36539E-16	0.53813E-16	0.85584E-16	0.14632E-15	0.28215E-15	0.68276E-15	0.22825E-14
2	0.44195E-16	0.65218E-16	0.10399E-15	0.17833E-15	0.34513E-15	0.83873E-15	0.28164E-14
3	0.48543E-16	0.71686E-16	0.11442E-15	0.19644E-15	0.38071E-15	0.92675E-15	0.31175E-14
4	0.51546E-16	0.76147E-16	0.12160E-15	0.20890E-15	0.40517E-15	0.98717E-15	0.33240E-14
5	0.53809E-16	0.79506E-16	0.12700E-15	0.21826E-15	0.42351E-15	0.10325E-14	0.34786E-14
6	0.55608E-16	0.82171E-16	0.13128E-15	0.22567E-15	0.43801E-15	0.10682E-14	0.36006E-14
7	0.57088E-16	0.84362E-16	0.13479E-15	0.23174E-15	0.44989E-15	0.10975E-14	0.37002E-14
8	0.58336E-16	0.86206E-16	0.13774E-15	0.23684E-15	0.45984E-15	0.11219E-14	0.37836E-14
9	0.59407E-16	0.87787E-16	0.14027E-15	0.24120E-15	0.46835E-15	0.11428E-14	0.38546E-14
10	0.60342E-16	0.89165E-16	0.14247E-15	0.24499E-15	0.47573E-15	0.11609E-14	0.39162E-14
11	0.61169E-16	0.90383E-16	0.14441E-15	0.24832E-15	0.48223E-15	0.11769E-14	0.39703E-14
12	0.61909E-16	0.91470E-16	0.14615E-15	0.25130E-15	0.48801E-15	0.11910E-14	0.40183E-14
13	0.62325E-16	0.92073E-16	0.14709E-15	0.25290E-15	0.49106E-15	0.11984E-14	0.40430E-14
14	0.62714E-16	0.92636E-16	0.14797E-15	0.25438E-15	0.49391E-15	0.12053E-14	0.40659E-14
15	0.63079E-16	0.93163E-16	0.14880E-15	0.25578E-15	0.49658E-15	0.12117E-14	0.40874E-14
16	0.63422E-16	0.93659E-16	0.14957E-15	0.25709E-15	0.49907E-15	0.12177E-14	0.41075E-14
17	0.63745E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
18	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
19	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
20	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
21	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
22	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
23	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14
24	0.64050E-16	0.94126E-16	0.15030E-15	0.25832E-15	0.50142E-15	0.12177E-14	0.41075E-14

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0167	0.0202	61.5779	5.942	38.4221	46.3205	3.865	53.6795
3.500E-07	1.414	0.049	0.1123	0.1109	59.6828	5.643	40.3172	54.1006	4.837	45.8994
4.500E-07	1.320	0.212	0.4931	0.4516	59.3004	5.584	40.6996	57.0617	5.251	42.9383
5.500E-07	1.261	0.597	1.3729	1.2265	59.7818	5.658	40.2182	58.6050	5.479	41.3950
7.000E-07	1.205	2.119	4.7520	4.2297	60.7853	5.815	39.2147	59.7872	5.659	40.2128
9.000E-07	1.159	2.985	6.3771	5.6849	62.6362	6.115	37.3638	61.6272	5.950	38.3728
1.100E-06	1.130	3.582	7.2861	6.5123	64.4255	6.420	35.5745	63.3683	6.238	36.6317
1.300E-06	1.110	3.283	6.3371	5.7199	66.2464	6.746	33.7536	64.9009	6.504	35.0991
1.600E-06	1.090	6.865	12.3416	11.2182	68.5606	7.188	31.4394	67.0765	6.901	32.9235
2.000E-06	1.072	7.164	11.7596	10.7662	71.2914	7.752	28.7086	69.7197	7.421	30.2803
2.600E-06	1.055	11.940	17.1893	16.0808	74.8217	8.567	25.1783	72.8635	8.102	27.1365
3.500E-06	1.041	10.447	12.7207	12.4193	78.7053	9.608	21.2947	76.0483	8.877	23.9517
5.000E-06	1.029	14.925	13.2607	13.7666	84.4609	11.565	15.5391	81.4150	10.453	18.5850
8.000E-06	1.018	14.925	5.1734	7.2808	93.9378	17.412	6.0622	90.1708	14.410	9.8292
1.500E-05	1.010	20.899	0.8075	4.5119	99.3242	31.040	0.6758	95.6500	19.473	4.3500

EFFICIENCY - STATED = 99.00 COMPUTED = 76.9624 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 82.5108
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.182E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.818E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.831

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 79.8513
CORRECTED MMD OF EFFLUENT = 2.546E+00
CORRECTED SIGMAP OF EFFLUENT = 1.956E+00
LOG-NORMAL GOODNESS OF FIT = 0.992
CORRECTED PRECIPITATION RATE PARAMETER = 9.95

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.556E+00	3.373E+01	2.692E-02	1.069E-02	3.762E-02	4.360E-02	2.500E-07
2.600E+00	3.420E+01	2.552E-01	3.533E-02	2.905E-01	1.022E-01	3.500E-07
2.724E+00	3.550E+01	1.445E+00	7.948E-02	1.524E+00	1.784E-01	4.500E-07
2.879E+00	3.709E+01	4.923E+00	1.441E-01	5.067E+00	2.642E-01	5.500E-07
3.143E+00	3.971E+01	1.080E+01	2.749E-01	1.108E+01	7.953E-01	7.000E-07
3.514E+00	4.321E+01	1.869E+01	5.046E-01	1.919E+01	1.132E+00	9.000E-07
3.896E+00	4.659E+01	2.613E+01	7.765E-01	2.691E+01	1.424E+00	1.100E-06
4.286E+00	4.984E+01	2.688E+01	1.071E+00	2.795E+01	1.661E+00	1.300E-06
4.876E+00	5.439E+01	3.211E+01	1.916E+00	3.362E+01	3.831E+00	1.600E-06
5.658E+00	5.979E+01	3.832E+01	2.098E+00	4.041E+01	4.234E+00	2.000E-06
6.843E+00	6.677E+01	3.624E+01	2.818E+00	3.906E+01	8.791E+00	2.600E-06
8.617E+00	7.502E+01	2.891E+01	3.607E+00	3.252E+01	1.044E+01	3.500E-06
1.156E+01	8.446E+01	2.138E+01	4.192E+00	2.558E+01	1.709E+01	5.000E-06
1.741E+01	9.394E+01	6.622E+00	4.115E+00	1.074E+01	2.114E+01	8.000E-06
3.104E+01	9.932E+01	7.617E-01	4.142E+00	4.903E+00	2.887E+01	1.500E-05

```
SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  79.8513 %     SCA =  1.610E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.011E+04 V
                           AVG. CURRENT DENSITY =   10.49 NA/CM**2
                           RESISTIVITY =  1.000E+09 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00
                        OUTLET MMD =  2.546E+00 UM     OUTLET SIGMAP =  1.956E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
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PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.500E-07	1.589	0.008	0.0152	0.0184	57.2627	5.281	42.7373	41.7072	3.352	58.2928
3.500E-07	1.414	0.049	0.1017	0.1018	55.3868	5.014	44.6132	49.6955	4.268	50.3045
4.500E-07	1.320	0.212	0.4466	0.4164	54.9903	4.959	45.0097	52.7080	4.651	47.2920
5.500E-07	1.261	0.597	1.2457	1.1351	55.4376	5.021	44.5624	54.2378	4.856	45.7622
7.000E-07	1.205	2.119	4.3284	3.9304	56.3817	5.154	43.6183	55.3642	5.011	44.6358
9.000E-07	1.159	2.985	5.8493	5.3179	58.1498	5.411	41.8502	57.1211	5.260	42.8789
1.100E-06	1.130	3.582	6.7315	6.1335	59.8652	5.671	40.1348	58.7874	5.506	41.2126
1.300E-06	1.110	3.283	5.9005	5.4229	61.6215	5.949	38.3785	60.2497	5.731	39.7503
1.600E-06	1.090	6.865	11.6190	10.7416	63.8560	6.321	36.1440	62.3428	6.067	37.6572
2.000E-06	1.072	7.164	11.2346	10.4458	66.5080	6.795	33.4920	64.9056	6.504	35.0944
2.600E-06	1.055	11.940	16.7918	15.8904	69.9648	7.471	30.0352	67.9684	7.072	32.0316
3.500E-06	1.041	10.447	12.8226	12.5539	73.7878	8.317	26.2122	71.0789	7.706	28.9211
5.000E-06	1.029	14.925	14.2193	14.5430	79.6530	9.890	20.3470	76.5476	9.008	23.4524
8.000E-06	1.018	14.925	6.7369	8.3595	90.3599	14.531	9.6401	86.5193	12.448	13.4807
1.500E-05	1.010	20.899	1.9570	4.9892	98.0001	24.301	1.9999	94.2541	17.745	5.7459

EFFICIENCY = STATED = 99.00 COMPUTED = 76.9624 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 78.6433
MMD OF INLET SIZE DISTRIBUTION = 3.987E+00
SIGMAP OF INLET SIZE DISTRIBUTION = 2.165E+00
LOG-NORMAL GOODNESS OF FIT = 0.985
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.386E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.881E+00
LOG-NORMAL GOODNESS OF FIT = 0.995
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 9.590

SIGMAG= 0.100 WITH 0.100 SNEAKAGE OVER 4.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 75.9318
CORRECTED MMD OF EFFLUENT = 2.641E+00
CORRECTED SIGMAP OF EFFLUENT = 1.967E+00
LOG-NORMAL GOODNESS OF FIT = 0.992
CORRECTED PRECIPITATION RATE PARAMETER = 8.85

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2,556E+00	3,373E+01	2,995E-02	1.090E-02	4,085E-02	4,360E-02	2,500E-07
2,600E+00	3,420E+01	2,823E-01	3.602E-02	3.184E-01	1,022E-01	3,500E-07
2,724E+00	3,550E+01	1,598E+00	8.103E-02	1.679E+00	1,784E-01	4,500E-07
2,879E+00	3.709E+01	5,455E+00	1.469E-01	5.602E+00	2,642E-01	5,500E-07
3,143E+00	3,971E+01	1,201E+01	2.802E-01	1.229E+01	7,953E-01	7,000E-07
3,514E+00	4,321E+01	2,093E+01	5.145E-01	2.144E+01	1,132E+00	9,000E-07
3,896E+00	4.659E+01	2,948E+01	7.917E-01	3.027E+01	1,424E+00	1,100E-06
4.286E+00	4,984E+01	3,056E+01	1.092E+00	3,165E+01	1,661E+00	1,300E-06
4,876E+00	5,439E+01	3,691E+01	1.545E+00	3.846E+01	3,831E+00	1,600E-06
5,658E+00	5.979E+01	4.470E+01	2.139E+00	4.684E+01	4,234E+00	2,000E-06
6,843E+00	6,677E+01	4,323E+01	2.873E+00	4.610E+01	8,791E+00	2,600E-06
8,617E+00	7,502E+01	3,559E+01	3.678E+00	3.927E+01	1,044E+01	3,500E-06
1,156E+01	8.446E+01	2.800E+01	4,274E+00	3.227E+01	1,709E+01	5,000E-06
1,741E+01	9,394E+01	1,053E+01	4.195E+00	1.473E+01	2,114E+01	8,000E-06
3.104E+01	9.932E+01	2.254E+00	4.223E+00	6.477E+00	2,887E+01	1,500E-05

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*****************************************************************************************************
*                                                                                                   *
*                                  SUMMARY TABLE OF ESP OPERATING                                   *
*                                    PARAMETERS AND PERFORMANCE                                     *
*                                                                                                   *
*                                                                                                   *
*                                                                                                   *
*                                        DATA SET NUMBER   2                                        *
*                                                                                                   *
*                                                                                                   *
*          ESP PERFORMANCE:     EFFICIENCY =  75.9318 %     SCA =  1.610E+01 M**2/(M**3/SEC)       *
*                                                                                                   *
*                                                                                                   *
*          ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.011E+04 V                           *
*                                                                                                   *
*                                     AVG. CURRENT DENSITY =   10.49 NA/CM**2                       *
*                                                                                                   *
*                                     RESISTIVITY =  1.000E+09 OHM-CM                               *
*                                                                                                   *
*                                                                                                   *
*          SIZE DISTRIBUTIONS:     INLET MMD =  3.987E+00 UM     INLET SIGMAP =  2.165E+00          *
*                                                                                                   *
*                                  OUTLET MMD =  2.641E+00 UM     OUTLET SIGMAP =  1.967E+00         *
*                                                                                                   *
*                                                                                                   *
*          NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.10  *
*                                                                                                   *
*                                   RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00     *
*                                                                                                   *
*                                                                                                   *
*****************************************************************************************************
STOP  011111
```

APPENDIX M

OUTPUT DATA FOR EXAMPLE 4 (REVISION 2)

```
*************************************
*                                   *
*          E.P.A. ESP MODEL         *
*                                   *
*    T.E.R.L.-R.T.P. AND SO.R.T.    *
*                                   *
*       REVISION II, AUG., 1979     *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 14 NDATA = 1

DATA ON CARD NUMBER 2

FULL-SCALE,COLD-SIDE ESP; PLANT A; SCA=243FT2/1000ACFM;J=15.0UA/FT2

DATA ON CARD NUMBER 3

NEST = 1 NDIST = 1 NVI = 3 NX = 10 NY = 10 NITER = 3 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 5 NUMINC = 3

DATA ON CARD NUMBER 5

DL = 1.96600 GRN/ACF PL = 27.0000 FT ETAO = 99.60000 % DD = 2270.00 KG/M**3 EPS = 1.000E+02
VRATIO = 1.2000 US = 0.000220 M**2/V-SEC FPATH = 1.0000 EBD = 1500000. V/M RHOCGS = 5.00E+10 OHM-CM

DATA ON CARD NUMBER 6

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 3.0
ASNUCK(2) = 0.10 AZIGGY(2) = 0.25 AZNUMS(2) = 3.0

DATA ON CARD NUMBER 7

```
ENDPT( 1) =    0.100 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.500 UM   ENDPT( 4) =    0.900 UM   ENDPT( 5) =    1.300 UM
ENDPT( 6) =    1.900 UM   ENDPT( 7) =    3.100 UM   ENDPT( 8) =    3.900 UM   ENDPT( 9) =    5.100 UM   ENDPT(10) =    6.900 UM

DATA ON CARD NUMBER   8

ENDPT(11) =   10.100 UM   ENDPT(12) =   14.900 UM   ENDPT(13) =   25.100 UM   ENDPT(14) =   29.900 UM

DATA ON CARD NUMBER   9

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0330 %   PRCU( 3) =   0.2860 %   PRCU( 4) =   1.1890 %   PRCU( 5) =   2.0040 %
PRCU( 6) =   3.5240 %   PRCU( 7) =   7.0480 %   PRCU( 8) =   8.7000 %   PRCU( 9) =  10.3520 %   PRCU(10) =  12.3340 %

DATA ON CARD NUMBER  10

PRCU(11) =  15.6380 %   PRCU(12) =  20.4840 %   PRCU(13) =  32.5990 %   PRCU(14) = 100.0000 %

DATA ON CARD NUMBER  11

NUMBEC =  3    LSECT( 1) = 10  LSECT( 2) = 10  LSECT( 3) = 10

DATA ON CARD NUMBER  12

AS( 1) =  2.6460E+04 FT**2  VOS( 1) =  4.0600E+04 V  TCS( 1) =  2.7300E-01 A  WLS( 1) =  1.5720E+04 FT
ACS( 1) =  8.2500E-02 IN  BS( 1) =  5.5000E+00 IN  NWS( 1) =  1.2000E+01

DATA ON CARD NUMBER  13

BYS( 1) =  3.6250E+00 IN  VGS( 1) =  3.2724E+05 FT**3/MIN  VGASS( 1) =  4.1000E+00 FT/SEC  TEMPS( 1) =  3.1500E+02 F
PS( 1) =  1.0000E+00 ATM  VTSS( 1) =  2.2900E-05 KG/M-SEC  LINCS( 1) =  9.0000E-01 FT

DATA ON CARD NUMBER  14

AS( 2) =  2.6460E+04 FT**2  VOS( 2) =  4.2100E+04 V  TCS( 2) =  4.3300E-01 A  WLS( 2) =  1.5720E+04 FT
ACS( 2) =  8.2500E-02 IN  BS( 2) =  5.5000E+00 IN  NWS( 2) =  1.2000E+01

DATA ON CARD NUMBER  15
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SYS( 2) =  3.6250E+00 IN  VGS( 2) =  3.2724E+05 FT**3/MIN  VGASS( 2) =  4.1000E+00 FT/SEC  TEMPS( 2) =  3.1500E+02 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  2.2900E-05 KG/M-SEC  LINCS( 2) =  9.0000E-01 FT

DATA ON CARD NUMBER  16

AS( 3) =  2.6460E+04 FT**2  VDS( 3) =  4.2850E+04 V  TCS( 3) =  5.5800E-01 A  WLS( 3) =  1.5720E+04 FT
ACS( 3) =  8.2500E-02 IN  BS( 3) =  5.5000E+00 IN  NWS( 3) =  1.2000E+01

DATA ON CARD NUMBER  17

SYS( 3) =  3.6250E+00 IN  VGS( 3) =  3.2724E+05 FT**3/MIN  VGASS( 3) =  4.1000E+00 FT/SEC  TEMPS( 3) =  3.1500E+02 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  2.2900E-05 KG/M-SEC  LINCS( 3) =  9.0000E-01 FT
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INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

FULL-SCALE,COLD-SIDE ESP; PLANT A; SCA=243FT2/1000ACFM;J=15.9UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 5.694E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.060E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.109E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 2.730E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 5.547E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

ROVRI	ERAVG	EPLT	APID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
3.1566	2.906E+05	2.0373E+05	2.1825E+12	11.1	2.29E-05	1.496E-03	5.646E-02	4.74E-07	1.10E-04	1
2.5220	2.906E+05	1.9259E+05	2.7316E+12	11.1	2.27E-05	1.185E-03	4.471E-02	6.12E-07	1.10E-04	2
2.0657	2.906E+05	1.8411E+05	3.3351E+12	11.1	2.22E-05	6.906E-04	2.606E-02	5.13E-07	1.10E-04	3
1.7689	2.906E+05	1.7833E+05	3.8945E+12	11.1	2.14E-05	3.727E-04	1.407E-02	4.05E-07	1.11E-04	4
1.5705	2.906E+05	1.7435E+05	4.3866E+12	11.1	1.98E-05	2.035E-04	7.681E-03	3.32E-07	1.11E-04	5
1.4311	2.906E+05	1.7149E+05	4.8138E+12	11.1	1.30E-05	1.182E-04	4.462E-03	2.87E-07	1.11E-04	6
1.3294	2.906E+05	1.6936E+05	5.1823E+12	11.1	8.05E-06	7.498E-05	2.830E-03	2.57E-07	1.11E-04	7
1.2532	2.906E+05	1.6774E+05	5.4972E+12	11.1	5.55E-06	5.212E-05	1.967E-03	2.37E-07	1.11E-04	8
1.1954	2.906E+05	1.6650E+05	5.7629E+12	11.1	4.15E-06	3.913E-05	1.477E-03	2.20E-07	1.11E-04	9
1.1512	2.906E+05	1.6555E+05	5.9843E+12	11.1	3.38E-06	3.110E-05	1.174E-03	2.06E-07	1.11E-04	10

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 9.031E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.210E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.760E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 4.330E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 8.798E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

ROVRI	ERAVG	EPLT	APID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0766	3.014E+05	1.8116E+05	9.7875E+12	17.6	2.83E-06	2.841E-05	1.072E-03	2.18E-07	1.76E-04	11
1.0590	3.014E+05	1.8061E+05	9.9504E+12	17.6	2.46E-06	2.387E-05	9.009E-04	2.07E-07	1.76E-04	12
1.0455	3.014E+05	1.8019E+05	1.0079E+13	17.6	2.33E-06	2.038E-05	7.693E-04	1.96E-07	1.76E-04	13
1.0350	3.014E+05	1.7986E+05	1.0181E+13	17.6	2.22E-06	1.760E-05	6.644E-04	1.85E-07	1.76E-04	14
1.0270	3.014E+05	1.7986E+05	1.0260E+13	17.6	2.13E-06	1.535E-05	5.795E-04	1.74E-07	1.76E-04	15
1.0209	3.014E+05	1.7986E+05	1.0322E+13	17.6	2.05E-06	1.347E-05	5.084E-04	1.63E-07	1.76E-04	16
1.0161	3.014E+05	1.7986E+05	1.0370E+13	17.6	1.98E-06	1.187E-05	4.481E-04	1.54E-07	1.76E-04	17
1.0124	3.014E+05	1.7986E+05	1.0408E+13	17.6	1.91E-06	1.051E-05	3.965E-04	1.44E-07	1.76E-04	18
1.0096	3.014E+05	1.7986E+05	1.0437E+13	17.6	1.85E-06	9.329E-06	3.521E-04	1.35E-07	1.76E-04	19
1.0074	3.014E+05	1.7986E+05	1.0460E+13	17.6	1.79E-06	8.308E-06	3.136E-04	1.27E-07	1.76E-04	20

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 1.164E-04 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.245E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 2.268E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 5.580E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 1.134E+05 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0045	3.039E+05	1.8870E+05	1.3407E+13	22.7	1.73E-06	7.779E-06	2.936E-04	1.25E-07	2.27E-04	21
1.0035	3.039E+05	1.8870E+05	1.3421E+13	22.7	1.67E-06	6.934E-06	2.617E-04	1.17E-07	2.27E-04	22
1.0027	3.039E+05	1.8870E+05	1.3432E+13	22.7	1.61E-06	6.193E-06	2.337E-04	1.10E-07	2.27E-04	23
1.0021	3.039E+05	1.8870E+05	1.3440E+13	22.7	1.56E-06	5.538E-06	2.090E-04	1.03E-07	2.27E-04	24
1.0016	3.039E+05	1.8870E+05	1.3446E+13	22.7	1.51E-06	4.962E-06	1.873E-04	9.64E-08	2.27E-04	25
1.0012	3.039E+05	1.8870E+05	1.3451E+13	22.7	1.46E-06	4.449E-06	1.679E-04	9.01E-08	2.27E-04	26
1.0010	3.039E+05	1.8870E+05	1.3455E+13	22.7	1.42E-06	3.992E-06	1.507E-04	8.42E-08	2.27E-04	27
1.0007	3.039E+05	1.8870E+05	1.3458E+13	22.7	1.38E-06	3.590E-06	1.355E-04	7.87E-08	2.27E-04	28
1.0006	3.039E+05	1.8870E+05	1.3460E+13	22.7	1.34E-06	3.231E-06	1.220E-04	7.34E-08	2.27E-04	29
1.0004	3.039E+05	1.8870E+05	1.3462E+13	22.7	1.30E-06	2.914E-06	1.100E-04	6.86E-08	2.27E-04	30

EST. EFFICIENCY = 99.60 UNCORRECTED COMPUTED EFFICIENCY = 99.32

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

FULL-SCALE,COLD-SIDE ESP: PLANT A; SCA=243FT2/1000ACFM;J=15.9UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 5.694E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.060E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.109E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 2.730E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 5.547E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.34

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
2.9685	2.906E+05	2.0050E+05	2.3207E+12	11.1	2.29E-05	1.517E-03	5.727E-02	4.98E-07	1.10E-04	1
2.4100	2.906E+05	1.9055E+05	2.8586E+12	11.1	2.27E-05	1.182E-03	4.460E-02	6.24E-07	1.10E-04	2
2.0041	2.906E+05	1.8293E+05	3.4375E+12	11.1	2.22E-05	6.838E-04	2.581E-02	5.17E-07	1.10E-04	3
1.7374	2.906E+05	1.7771E+05	3.9652E+12	11.1	2.14E-05	3.679E-04	1.389E-02	4.06E-07	1.11E-04	4
1.5569	2.906E+05	1.7407E+05	4.4250E+12	11.1	1.97E-05	2.008E-04	7.580E-03	3.33E-07	1.11E-04	5
1.4283	2.906E+05	1.7143E+05	4.8234E+12	11.1	1.28E-05	1.168E-04	4.407E-03	2.87E-07	1.11E-04	6
1.3329	2.906E+05	1.6944E+05	5.1684E+12	11.1	7.96E-06	7.421E-05	2.801E-03	2.58E-07	1.11E-04	7
1.2605	2.906E+05	1.6789E+05	5.4655E+12	11.1	5.49E-06	5.168E-05	1.950E-03	2.37E-07	1.11E-04	8
1.2046	2.906E+05	1.6670E+05	5.7192E+12	11.1	4.12E-06	3.886E-05	1.467E-03	2.20E-07	1.11E-04	9
1.1610	2.906E+05	1.6577E+05	5.9336E+12	11.1	3.36E-06	3.092E-05	1.167E-03	2.06E-07	1.11E-04	10

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M

APPLIED VOLTAGE = 4.210E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M

TOTAL CURRENT = 4.330E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M

CURRENT/M = 9.031E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

CURRENT DENSITY = 1.760E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

DEPOSIT E FIELD = 8.798E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.34

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0830	3.014E+05	1.8135E+05	9.7295E+12	17.6	2.82E-06	2.825E-05	1.066E-03	2.18E-07	1.76E-04	11
1.0651	3.014E+05	1.8080E+05	9.8937E+12	17.6	2.45E-06	2.375E-05	8.963E-04	2.07E-07	1.76E-04	12
1.0510	3.014E+05	1.8036E+05	1.0026E+13	17.6	2.32E-06	2.028E-05	7.655E-04	1.95E-07	1.76E-04	13
1.0400	3.014E+05	1.8002E+05	1.0132E+13	17.6	2.22E-06	1.752E-05	6.612E-04	1.84E-07	1.76E-04	14
1.0314	3.014E+05	1.8002E+05	1.0217E+13	17.6	2.13E-06	1.528E-05	5.768E-04	1.73E-07	1.76E-04	15
1.0247	3.014E+05	1.8002E+05	1.0284E+13	17.6	2.05E-06	1.341E-05	5.061E-04	1.63E-07	1.76E-04	16
1.0194	3.014E+05	1.8002E+05	1.0337E+13	17.6	1.97E-06	1.182E-05	4.461E-04	1.53E-07	1.76E-04	17
1.0152	3.014E+05	1.8002E+05	1.0379E+13	17.6	1.91E-06	1.046E-05	3.948E-04	1.44E-07	1.76E-04	18
1.0120	3.014E+05	1.8002E+05	1.0413E+13	17.6	1.85E-06	9.288E-06	3.505E-04	1.35E-07	1.76E-04	19
1.0094	3.014E+05	1.8002E+05	1.0439E+13	17.6	1.79E-06	8.273E-06	3.122E-04	1.26E-07	1.76E-04	20

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 1.164E-04 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.245E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 2.268E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 5.580E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 1.134E+05 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.34

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0058	3.039E+05	1.8875E+05	1.3390E+13	22.7	1.73E-06	7.742E-06	2.922E-04	1.25E-07	2.27E-04	21
1.0046	3.039E+05	1.8875E+05	1.3406E+13	22.7	1.67E-06	6.902E-06	2.605E-04	1.17E-07	2.27E-04	22
1.0036	3.039E+05	1.8875E+05	1.3419E+13	22.7	1.61E-06	6.165E-06	2.327E-04	1.10E-07	2.27E-04	23
1.0028	3.039E+05	1.8875E+05	1.3430E+13	22.7	1.56E-06	5.513E-06	2.081E-04	1.03E-07	2.27E-04	24
1.0022	3.039E+05	1.8875E+05	1.3438E+13	22.7	1.51E-06	4.940E-06	1.864E-04	9.61E-08	2.27E-04	25
1.0017	3.039E+05	1.8875E+05	1.3444E+13	22.7	1.46E-06	4.429E-06	1.672E-04	8.99E-08	2.27E-04	26
1.0014	3.039E+05	1.8875E+05	1.3449E+13	22.7	1.42E-06	3.975E-06	1.500E-04	8.39E-08	2.27E-04	27
1.0011	3.039E+05	1.8875E+05	1.3453E+13	22.7	1.37E-06	3.574E-06	1.349E-04	7.84E-08	2.27E-04	28
1.0008	3.039E+05	1.8875E+05	1.3456E+13	22.7	1.33E-06	3.218E-06	1.214E-04	7.32E-08	2.27E-04	29
1.0007	3.039E+05	1.8875E+05	1.3459E+13	22.7	1.30E-06	2.902E-06	1.095E-04	6.84E-08	2.27E-04	30

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2000E-06	0.4000E-06	0.7000E-06	0.1100E-05	0.1600E-05	0.2500E-05	0.3500E-05	0.4500E-05
1	0.5314	0.5228	0.4934	0.4720	0.4586	0.4470	0.4409	0.4374
2	0.7618	0.7543	0.7124	0.6797	0.6579	0.6388	0.6286	0.6231
3	0.9210	0.9215	0.8587	0.8079	0.7749	0.7468	0.7324	0.7251
4	1.0579	1.0642	0.9817	0.9027	0.8545	0.8156	0.7965	0.7873
5	1.1664	1.1669	1.0731	0.9832	0.9164	0.8641	0.8397	0.8282
6	1.2550	1.2460	1.1384	1.0406	0.9688	0.9017	0.8709	0.8570
7	1.3295	1.3100	1.1890	1.0828	1.0068	0.9335	0.8951	0.8784
8	1.3936	1.3634	1.2301	1.1161	1.0357	0.9611	0.9150	0.8950
9	1.4494	1.4091	1.2646	1.1434	1.0589	0.9819	0.9324	0.9085
10	1.4988	1.4488	1.2941	1.1665	1.0783	0.9986	0.9484	0.9199
11	1.5703	1.5080	1.3399	1.2039	1.1110	1.0285	0.9749	0.9431
12	1.6298	1.5562	1.3763	1.2329	1.1357	1.0498	0.9970	0.9599
13	1.6806	1.5968	1.4065	1.2566	1.1554	1.0664	1.0133	0.9736
14	1.7249	1.6317	1.4322	1.2765	1.1719	1.0799	1.0259	0.9858
15	1.7642	1.6624	1.4546	1.2937	1.1859	1.0912	1.0362	0.9969
16	1.7994	1.6896	1.4743	1.3088	1.1981	1.1009	1.0448	1.0059
17	1.8312	1.7141	1.4920	1.3222	1.2090	1.1094	1.0522	1.0134
18	1.8602	1.7364	1.5080	1.3342	1.2186	1.1170	1.0588	1.0199
19	1.8869	1.7567	1.5225	1.3452	1.2274	1.1238	1.0646	1.0254
20	1.9116	1.7755	1.5359	1.3552	1.2354	1.1299	1.0698	1.0304
21	1.9411	1.7981	1.5522	1.3676	1.2455	1.1379	1.0766	1.0369
22	1.9681	1.8187	1.5670	1.3789	1.2545	1.1450	1.0827	1.0426
23	1.9930	1.8376	1.5806	1.3891	1.2627	1.1513	1.0881	1.0476
24	2.0161	1.8551	1.5930	1.3985	1.2702	1.1571	1.0881	1.0476
25	2.0376	1.8714	1.6046	1.4071	1.2771	1.1625	1.0881	1.0476
26	2.0578	1.8865	1.6154	1.4152	1.2835	1.1625	1.0881	1.0476
27	2.0767	1.9008	1.6254	1.4227	1.2835	1.1625	1.0881	1.0476
28	2.0945	1.9141	1.6349	1.4298	1.2835	1.1625	1.0881	1.0476
29	2.1114	1.9268	1.6438	1.4298	1.2835	1.1625	1.0881	1.0476
30	2.1274	1.9387	1.6522	1.4298	1.2835	1.1625	1.0881	1.0476

	0.6000E-05	0.8500E-05	0.1250E-04	0.2000E-04	0.2750E-04
1	0.4345	0.4323	0.4310	0.4305	0.4304
2	0.6189	0.6163	0.6152	0.6149	0.6149
3	0.7200	0.7172	0.7164	0.7162	0.7162
4	0.7812	0.7783	0.7776	0.7775	0.7774
5	0.8211	0.8179	0.8172	0.8171	0.8171
6	0.8486	0.8450	0.8443	0.8442	0.8442
7	0.8685	0.8644	0.8636	0.8635	0.8635
8	0.8834	0.8788	0.8779	0.8779	0.8779
9	0.8951	0.8898	0.8888	0.8888	0.8888
10	0.9044	0.8984	0.8974	0.8973	0.8973
11	0.9271	0.9211	0.9202	0.9201	0.9201
12	0.9418	0.9353	0.9343	0.9342	0.9342
13	0.9523	0.9450	0.9439	0.9438	0.9438
14	0.9604	0.9521	0.9508	0.9507	0.9507
15	0.9670	0.9575	0.9560	0.9559	0.9559

16	0.9727	0.9617	0.9601	0.9600	0.9600
17	0.9777	0.9617	0.9601	0.9600	0.9600
18	0.9823	0.9617	0.9601	0.9600	0.9600
19	0.9823	0.9617	0.9601	0.9600	0.9600
20	0.9823	0.9617	0.9601	0.9600	0.9600
21	0.9883	0.9681	0.9663	0.9662	0.9662
22	0.9883	0.9681	0.9663	0.9662	0.9662
23	0.9883	0.9681	0.9663	0.9662	0.9662
24	0.9883	0.9681	0.9663	0.9662	0.9662
25	0.9883	0.9681	0.9663	0.9662	0.9662
26	0.9883	0.9681	0.9663	0.9662	0.9662
27	0.9883	0.9681	0.9663	0.9662	0.9662
28	0.9883	0.9681	0.9663	0.9662	0.9662
29	0.9883	0.9681	0.9663	0.9662	0.9662
30	0.9883	0.9681	0.9663	0.9662	0.9662

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2000E-06	0.4000E-06	0.7000E-06	0.1100E-05	0.1600E-05	0.2500E-05	0.3500E-05	0.4500E-05
1	0.94670E-18	0.28569E-17	0.75930E-17	0.17430E-16	0.35425E-16	0.83762E-16	0.16153E-15	0.26467E-15
2	0.13570E-17	0.41220E-17	0.10963E-16	0.25100E-16	0.50824E-16	0.11970E-15	0.23032E-15	0.37703E-15
3	0.16408E-17	0.50362E-17	0.13214E-16	0.29835E-16	0.59861E-16	0.13994E-15	0.26836E-15	0.43872E-15
4	0.18846E-17	0.58155E-17	0.15108E-16	0.33337E-16	0.66010E-16	0.15283E-15	0.29185E-15	0.47634E-15
5	0.20778E-17	0.63772E-17	0.16513E-16	0.36308E-16	0.70794E-16	0.16192E-15	0.30765E-15	0.50113E-15
6	0.22357E-17	0.68094E-17	0.17518E-16	0.38428E-16	0.74840E-16	0.16897E-15	0.31910E-15	0.51853E-15
7	0.23685E-17	0.71589E-17	0.18297E-16	0.39988E-16	0.77779E-16	0.17492E-15	0.32796E-15	0.53145E-15
8	0.24826E-17	0.74508E-17	0.18929E-16	0.41216E-16	0.80013E-16	0.18010E-15	0.33527E-15	0.54150E-15
9	0.25821E-17	0.77005E-17	0.19460E-16	0.42225E-16	0.81806E-16	0.18399E-15	0.34164E-15	0.54968E-15
10	0.26700E-17	0.79178E-17	0.19915E-16	0.43078E-16	0.83297E-16	0.18712E-15	0.34749E-15	0.55660E-15
11	0.27974E-17	0.82412E-17	0.20619E-16	0.44459E-16	0.85825E-16	0.19272E-15	0.35719E-15	0.57062E-15
12	0.29033E-17	0.85046E-17	0.21179E-16	0.45531E-16	0.87732E-16	0.19672E-15	0.36531E-15	0.58078E-15
13	0.29939E-17	0.87262E-17	0.21644E-16	0.46404E-16	0.89260E-16	0.19983E-15	0.37126E-15	0.58904E-15
14	0.30729E-17	0.89172E-17	0.22040E-16	0.47140E-16	0.90530E-16	0.20235E-15	0.37588E-15	0.59643E-15
15	0.31428E-17	0.90846E-17	0.22384E-16	0.47775E-16	0.91614E-16	0.20447E-15	0.37965E-15	0.60317E-15
16	0.32055E-17	0.92336E-17	0.22688E-16	0.48331E-16	0.92559E-16	0.20629E-15	0.38281E-15	0.60864E-15
17	0.32622E-17	0.93676E-17	0.22960E-16	0.48827E-16	0.93395E-16	0.20789E-15	0.38554E-15	0.61318E-15
18	0.33139E-17	0.94892E-17	0.23206E-16	0.49272E-16	0.94143E-16	0.20931E-15	0.38793E-15	0.61706E-15
19	0.33614E-17	0.96004E-17	0.23430E-16	0.49677E-16	0.94820E-16	0.21058E-15	0.39006E-15	0.62044E-15
20	0.34054E-17	0.97029E-17	0.23635E-16	0.50047E-16	0.95438E-16	0.21173E-15	0.39197E-15	0.62342E-15
21	0.34580E-17	0.98265E-17	0.23886E-16	0.50506E-16	0.96214E-16	0.21322E-15	0.39448E-15	0.62739E-15
22	0.35061E-17	0.99391E-17	0.24114E-16	0.50920E-16	0.96912E-16	0.21455E-15	0.39669E-15	0.63083E-15
23	0.35505E-17	0.10043E-16	0.24323E-16	0.51297E-16	0.97545E-16	0.21574E-15	0.39867E-15	0.63385E-15
24	0.35916E-17	0.10138E-16	0.24515E-16	0.51644E-16	0.98124E-16	0.21683E-15	0.39867E-15	0.63385E-15
25	0.36299E-17	0.10227E-16	0.24692E-16	0.51964E-16	0.98658E-16	0.21783E-15	0.39867E-15	0.63385E-15
26	0.36658E-17	0.10310E-16	0.24858E-16	0.52262E-16	0.99152E-16	0.21783E-15	0.39867E-15	0.63385E-15
27	0.36995E-17	0.10387E-16	0.25013E-16	0.52539E-16	0.99152E-16	0.21783E-15	0.39867E-15	0.63385E-15
28	0.37313E-17	0.10461E-16	0.25159E-16	0.52800E-16	0.99152E-16	0.21783E-15	0.39867E-15	0.63385E-15
29	0.37614E-17	0.10530E-16	0.25296E-16	0.52800E-16	0.99152E-16	0.21783E-15	0.39867E-15	0.63385E-15
30	0.37900E-17	0.10595E-16	0.25426E-16	0.52800E-16	0.99152E-16	0.21783E-15	0.39867E-15	0.63385E-15

	0.6000E-05	0.8500E-05	0.1250E-04	0.2000E-04	0.2750E-04
1	0.46706E-15	0.93203E-15	0.20091E-14	0.51358E-14	0.97067E-14
2	0.66524E-15	0.13287E-14	0.28676E-14	0.73361E-14	0.13868E-13
3	0.77385E-15	0.15463E-14	0.33392E-14	0.85445E-14	0.16153E-13
4	0.83967E-15	0.16780E-14	0.36243E-14	0.92750E-14	0.17534E-13
5	0.88251E-15	0.17633E-14	0.38089E-14	0.97479E-14	0.18428E-13
6	0.91206E-15	0.18217E-14	0.39351E-14	0.10071E-13	0.19039E-13
7	0.93344E-15	0.18635E-14	0.40253E-14	0.10302E-13	0.19476E-13
8	0.94953E-15	0.18946E-14	0.40921E-14	0.10473E-13	0.19799E-13
9	0.96205E-15	0.19183E-14	0.41430E-14	0.10603E-13	0.20045E-13
10	0.97209E-15	0.19369E-14	0.41827E-14	0.10705E-13	0.20237E-13
11	0.99642E-15	0.19860E-14	0.42890E-14	0.10977E-13	0.20752E-13
12	0.10122E-14	0.20165E-14	0.43548E-14	0.11145E-13	0.21070E-13
13	0.10236E-14	0.20374E-14	0.43995E-14	0.11260E-13	0.21286E-13
14	0.10323E-14	0.20527E-14	0.44317E-14	0.11342E-13	0.21442E-13
15	0.10394E-14	0.20643E-14	0.44560E-14	0.11404E-13	0.21559E-13
16	0.10454E-14	0.20735E-14	0.44749E-14	0.11453E-13	0.21651E-13
17	0.10508E-14	0.20735E-14	0.44749E-14	0.11453E-13	0.21651E-13
18	0.10558E-14	0.20735E-14	0.44749E-14	0.11453E-13	0.21651E-13
19	0.10558E-14	0.20735E-14	0.44749E-14	0.11453E-13	0.21651E-13

20	0.10558E-14	0.20735E-14	0.44749E-14	0.11453E-13	0.21651E-13
21	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
22	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
23	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
24	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
25	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
26	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
27	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
28	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
29	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13
30	0.10623E-14	0.20871E-14	0.45040E-14	0.11527E-13	0.21791E-13

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.000E-07	2.123	0.033	0.7203	0.4526	95.2710	6.398	4.7290	95.0353	6.296	4.9647
4.000E-07	1.530	0.253	7.4214	4.5547	93.6452	5.778	6.3548	93.4839	5.726	6.5161
7.000E-07	1.297	0.903	23.1836	14.5134	94.4380	6.058	5.5620	94.1826	5.964	5.8174
1.100E-06	1.188	0.815	15.2173	10.2466	95.9550	6.726	4.0450	95.4494	6.479	4.5506
1.600E-06	1.130	1.520	19.2314	13.8084	97.2590	7.541	2.7410	96.7119	7.160	3.2881
2.500E-06	1.083	3.524	23.2589	19.1755	98.5701	8.906	1.4299	98.0305	8.234	1.9695
3.500E-06	1.059	1.652	6.0486	6.9775	99.2068	10.141	0.7932	98.4713	8.766	1.5287
4.500E-06	1.046	1.652	3.7049	6.6554	99.5141	11.169	0.4859	98.5418	8.865	1.4582
6.000E-06	1.035	1.982	1.0448	5.8876	99.8858	14.205	0.1142	98.9248	9.504	1.0752
8.500E-06	1.024	3.304	0.1301	6.2833	99.9915	19.645	0.0085	99.3117	10.439	0.6883
1.250E-05	1.017	4.846	0.0022	5.0000	99.9999	32.033	0.0001	99.6265	11.721	0.3735
2.000E-05	1.010	12.115	0.0055	4.0677	99.9999	50.924	0.0001	99.8785	14.075	0.1215
2.750E-05	1.008	67.401	0.0309	2.3772	99.9999	69.820	0.0001	99.9872	18.799	0.0128

EFFICIENCY - STATED = 99.32 COMPUTED = 99.3273 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 99.7834
MMD OF INLET SIZE DISTRIBUTION = 4.465E+01
SIGMAP OF INLET SIZE DISTRIBUTION = 5.122E+00
LOG-NORMAL GOODNESS OF FIT = 0.984
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.334E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.891E+00
LOG-NORMAL GOODNESS OF FIT = 0.997
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 12.862

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 3.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 99.6381
CORRECTED MMD OF EFFLUENT = 2.667E+00
CORRECTED SIGMAP OF EFFLUENT = 2.796E+00
LOG-NORMAL GOODNESS OF FIT = 0.988
CORRECTED PRECIPITATION RATE PARAMETER = 11.79

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.633E+00	7,151E+01	2,324E-01	1.158E-02	2.440E-01	5,350E-02	2,000E-07
2,739E+00	7,291E+01	5,149E+00	1.306E-01	5,280E+00	2,806E-01	4,000E-07
3,274E+00	7.902E+01	1,398E+01	6.418E-01	1.462E+01	1,586E+00	7,000E-07
4,081E+00	8,572E+01	1,467E+01	1,833E+00	1.650E+01	2,834E+00	1,100E-06
5,116E+00	9,129E+01	1,796E+01	3,585E+00	2.155E+01	5,720E+00	1,600E-06
7,013E+00	9,647E+01	1,684E+01	6,355E+00	2.319E+01	1,308E+01	2,500E-06
9,095E+00	9,869E+01	9,338E+00	8.659E+00	1,800E+01	8,358E+00	3,500E-06
1,117E+01	9,951E+01	4,895E+00	9.796E+00	1.469E+01	1,105E+01	4,500E-06
1.420E+01	9,989E+01	1,225E+00	1.031E+01	1.153E+01	1,310E+01	6,000E-06
1,965E+01	9,999E+01	1,210E-01	9,644E+00	9.765E+00	1,545E+01	8,500E-06
3,203E+01	1,000E+02	2,022E-03	7,614E+00	7.616E+00	1,245E+01	1,250E-05
5.092E+01	1,000E+02	3,769E-03	4.619E+00	4,622E+00	1,013E+01	2,000E-05
6.982E+01	1.000E+02	6.250E-02	8.044E+00	8.107E+00	5,918E+00	2,750E-05

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SUMMARY TABLE OF ESP OPERATING
  PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  99.6381 %     SCA =  4.769E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.172E+04 V
                           AVG. CURRENT DENSITY =   17.12 NA/CM**2
                           RESISTIVITY =  5.000E+10 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  4.465E+01 UM     INLET SIGMAP =  5.122E+00
                        OUTLET MMD =  2.667E+00 UM     OUTLET SIGMAP =  2.796E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
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PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.000E-07	2.123	0.033	0.4412	0.3266	91.8499	5.257	8.1501	91.4343	5.152	8.5657
4.000E-07	1.530	0.253	4.3398	3.1396	89.5441	4.734	10.4559	89.2598	4.678	10.7402
7.000E-07	1.297	0.903	14.3436	10.5717	90.3176	4.895	9.6824	89.8674	4.800	10.1326
1.100E-06	1.188	0.815	10.5249	8.2518	92.1282	5.330	7.8718	91.2369	5.105	8.7631
1.600E-06	1.130	1.520	15.4375	12.5663	93.8092	5.833	6.1908	92.8447	5.530	7.1553
2.500E-06	1.083	3.524	24.9331	21.4337	95.6873	6.591	4.3127	94.7359	6.173	5.2641
3.500E-06	1.059	1.652	9.0291	8.8341	96.6685	7.132	3.3315	95.3717	6.443	4.6283
4.500E-06	1.046	1.652	7.8160	8.7766	97.1160	7.435	2.8840	95.4019	6.457	4.5981
6.000E-06	1.035	1.982	5.2527	7.5790	98.3846	8.650	1.6154	96.6904	7.146	3.3096
8.500E-06	1.024	3.304	4.6493	7.8495	99.1422	9.977	0.8578	97.9438	8.144	2.0562
1.250E-05	1.017	4.846	2.8772	5.7125	99.6381	11.787	0.3619	98.9798	9.614	1.0202
2.000E-05	1.010	12.115	0.2936	3.2058	99.9852	18.493	0.0148	99.7710	12.746	0.2290
2.750E-05	1.008	67.401	0.0620	1.7527	099.9994	69.820	0.0006	99.9775	17.610	0.0225

EFFICIENCY = STATED = 99.32 COMPUTED = 99.3273 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 99.3904
MMD OF INLET SIZE DISTRIBUTION = 4.465E+01
SIGMAP OF INLET SIZE DISTRIBUTION = 5.122E+00
LOG-NORMAL GOODNESS OF FIT = 0.984
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.086E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.253E+00
LOG-NORMAL GOODNESS OF FIT = 0.997
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.694

SIGMAG= 0.250 WITH 0.100 SNEAKAGE OVER 3.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 99.1345
CORRECTED MMD OF EFFLUENT = 2.927E+00
CORRECTED SIGMAP OF EFFLUENT = 2.596E+00
LOG-NORMAL GOODNESS OF FIT = 0.996
CORRECTED PRECIPITATION RATE PARAMETER = 9.96

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.633E+00	7.151E+01	4.005E-01	2.042E-02	4.209E-01	5.350E-02	2.000E-07
2.739E+00	7.291E+01	8.472E+00	2.303E-01	8.702E+00	2.806E-01	4.000E-07
3.274E+00	7.902E+01	2.433E+01	1.132E+00	2.547E+01	1.586E+00	7.000E-07
4.081E+00	8.572E+01	2.854E+01	3.232E+00	3.177E+01	2.834E+00	1.100E-06
5.116E+00	9.129E+01	4.057E+01	6.320E+00	4.689E+01	5.720E+00	1.600E-06
7.013E+00	9.647E+01	5.079E+01	1.120E+01	6.199E+01	1.308E+01	2.500E-06
9.095E+00	9.869E+01	3.922E+01	1.527E+01	5.448E+01	8.358E+00	3.500E-06
1.117E+01	9.951E+01	2.905E+01	1.727E+01	4.632E+01	1.105E+01	4.500E-06
1.420E+01	9.989E+01	1.733E+01	1.817E+01	3.550E+01	1.310E+01	6.000E-06
1.965E+01	9.999E+01	1.217E+01	1.700E+01	2.917E+01	1.545E+01	8.500E-06
3.203E+01	1.000E+02	7.379E+00	1.342E+01	2.080E+01	1.245E+01	1.250E-05
5.092E+01	1.000E+02	5.615E-01	8.142E+00	8.704E+00	1.013E+01	2.000E-05
6.982E+01	1.000E+02	3.533E-01	1.418E+01	1.454E+01	5.918E+00	2.750E-05

```
SUMMARY TABLE OF ESP OPERATING
 PARAMETERS AND PERFORMANCE

DATA SET NUMBER   2

ESP PERFORMANCE:     EFFICIENCY =  99.1345 %     SCA =  4.769E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.172E+04 V
                           AVG. CURRENT DENSITY =   17.12 NA/CM**2
                           RESISTIVITY =  5.000E+10 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  4.465E+01 UM     INLET SIGMAP =  5.122E+00
                        OUTLET MMD =  2.927E+00 UM     OUTLET SIGMAP =  2.596E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.25
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

STOP 011111

APPENDIX N

OUTPUT DATA FOR EXAMPLE 4 (REVISION 1)

```
*************************************
*                                   *
*          E.P.A. ESP MODEL         *
*                                   *
*     T.E.R.L.-R.T.P. AND SO.R.I.   *
*                                   *
*       REVISION I,JAN. 1, 1978     *
*                                   *
*************************************
```

PRINTOUT OF INPUT DATA FOR DATA SET NUMBER 1

DATA ON CARD NUMBER 1

NENDPT = 14 NDATA = 1

DATA ON CARD NUMBER 2

FULL-SCALE,COLD-SIDE ESP: PLANT A: SCA=243FT2/1000ACFM;J=15.9UA/FT2

DATA ON CARD NUMBER 3

NEST = 1 NDIST = 1 NVI = 1 NX = 10 NY = 10 NITER = 3 NCALC = 0 NRAPD = 1 NEFF = 1 NTEMP = 1 NONID = 2

DATA ON CARD NUMBER 4

NN = 10 NUMINC = 20

DATA ON CARD NUMBER 5

DL = 1.96600 GRN/ACF PL = 27.0000 FT ETAO = 99.60000 % DD = 2270.00 KG/M**3 EPS = 1.000E+02
VRATIO = 1.2000 US = 0.000220 M**2/V-SEC FPATH = 1.0000 ERD = 1500000. V/M RHOCGS = 5.00E+10 OHM-CM

DATA ON CARD NUMBER 6

ASNUCK(1) = 0.00 AZIGGY(1) = 0.00 AZNUMS(1) = 3.0
ASNUCK(2) = 0.10 AZIGGY(2) = 0.25 AZNUMS(2) = 3.0

DATA ON CARD NUMBER 7

```
ENDPT( 1) =    0.100 UM   ENDPT( 2) =    0.300 UM   ENDPT( 3) =    0.500 UM   ENDPT( 4) =    0.900 UM   ENDPT( 5) =    1.300 UM
ENDPT( 6) =    1.900 UM   ENDPT( 7) =    3.100 UM   ENDPT( 8) =    3.900 UM   ENDPT( 9) =    5.100 UM   ENDPT(10) =    6.900 UM

DATA ON CARD NUMBER   8

ENDPT(11) =   10.100 UM   ENDPT(12) =   14.900 UM   ENDPT(13) =   25.100 UM   ENDPT(14) =   29.900 UM

DATA ON CARD NUMBER   9

PRCU( 1) =   0.0000 %   PRCU( 2) =   0.0330 %   PRCU( 3) =   0.2860 %   PRCU( 4) =   1.1890 %   PRCU( 5) =   2.0040 %
PRCU( 6) =   3.5240 %   PRCU( 7) =   7.0480 %   PRCU( 8) =   8.7000 %   PRCU( 9) =  10.3520 %   PRCU(10) =  12.3340 %

DATA ON CARD NUMBER  10

PRCU(11) =  15.6380 %   PRCU(12) =  20.4840 %   PRCU(13) =  32.5990 %   PRCU(14) = 100.0000 %

DATA ON CARD NUMBER  11

NUMSEC =  3    LSECT( 1) = 10  LSECT( 2) = 10  LSECT( 3) = 10

DATA ON CARD NUMBER  12

AS( 1) =  2.6460E+04 FT**2  VOS( 1) =  4.0600E+04 V  TCS( 1) =  2.7300E-01 A  WLS( 1) =  1.5720E+04 FT
ACS( 1) =  8.2500E-02 IN  BS( 1) =  5.5000E+00 IN  NWS( 1) =  1.2000E+01

DATA ON CARD NUMBER  13

SYS( 1) =  3.6250E+00 IN  VGS( 1) =  3.2724E+05 FT**3/MIN  VGASS( 1) =  4.1000E+00 FT/SEC  TEMPS( 1) =  3.1500E+02 F
PS( 1) =  1.0000E+00 ATM  VISS( 1) =  2.2900E-05 KG/M-SEC  LINCS( 1) =  9.0000E-01 FT

DATA ON CARD NUMBER  14

AS( 2) =  2.6460E+04 FT**2  VOS( 2) =  4.2100E+04 V  TCS( 2) =  4.3300E-01 A  WLS( 2) =  1.5720E+04 FT
ACS( 2) =  8.2500E-02 IN  BS( 2) =  5.5000E+00 IN  NWS( 2) =  1.2000E+01

DATA ON CARD NUMBER  15
```

```
SYS( 2) =  3.6250E+00 IN  VGS( 2) =  3.2724E+05 FT**3/MIN  VGASS( 2) =  4.1000E+00 FT/SEC  TEMPS( 2) =  3.1500E+02 F
PS( 2) =  1.0000E+00 ATM  VISS( 2) =  2.2900E-05 KG/M-SEC  LINCS( 2) =  9.0000E-01 FT

DATA ON CARD NUMBER  16

AS( 3) =  2.6460E+04 FT**2  VOS( 3) =  4.2450E+04 V  TCS( 3) =  5.5800E-01 A  WLS( 3) =  1.5720E+04 FT
ACS( 3) =  8.2500E-02 IN  BS( 3) =  5.5000E+00 IN  NWS( 3) =  1.2000E+01

DATA ON CARD NUMBER  17

SYS( 3) =  3.6250E+00 IN  VGS( 3) =  3.2724E+05 FT**3/MIN  VGASS( 3) =  4.1000E+00 FT/SEC  TEMPS( 3) =  3.1500E+02 F
PS( 3) =  1.0000E+00 ATM  VISS( 3) =  2.2900E-05 KG/M-SEC  LINCS( 3) =  9.0000E-01 FT
```

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

FULL-SCALE,COLD-SIDE ESP: PLANT A; SCA=243FT2/1000ACFM;J=15.9UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 5.694E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.060E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.109E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 2.730E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 5.547E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

RDVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
3.1566	2.906E+05	2.0924E+05	2.1825E+12	11.1	2.29E-05	1.523E-03	5.750E-02	4.82E-07	1.10E-04	1
2.5167	2.906E+05	1.9692E+05	2.7374E+12	11.1	2.27E-05	1.195E-03	4.511E-02	6.23E-07	1.10E-04	2
2.0587	2.906E+05	1.8844E+05	3.3464E+12	11.1	2.22E-05	6.878E-04	2.596E-02	5.22E-07	1.10E-04	3
1.7622	2.906E+05	1.8269E+05	3.9093E+12	11.1	2.13E-05	3.653E-04	1.379E-02	4.11E-07	1.11E-04	4
1.5647	2.906E+05	1.7873E+05	4.4030E+12	11.1	1.91E-05	1.968E-04	7.426E-03	3.38E-07	1.11E-04	5
1.4261	2.906E+05	1.7588E+05	4.8308E+12	11.1	1.20E-05	1.134E-04	4.282E-03	2.93E-07	1.11E-04	6
1.3250	2.906E+05	1.7378E+05	5.1994E+12	11.1	7.46E-06	7.195E-05	2.715E-03	2.64E-07	1.11E-04	7
1.2494	2.906E+05	1.7218E+05	5.5139E+12	11.1	5.13E-06	5.023E-05	1.896E-03	2.42E-07	1.11E-04	8
1.1921	2.906E+05	1.7096E+05	5.7788E+12	11.1	3.90E-06	3.792E-05	1.431E-03	2.25E-07	1.11E-04	9
1.1484	2.906E+05	1.7002E+05	5.9990E+12	11.1	3.19E-06	3.025E-05	1.142E-03	2.10E-07	1.11E-04	10

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 9.031E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.210E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.760E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 4.330E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 8.798E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

RDVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0750	3.014E+05	1.8591E+05	9.8018E+12	17.6	2.68E-06	2.766E-05	1.044E-03	2.22E-07	1.76E-04	11
1.0577	3.014E+05	1.8536E+05	9.9629E+12	17.6	2.41E-06	2.324E-05	8.770E-04	2.10E-07	1.76E-04	12
1.0443	3.014E+05	1.8495E+05	1.0090E+13	17.6	2.28E-06	1.981E-05	7.476E-04	1.98E-07	1.76E-04	13
1.0341	3.014E+05	1.8463E+05	1.0190E+13	17.6	2.17E-06	1.707E-05	6.441E-04	1.86E-07	1.76E-04	14
1.0263	3.014E+05	1.8463E+05	1.0268E+13	17.6	2.08E-06	1.485E-05	5.604E-04	1.74E-07	1.76E-04	15
1.0202	3.014E+05	1.8463E+05	1.0328E+13	17.6	2.00E-06	1.300E-05	4.905E-04	1.64E-07	1.76E-04	16
1.0156	3.014E+05	1.8463E+05	1.0375E+13	17.6	1.93E-06	1.144E-05	4.317E-04	1.53E-07	1.76E-04	17
1.0120	3.014E+05	1.8463E+05	1.0412E+13	17.6	1.87E-06	1.011E-05	3.814E-04	1.44E-07	1.76E-04	18
1.0093	3.014E+05	1.8463E+05	1.0440E+13	17.6	1.80E-06	8.962E-06	3.382E-04	1.35E-07	1.76E-04	19
1.0072	3.014E+05	1.8463E+05	1.0462E+13	17.6	1.74E-06	7.970E-06	3.008E-04	1.26E-07	1.76E-04	20

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 1.164E-04 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.245E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 2.268E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 5.580E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 1.134E+05 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 16.81

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0043	3.039E+05	1.9360E+05	1.3409E+13	22.7	1.69E-06	7.453E-06	2.813E-04	1.24E-07	2.27E-04	21
1.0033	3.039E+05	1.9360E+05	1.3423E+13	22.7	1.63E-06	6.633E-06	2.503E-04	1.16E-07	2.27E-04	22
1.0026	3.039E+05	1.9360E+05	1.3433E+13	22.7	1.57E-06	5.916E-06	2.233E-04	1.09E-07	2.27E-04	23
1.0020	3.039E+05	1.9360E+05	1.3441E+13	22.7	1.52E-06	5.287E-06	1.995E-04	1.02E-07	2.27E-04	24
1.0015	3.039E+05	1.9360E+05	1.3447E+13	22.7	1.47E-06	4.727E-06	1.784E-04	9.49E-08	2.27E-04	25
1.0012	3.039E+05	1.9360E+05	1.3452E+13	22.7	1.43E-06	4.235E-06	1.598E-04	8.86E-08	2.27E-04	26
1.0009	3.039E+05	1.9360E+05	1.3455E+13	22.7	1.38E-06	3.798E-06	1.433E-04	8.27E-08	2.27E-04	27
1.0007	3.039E+05	1.9360E+05	1.3458E+13	22.7	1.34E-06	3.412E-06	1.288E-04	7.72E-08	2.27E-04	28
1.0005	3.039E+05	1.9360E+05	1.3460E+13	22.7	1.30E-06	3.068E-06	1.158E-04	7.19E-08	2.27E-04	29
1.0004	3.039E+05	1.9360E+05	1.3462E+13	22.7	1.26E-06	2.763E-06	1.043E-04	6.71E-08	2.27E-04	30

EST. EFFICIENCY = 99.60 UNCORRECTED COMPUTED EFFICIENCY = 99.37

INCREMENTAL ANALYSIS OF PRECIPITATOR PERFORMANCE

FULL-SCALE,COLD-SIDE ESP; PLANT A; SCA=243FT2/1000ACFM;J=15.9UA/FT2

CALCULATION IS IN SECTION NO. = 1 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 5.694E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.060E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 1.109E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 2.730E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 5.547E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.55

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
2.9945	2.906E+05	2.0637E+05	2.3006E+12	11.1	2.29E-05	1.542E-03	5.821E-02	5.03E-07	1.10E-04	1
2.4206	2.906E+05	1.9518E+05	2.8460E+12	11.1	2.26E-05	1.193E-03	4.502E-02	6.34E-07	1.10E-04	2
2.0061	2.906E+05	1.8744E+05	3.4340E+12	11.1	2.22E-05	6.816E-04	2.572E-02	5.25E-07	1.10E-04	3
1.7356	2.906E+05	1.8216E+05	3.9694E+12	11.1	2.13E-05	3.610E-04	1.362E-02	4.13E-07	1.11E-04	4
1.5533	2.906E+05	1.7849E+05	4.4353E+12	11.1	1.89E-05	1.944E-04	7.335E-03	3.39E-07	1.11E-04	5
1.4239	2.906E+05	1.7584E+05	4.8384E+12	11.1	1.18E-05	1.122E-04	4.234E-03	2.93E-07	1.11E-04	6
1.3282	2.906E+05	1.7344E+05	5.1869E+12	11.1	7.38E-06	7.128E-05	2.690E-03	2.64E-07	1.11E-04	7
1.2557	2.906E+05	1.7232E+05	5.4863E+12	11.1	5.08E-06	4.985E-05	1.881E-03	2.42E-07	1.11E-04	8
1.2000	2.906E+05	1.7113E+05	5.7412E+12	11.1	3.88E-06	3.768E-05	1.422E-03	2.25E-07	1.11E-04	9
1.1568	2.906E+05	1.7021E+05	5.9556E+12	11.1	3.18E-06	3.009E-05	1.136E-03	2.10E-07	1.11E-04	10

CALCULATION IS IN SECTION NO. = 2 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M

APPLIED VOLTAGE = 4.210E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M

TOTAL CURRENT = 4.330E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M

CURRENT/M = 9.031E-05 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

CURRENT DENSITY = 1.760E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

DEPOSIT E FIELD = 8.798E+04 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.55

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0805	3.014E+05	1.8607E+05	9.7525E+12	17.6	2.67E-06	2.752E-05	1.039E-03	2.21E-07	1.76E-04	11
1.0628	3.014E+05	1.8553E+05	9.9149E+12	17.6	2.40E-06	2.313E-05	8.729E-04	2.10E-07	1.76E-04	12
1.0490	3.014E+05	1.8510E+05	1.0045E+13	17.6	2.27E-06	1.972E-05	7.442E-04	1.97E-07	1.76E-04	13
1.0383	3.014E+05	1.8476E+05	1.0149E+13	17.6	2.17E-06	1.699E-05	6.413E-04	1.85E-07	1.76E-04	14
1.0299	3.014E+05	1.8476E+05	1.0231E+13	17.6	2.08E-06	1.479E-05	5.580E-04	1.74E-07	1.76E-04	15
1.0234	3.014E+05	1.8476E+05	1.0296E+13	17.6	2.00E-06	1.294E-05	4.885E-04	1.63E-07	1.76E-04	16
1.0183	3.014E+05	1.8476E+05	1.0348E+13	17.6	1.93E-06	1.139E-05	4.300E-04	1.53E-07	1.76E-04	17
1.0143	3.014E+05	1.8476E+05	1.0388E+13	17.6	1.86E-06	1.007E-05	3.799E-04	1.43E-07	1.76E-04	18
1.0112	3.014E+05	1.8476E+05	1.0420E+13	17.6	1.80E-06	8.928E-06	3.369E-04	1.34E-07	1.76E-04	19
1.0088	3.014E+05	1.8476E+05	1.0445E+13	17.6	1.74E-06	7.939E-06	2.996E-04	1.26E-07	1.76E-04	20

CALCULATION IS IN SECTION NO. = 3 AND THE SECTION LENGTH IS = 2.7450 M

COLLECTION AREA = 2.461E+03 M2
WIRE TO PLATE = 1.397E-01 M
CURRENT/M = 1.164E-04 AMP/M
1/2 WIRE TO WIRE = 9.208E-02 M
TEMPERATURE = 430.000 K
ION MOBILITY = 3.463E-04 M2/VOLT-SEC
DUST WEIGHT = 6.969E-01 KG/SEC

APPLIED VOLTAGE = 4.245E+04 VOLTS
CORONA WIRE RADIUS = 2.096E-03 M
CURRENT DENSITY = 2.268E-04 AMP/M2
GAS FLOW RATE = 1.548E+02 M3/SEC
PRESSURE = 1.000 ATM
MEAN THERMAL SPEED = 5.335E+02 M/SEC
LENGTH INCR. =0.27450000 M

TOTAL CURRENT = 5.580E-01 AMPS
CORONA WIRE LENGTH = 4.795E+03 M
DEPOSIT E FIELD = 1.134E+05 VOLT/M
GAS VELOCITY = 1.250E+00 M/SEC
VISCOSITY = 2.290E-05 KG/M-SEC
PART. PATH PARAM. = 8.246E-08 M
INPUT EFF./INCR. = 15.55

ROVRI	ERAVG	EPLT	AFID	CMCD	MMD	WEIGHT	DUST LAYER	J(PART)	J(ION)	INCR. NO.
1.0054	3.039E+05	1.9363E+05	1.3395E+13	22.7	1.68E-06	7.422E-06	2.801E-04	1.24E-07	2.27E-04	21
1.0042	3.039E+05	1.9363E+05	1.3411E+13	22.7	1.62E-06	6.606E-06	2.493E-04	1.16E-07	2.27E-04	22
1.0033	3.039E+05	1.9363E+05	1.3423E+13	22.7	1.57E-06	5.892E-06	2.224E-04	1.08E-07	2.27E-04	23
1.0026	3.039E+05	1.9363E+05	1.3433E+13	22.7	1.52E-06	5.266E-06	1.987E-04	1.01E-07	2.27E-04	24
1.0020	3.039E+05	1.9363E+05	1.3440E+13	22.7	1.47E-06	4.709E-06	1.777E-04	9.46E-08	2.27E-04	25
1.0016	3.039E+05	1.9363E+05	1.3446E+13	22.7	1.42E-06	4.219E-06	1.592E-04	8.84E-08	2.27E-04	26
1.0012	3.039E+05	1.9363E+05	1.3451E+13	22.7	1.38E-06	3.783E-06	1.428E-04	8.25E-08	2.27E-04	27
1.0010	3.039E+05	1.9363E+05	1.3454E+13	22.7	1.34E-06	3.399E-06	1.283E-04	7.69E-08	2.27E-04	28
1.0008	3.039E+05	1.9363E+05	1.3457E+13	22.7	1.30E-06	3.057E-06	1.154E-04	7.17E-08	2.27E-04	29
1.0006	3.039E+05	1.9363E+05	1.3459E+13	22.7	1.26E-06	2.753E-06	1.039E-04	6.69E-08	2.27E-04	30

CHARGING RATES FOR PARTICLE SIZES FROM SUBROUTINE CHARGN OR CHGSUM

SRI THEORY USED FOR PARTICLE CHARGING

INCREMENT NO. Q/QSATF FOR INDICATED PARTICLE SIZES

	0.2000E-06	0.4000E-06	0.7000E-06	0.1100E-05	0.1600E-05	0.2500E-05	0.3500E-05	0.4500E-05
1	0.5293	0.5206	0.4911	0.4693	0.4555	0.4436	0.4373	0.4339
2	0.7611	0.7536	0.7120	0.6794	0.6576	0.6388	0.6293	0.6244
3	0.9222	0.9229	0.8609	0.8104	0.7773	0.7500	0.7370	0.7308
4	1.0587	1.0651	0.9861	0.9085	0.8596	0.8215	0.8046	0.7969
5	1.1669	1.1677	1.0774	0.9919	0.9244	0.8725	0.8508	0.8413
6	1.2554	1.2469	1.1432	1.0502	0.9793	0.9122	0.8847	0.8733
7	1.3299	1.3110	1.1942	1.0931	1.0184	0.9455	0.9113	0.8975
8	1.3939	1.3647	1.2357	1.1268	1.0478	0.9721	0.9330	0.9167
9	1.4498	1.4106	1.2706	1.1544	1.0712	0.9920	0.9512	0.9324
10	1.4992	1.4505	1.3005	1.1777	1.0906	1.0079	0.9644	0.9453
11	1.5706	1.5100	1.3468	1.2156	1.1234	1.0368	0.9921	0.9710
12	1.6301	1.5584	1.3836	1.2449	1.1480	1.0573	1.0088	0.9886
13	1.6809	1.5991	1.4141	1.2687	1.1677	1.0732	1.0216	0.9982
14	1.7252	1.6342	1.4401	1.2888	1.1840	1.0861	1.0319	1.0055
15	1.7644	1.6650	1.4627	1.3060	1.1978	1.0969	1.0405	1.0117
16	1.7996	1.6924	1.4827	1.3212	1.2099	1.1062	1.0479	1.0172
17	1.8314	1.7170	1.5005	1.3346	1.2206	1.1143	1.0543	1.0220
18	1.8604	1.7394	1.5166	1.3467	1.2301	1.1216	1.0600	1.0220
19	1.8871	1.7598	1.5313	1.3577	1.2388	1.1281	1.0652	1.0220
20	1.9117	1.7786	1.5448	1.3678	1.2466	1.1340	1.0652	1.0220
21	1.9412	1.8014	1.5613	1.3802	1.2565	1.1416	1.0719	1.0285
22	1.9683	1.8221	1.5762	1.3914	1.2654	1.1484	1.0719	1.0285
23	1.9932	1.8411	1.5899	1.4017	1.2735	1.1545	1.0719	1.0285
24	2.0163	1.8587	1.6025	1.4111	1.2809	1.1601	1.0719	1.0285
25	2.0378	1.8750	1.6141	1.4197	1.2877	1.1601	1.0719	1.0285
26	2.0579	1.8903	1.6250	1.4278	1.2940	1.1601	1.0719	1.0285
27	2.0768	1.9045	1.6351	1.4353	1.2940	1.1601	1.0719	1.0285
28	2.0947	1.9180	1.6447	1.4424	1.2940	1.1601	1.0719	1.0285
29	2.1116	1.9307	1.6537	1.4424	1.2940	1.1601	1.0719	1.0285
30	2.1276	1.9427	1.6622	1.4424	1.2940	1.1601	1.0719	1.0285

	0.6000E-05	0.8500E-05	0.1250E-04	0.2000E-04	0.2750E-04
1	0.4311	0.4289	0.4277	0.4272	0.4270
2	0.6208	0.6184	0.6174	0.6170	0.6170
3	0.7265	0.7241	0.7232	0.7230	0.7229
4	0.7919	0.7893	0.7884	0.7883	0.7883
5	0.8355	0.8326	0.8318	0.8317	0.8317
6	0.8664	0.8632	0.8624	0.8623	0.8622
7	0.8895	0.8859	0.8850	0.8849	0.8849
8	0.9074	0.9033	0.9024	0.9023	0.9023
9	0.9217	0.9171	0.9161	0.9160	0.9160
10	0.9334	0.9283	0.9272	0.9271	0.9271
11	0.9583	0.9532	0.9521	0.9520	0.9520
12	0.9754	0.9699	0.9687	0.9686	0.9686
13	0.9870	0.9814	0.9803	0.9802	0.9802
14	0.9928	0.9889	0.9879	0.9878	0.9878
15	0.9958	0.9919	0.9918	0.9917	0.9917

16	0.9958	0.9919	0.9918	0.9917	0.9917
17	0.9958	0.9919	0.9918	0.9917	0.9917
18	0.9958	0.9919	0.9918	0.9917	0.9917
19	0.9958	0.9919	0.9918	0.9917	0.9917
20	0.9958	0.9919	0.9918	0.9917	0.9917
21	1.0021	0.9996	0.9992	0.9991	0.9991
22	1.0021	0.9996	0.9992	0.9991	0.9991
23	1.0021	0.9996	0.9992	0.9991	0.9991
24	1.0021	0.9996	0.9992	0.9991	0.9991
25	1.0021	0.9996	0.9992	0.9991	0.9991
26	1.0021	0.9996	0.9992	0.9991	0.9991
27	1.0021	0.9996	0.9992	0.9991	0.9991
28	1.0021	0.9996	0.9992	0.9991	0.9991
29	1.0021	0.9996	0.9992	0.9991	0.9991
30	1.0021	0.9996	0.9992	0.9991	0.9991

CHARGE ACCUMULATED ON PARTICLE SIZES IN EACH INCREMENT

INCREMENT	CHARGE FOR INDICATED PARTICLE SIZES							
	0.2000E-06	0.4000E-06	0.7000E-06	0.1100E-05	0.1600E-05	0.2500E-05	0.3500E-05	0.4500E-05
1	0.94287E-18	0.28449E-17	0.75571E-17	0.17331E-16	0.35188E-16	0.83125E-16	0.16024E-15	0.26252E-15
2	0.13559E-17	0.41186E-17	0.10957E-16	0.25090E-16	0.50804E-16	0.11970E-15	0.23057E-15	0.37780E-15
3	0.16428E-17	0.50437E-17	0.13248E-16	0.29927E-16	0.60052E-16	0.14053E-15	0.27004E-15	0.44217E-15
4	0.18860E-17	0.58206E-17	0.15174E-16	0.33551E-16	0.66406E-16	0.15394E-15	0.29479E-15	0.48215E-15
5	0.20787E-17	0.63813E-17	0.16580E-16	0.36630E-16	0.71415E-16	0.16349E-15	0.31172E-15	0.50905E-15
6	0.22364E-17	0.68142E-17	0.17592E-16	0.38783E-16	0.75655E-16	0.17093E-15	0.32416E-15	0.52837E-15
7	0.23692E-17	0.71647E-17	0.18377E-16	0.40365E-16	0.78676E-16	0.17717E-15	0.33388E-15	0.54303E-15
8	0.24832E-17	0.74579E-17	0.19016E-16	0.41610E-16	0.80944E-16	0.18215E-15	0.34185E-15	0.55465E-15
9	0.25828E-17	0.77087E-17	0.19552E-16	0.42631E-16	0.82752E-16	0.18589E-15	0.34850E-15	0.56412E-15
10	0.26707E-17	0.79269E-17	0.20012E-16	0.43493E-16	0.84248E-16	0.18887E-15	0.35337E-15	0.57194E-15
11	0.27980E-17	0.82517E-17	0.20725E-16	0.44890E-16	0.86785E-16	0.19429E-15	0.36352E-15	0.58747E-15
12	0.29039E-17	0.85163E-17	0.21292E-16	0.45972E-16	0.88688E-16	0.19813E-15	0.36963E-15	0.59816E-15
13	0.29944E-17	0.87389E-17	0.21761E-16	0.46852E-16	0.90205E-16	0.20110E-15	0.37430E-15	0.60393E-15
14	0.30734E-17	0.89308E-17	0.22161E-16	0.47592E-16	0.91463E-16	0.20351E-15	0.37807E-15	0.60836E-15
15	0.31433E-17	0.90990E-17	0.22509E-16	0.48230E-16	0.92536E-16	0.20554E-15	0.38123E-15	0.61214E-15
16	0.32059E-17	0.92487E-17	0.22816E-16	0.48789E-16	0.93469E-16	0.20728E-15	0.38393E-15	0.61545E-15
17	0.32626E-17	0.93833E-17	0.23091E-16	0.49286E-16	0.94293E-16	0.20881E-15	0.38630E-15	0.61838E-15
18	0.33143E-17	0.95054E-17	0.23339E-16	0.49733E-16	0.95031E-16	0.21016E-15	0.38839E-15	0.61838E-15
19	0.33618E-17	0.96172E-17	0.23565E-16	0.50139E-16	0.95698E-16	0.21138E-15	0.39028E-15	0.61838E-15
20	0.34057E-17	0.97201E-17	0.23773E-16	0.50510E-16	0.96306E-16	0.21249E-15	0.39028E-15	0.61838E-15
21	0.34583E-17	0.98443E-17	0.24026E-16	0.50970E-16	0.97071E-16	0.21392E-15	0.39275E-15	0.62230E-15
22	0.35064E-17	0.99575E-17	0.24256E-16	0.51385E-16	0.97758E-16	0.21519E-15	0.39275E-15	0.62230E-15
23	0.35507E-17	0.10061E-16	0.24466E-16	0.51762E-16	0.98381E-16	0.21634E-15	0.39275E-15	0.62230E-15
24	0.35919E-17	0.10158E-16	0.24660E-16	0.52109E-16	0.98951E-16	0.21738E-15	0.39275E-15	0.62230E-15
25	0.36302E-17	0.10247E-16	0.24839E-16	0.52430E-16	0.99476E-16	0.21738E-15	0.39275E-15	0.62230E-15
26	0.36661E-17	0.10330E-16	0.25006E-16	0.52727E-16	0.99962E-16	0.21738E-15	0.39275E-15	0.62230E-15
27	0.36998E-17	0.10408E-16	0.25162E-16	0.53005E-16	0.99962E-16	0.21738E-15	0.39275E-15	0.62230E-15
28	0.37316E-17	0.10482E-16	0.25309E-16	0.53266E-16	0.99962E-16	0.21738E-15	0.39275E-15	0.62230E-15
29	0.37617E-17	0.10551E-16	0.25448E-16	0.53266E-16	0.99962E-16	0.21738E-15	0.39275E-15	0.62230E-15
30	0.37902E-17	0.10617E-16	0.25578E-16	0.53266E-16	0.99962E-16	0.21738E-15	0.39275E-15	0.62230E-15

	0.6000E-05	0.8500E-05	0.1250E-04	0.2000E-04	0.2750E-04
1	0.46333E-15	0.92477E-15	0.19937E-14	0.50962E-14	0.96313E-14
2	0.66724E-15	0.13333E-14	0.28776E-14	0.73611E-14	0.13915E-13
3	0.78089E-15	0.15611E-14	0.33708E-14	0.86247E-14	0.16304E-13
4	0.85113E-15	0.17016E-14	0.36750E-14	0.94041E-14	0.17778E-13
5	0.89798E-15	0.17950E-14	0.38770E-14	0.99217E-14	0.18756E-13
6	0.93122E-15	0.18610E-14	0.40195E-14	0.10287E-13	0.19446E-13
7	0.95603E-15	0.19099E-14	0.41250E-14	0.10557E-13	0.19957E-13
8	0.97529E-15	0.19475E-14	0.42060E-14	0.10764E-13	0.20349E-13
9	0.99068E-15	0.19773E-14	0.42701E-14	0.10928E-13	0.20659E-13
10	0.10032E-14	0.20014E-14	0.43218E-14	0.11060E-13	0.20909E-13
11	0.10300E-14	0.20550E-14	0.44377E-14	0.11357E-13	0.21470E-13
12	0.10483E-14	0.20910E-14	0.45158E-14	0.11556E-13	0.21846E-13
13	0.10608E-14	0.21160E-14	0.45692E-14	0.11694E-13	0.22107E-13
14	0.10671E-14	0.21321E-14	0.46047E-14	0.11785E-13	0.22279E-13
15	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13
16	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13
17	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13
18	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13
19	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13

20	0.10703E-14	0.21386E-14	0.46226E-14	0.11831E-13	0.22367E-13
21	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
22	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
23	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
24	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
25	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
26	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
27	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
28	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
29	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13
30	0.10771E-14	0.21551E-14	0.46572E-14	0.11920E-13	0.22534E-13

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 1 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.000E-07	2.123	0.033	0.7460	0.4596	95.6337	6.565	4.3663	95.4127	6.462	4.5873
4.000E-07	1.530	0.253	7.7149	4.6397	94.1103	5.938	5.8897	93.9591	5.885	6.0409
7.000E-07	1.297	0.903	23.7497	14.5819	94.9201	6.248	5.0799	94.6806	6.151	5.3194
1.100E-06	1.188	0.815	15.2607	10.1210	96.3834	6.960	3.6166	95.9093	6.702	4.0907
1.600E-06	1.130	1.520	19.0143	13.5163	97.5839	7.806	2.4161	97.0708	7.402	2.9292
2.500E-06	1.083	3.524	22.9679	18.8810	98.7412	9.173	1.2588	98.2351	8.464	1.7649
3.500E-06	1.059	1.652	5.9857	6.9689	99.3002	10.404	0.6998	98.6104	8.966	1.3896
4.500E-06	1.046	1.652	3.5711	6.6668	99.5825	11.487	0.4175	98.6706	9.059	1.3294
6.000E-06	1.035	1.982	0.8603	5.9268	99.9162	14.853	0.0838	99.0150	9.687	0.9850
8.500E-06	1.024	3.304	0.0861	6.4448	99.9950	20.751	0.0050	99.3575	10.583	0.6425
1.250E-05	1.017	4.846	0.0025	5.1520	99.9999	33.981	0.0001	99.6498	11.855	0.3502
2.000E-05	1.010	12.115	0.0062	4.1915	99.9999	54.024	0.0001	99.8860	14.209	0.1140
2.750E-05	1.008	67.401	0.0346	2.4497	99.9999	74.070	0.0001	99.9880	18.934	0.0120

EFFICIENCY = STATED = 99.37 COMPUTED = 99.3736 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 99.8069
MMD OF INLET SIZE DISTRIBUTION = 4.465E+01
SIGMAP OF INLET SIZE DISTRIBUTION = 5.122E+00
LOG-NORMAL GOODNESS OF FIT = 0.984
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.336E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 1.919E+00
LOG-NORMAL GOODNESS OF FIT = 0.997
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 13.103

SIGMAG= 0.000 WITH 0.000 SNEAKAGE OVER 3.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 99.6706
CORRECTED MMD OF EFFLUENT = 2.687E+00
CORRECTED SIGMAP OF EFFLUENT = 2.816E+00
LOG-NORMAL GOODNESS OF FIT = 0.988
CORRECTED PRECIPITATION RATE PARAMETER = 11.98

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.702E+00	7.243E+01	2.146E-01	1.086E-02	2.254E-01	5.350E-02	2.000E-07
2.814E+00	7.387E+01	4.772E+00	1.225E-01	4.895E+00	2.806E-01	4.000E-07
3.377E+00	8.003E+01	1.277E+01	6.019E-01	1.337E+01	1.586E+00	7.000E-07
4.223E+00	8.666E+01	1.311E+01	1.719E+00	1.483E+01	2.834E+00	1.100E-06
5.296E+00	9.200E+01	1.583E+01	3.362E+00	1.919E+01	5.720E+00	1.600E-06
7.223E+00	9.681E+01	1.482E+01	5.960E+00	2.078E+01	1.308E+01	2.500E-06
9.331E+00	9.883E+01	8.238E+00	8.120E+00	1.636E+01	8.358E+00	3.500E-06
1.149E+01	9.958E+01	4.206E+00	9.186E+00	1.339E+01	1.105E+01	4.500E-06
1.485E+01	9.992E+01	8.992E-01	9.667E+00	1.057E+01	1.310E+01	6.000E-06
2.075E+01	9.999E+01	7.141E-02	9.044E+00	9.115E+00	1.545E+01	8.500E-06
3.398E+01	1.000E+02	2.022E-03	7.140E+00	7.142E+00	1.245E+01	1.250E-05
5.402E+01	1.000E+02	3.769E-03	4.331E+00	4.335E+00	1.013E+01	2.000E-05
7.407E+01	1.000E+02	6.250E-02	7.544E+00	7.606E+00	5.918E+00	2.750E-05

```
SUMMARY TABLE OF ESP OPERATING
PARAMETERS AND PERFORMANCE

DATA SET NUMBER   1

ESP PERFORMANCE:     EFFICIENCY =  99.6706 %     SCA =  4.769E+01 M**2/(M**3/SEC)

ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.172E+04 V
                           AVG. CURRENT DENSITY =   17.12 NA/CM**2
                           RESISTIVITY =  5.000E+10 OHM-CM

SIZE DISTRIBUTIONS:     INLET MMD =  4.465E+01 UM     INLET SIGMAP =  5.122E+00
                        OUTLET MMD =  2.687E+00 UM     OUTLET SIGMAP =  2.816E+00

NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.00 /SECTION     GAS VELOCITY SIGMAG = 0.00
                         RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00
```

PARTICLE SIZE RANGE STATISTICS

CORRECTIONS FOR NONIDEALITIES USING SET NO. 2 OF CORRECTION PARAMETERS

SIZE	CCF	INLET %	OUTLET %	COR. OUTLET %	NO-RAP EFF.	NO-RAP W	NO-RAP P	COR. EFF.	COR. W	COR. P
2.000E-07	2.123	0.033	0.4509	0.3301	92.3311	5.384	7.6689	91.9336	5.278	8.0664
4.000E-07	1.530	0.253	4.4488	3.1822	90.1301	4.855	9.8699	89.8582	4.798	10.1418
7.000E-07	1.297	0.903	14.5658	10.6218	90.9462	5.036	9.0538	90.5155	4.939	9.4845
1.100E-06	1.188	0.815	10.5527	8.2078	92.7324	5.497	7.2676	91.8797	5.264	8.1203
1.600E-06	1.130	1.520	15.3888	12.4518	94.3174	6.013	5.6826	93.3947	5.697	6.6053
2.500E-06	1.083	3.524	25.0413	21.4094	96.0115	6.755	3.9885	95.1014	6.324	4.8986
3.500E-06	1.059	1.652	9.1685	8.9240	96.8849	7.273	3.1151	95.6443	6.570	4.3557
4.500E-06	1.046	1.652	7.9239	8.8757	97.3078	7.579	2.6922	95.6679	6.582	4.3321
6.000E-06	1.035	1.982	5.1532	7.5712	98.5406	8.863	1.4594	96.9199	7.297	3.0801
8.500E-06	1.024	3.304	4.6876	7.9611	99.2037	10.133	0.7963	98.0571	8.263	1.9429
1.250E-05	1.017	4.846	2.3997	5.4557	99.7220	12.340	0.2780	99.0922	9.859	0.9078
2.000E-05	1.010	12.115	0.1864	3.2093	99.9914	19.619	0.0086	99.7864	12.892	0.2136
2.750E-05	1.008	67.401	0.0323	1.7999	99.9997	74.070	0.0003	99.9785	17.703	0.0215

EFFICIENCY = STATED = 99.37 COMPUTED = 99.3736 CONVERGENCE OBTAINED

ADJUSTED NO-RAP EFF. = 99.4387
MMD OF INLET SIZE DISTRIBUTION = 4.465E+01
SIGMAP OF INLET SIZE DISTRIBUTION = 5.122E+00
LOG-NORMAL GOODNESS OF FIT = 0.984
MMD OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.044E+00
SIGMAP OF EFFLUENT UNDER NO-RAP CONDITIONS = 2.230E+00
LOG-NORMAL GOODNESS OF FIT = 0.997
PRECIPITATION RATE PARAMETER UNDER NO-RAP CONDITIONS = 10.866

SIGMAG= 0.250 WITH 0.100 SNEAKAGE OVER 3.000 STAGES
NTEMP = 1
RMMD = 6.00
RSIGMA = 2.50
CORR. EFF. = 99.1937
CORRECTED MMD OF EFFLUENT = 2.924E+00
CORRECTED SIGMAP OF EFFLUENT = 2.600E+00
LOG-NORMAL GOODNESS OF FIT = 0.996
CORRECTED PRECIPITATION RATE PARAMETER = 10.11

UNADJUSTED MIGRATION VELOCITIES AND EFFICIENCIES, AND DISCRETE OUTLET MASS LOADINGS

IDEAL UNADJUSTED MIG. VEL.(CM/SEC)	IDEAL UNADJUSTED EFFICIENCY(%)	NO-RAP DM/DLOGD(MG/DSCM)	RAPPING PUFF DM/DLOGD(MG/DSCM)	NO-RAP+RAP PUFF DM/DLOGD(MG/DSCM)	RAPPING PUFF DISTRIBUTION(%)	PARTICLE DIAM.(M)
2.702E+00	7.243E+01	3.769E-01	1.953E-02	3.964E-01	5.350E-02	2.000E-07
2.814E+00	7.387E+01	7.997E+00	2.203E-01	8.217E+00	2.806E-01	4.000E-07
3.377E+00	8.003E+01	2.275E+01	1.082E+00	2.384E+01	1.586E+00	7.000E-07
4.223E+00	8.666E+01	2.635E+01	3.092E+00	2.944E+01	2.834E+00	1.100E-06
5.296E+00	9.200E+01	3.724E+01	6.046E+00	4.328E+01	5.720E+00	1.600E-06
7.223E+00	9.681E+01	4.697E+01	1.072E+01	5.769E+01	1.308E+01	2.500E-06
9.331E+00	9.883E+01	3.667E+01	1.460E+01	5.128E+01	8.358E+00	3.500E-06
1.149E+01	9.958E+01	2.712E+01	1.652E+01	4.364E+01	1.105E+01	4.500E-06
1.485E+01	9.992E+01	1.565E+01	1.739E+01	3.304E+01	1.310E+01	6.000E-06
2.075E+01	9.999E+01	1.130E+01	1.626E+01	2.756E+01	1.545E+01	8.500E-06
3.398E+01	1.000E+02	5.667E+00	1.284E+01	1.851E+01	1.245E+01	1.250E-05
5.402E+01	1.000E+02	3.282E-01	7.789E+00	8.118E+00	1.013E+01	2.000E-05
7.407E+01	1.000E+02	1.695E-01	1.357E+01	1.374E+01	5.918E+00	2.750E-05

```
*****************************************************************************************************
*                                                                                                   *
*                                  SUMMARY TABLE OF ESP OPERATING                                   *
*                                    PARAMETERS AND PERFORMANCE                                     *
*                                                                                                   *
*                                                                                                   *
*                                        DATA SET NUMBER   2                                        *
*                                                                                                   *
*          ESP PERFORMANCE:     EFFICIENCY =  99.1937 %     SCA =  4.769E+01 M**2/(M**3/SEC)       *
*                                                                                                   *
*          ELECTRICAL CONDITIONS:     AVG. APPLIED VOLTAGE =  4.172E+04 V                           *
*                                     AVG. CURRENT DENSITY =   17.12 NA/CM**2                       *
*                                     RESISTIVITY =  5.000E+10 OHM-CM                               *
*                                                                                                   *
*          SIZE DISTRIBUTIONS:     INLET MMD =  4.465E+01 UM     INLET SIGMAP =  5.122E+00          *
*                                  OUTLET MMD =  2.924E+00 UM     OUTLET SIGMAP =  2.600E+00         *
*                                                                                                   *
*          NONIDEAL PARAMETERS:     GAS SNEAKAGE FRACTION = 0.10 /SECTION     GAS VELOCITY SIGMAG = 0.25 *
*                                   RAPPING MMD =  6.000E+00 UM     RAPPING SIGMAP =  2.500E+00      *
*                                                                                                   *
*****************************************************************************************************
STOP  011111
```

APPENDIX O

DEFINITION OF VARIABLES USED IN THE PROGRAM

LIST OF VARIABLES, DEFINITIONS, AND UNITS FOR THE MAIN PROGRAM OF THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NWIRE - Number of wires per electrical section per gas passage in a particular electrical section

LTHICK - Thickness of the collected particulate layer in a particular increment of length (mm/min)

JPART - Current density due to particles in a particular increment of length (A/m^2)

JION - Current density due to ions in a particular increment of length (A/m^2)

LINC - Length of the increments taken in a particular linear electrical section (m)

NWS(I) - Number of wires per electrical section per gas passage for the different linear electrical sections

LINCS(I) - Lengths of the increments taken in the different linear electrical sections (ft)

VISKIP - Indicator which determines whether or not a dirty-gas voltage-current curve is calculated in each increment of length

VISAME - Indicator which determines whether or not a clean-gas voltage-current curve is calculated for each of the electrical sections or just the first electrical section

CHKSUM(K) - Fractional increase in charge from one increment to the next for the different particle sizes

DIAM(K) - Diameters of the different particle sizes (μm and m)

ONO(K) - Initial number of particles per cubic meter of gas in each particle size band ($\#/m^3$)

DXS(K) - Total number of particles removed per cubic meter of gas in each particle size band under ideal conditions and with no empirical corrections ($\#/m^3$)

XMV(K) - Effective migration velocities for the different particle sizes under ideal conditions and with no empirical corrections (m/sec)

PCNT(K) - Percentage or fraction by mass in the inlet particle size distribution of the different size bands (% and decimal)

RAD(K) - Radii of the different particle sizes (m)

CCF(K) - Cunningham correction factor for the different particle sizes

PRCU(L) - Cumulative percent by mass up to each particle size in the inlet particle size distribution (%)

LSECT(I) - Number of length increments in the different linear electrical sections

PS(I) - Gas pressure in the different electrical sections (atm)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

ATOTAL - Total collection plate area of the precipitator (m^2)

DD - Mass density of the particles (kg/m^3)

ETAO - Estimated or design overall mass collection efficiency (%)

DL - Inlet mass loading (grains/ft^3 and kg/m^3)

PL - Total electrical length of the precipitator (ft and m)

RHO - Resistivity of the collected particulate layer (ohm-cm and ohm-m)

NS - Number of different particle size bands in the inlet particle size distribution

ZMMDI - Specified or fitted mass median diameter of the inlet particle size distribution based on a log-normal distribution (μm)

SIGMI - Specified or fitted geometric standard deviation of the inlet particle size distribution based on a log-normal distribution

NONID - Number of nonideal conditions of gas velocity non-uniformity and gas sneakage and/or particle reen-trainment without rapping to be considered

NRAPD - Number of rapping puff particle size distributions to be considered

TDK - Temperature of the gas in a given electrical sec-tion (°K)

NUMSEC - Number of linear electrical sections in the precip-itator

NEFF - Indicator which determines whether the unadjusted, ideal or adjusted, no-rap efficiency is used to determine the mass reentrained due to rapping

NTEMP - Indicator which specifies whether the precipitator is cold or hot side

GFIT - Linear-correlation coefficient obtained in the log-normal fit of the inlet particle size distribution

VOL(K) - Total volume of particles per cubic meter of gas in the different size bands (m^3/m^3(gas))

XNO(K) - Number of particles per cubic meter of gas in each size band at the start of each increment (#/m^3)

Q(K) - Charge on each particle size at the end of a partic-ular increment (coul)

WS(K) - Total weight of material per cubic meter of gas removed in each size band in a particular incre-ment (kg/m^3)

ITL(M) - Identifying label for the calculations

DW(J) - Amount of material removed per increment on a total weight basis (kg)

AS(I) - Collection plate areas for the different linear electrical sections (m^2)

VOS(I) - Applied voltages for the different linear electrical sections (V)

TCS(I) - Total current for the different linear electrical sections (A)

WLS(I) - Total wire length for the different linear electri-cal sections (ft^2)

ACS(I) - Corona wire radii for the different linear electrical sections (in.)

BS(I) - Wire-to-plate spacing for the different linear electrical sections (in.)

SYS(I) - One-half the wire-to-wire spacing for the different linear electrical sections (in.)

VGS(I) - Gas volume flow rate for the different linear electrical sections (ft^3/min)

VGASS(I) - Gas velocity for the different linear electrical sections (ft/sec)

TEMPS(I) - Gas temperature for the different linear electrical sections (°F)

VISS(I) - Gas viscosity for the different linear electrical sections (kg/m-sec)

QSAT(K) - Saturation charge for the different particle sizes (coul)

U - Ion mobility adjusted for temperature and pressure (m^2/V-sec)

E - Elementary charge unit (coul)

EPSO - Permittivity of free space ($coul^2$/nt-m^2)

PI - Value of the constant π

ERAVG - Average electric field used for particle charging (V/m)

BC - Boltzmann's constant (J/°K)

TEMP - Gas temperature in a particular linear electrical section (°R)

EPS - Relative dielectric constant of the particles

VAVC - Root mean square velocity of the ions (m/sec)

OLDQ(K) - Charge on the different particle sizes in the increment prior to the one under consideration (coul)

OLDXNO(K) - Number of particles per cubic meter of gas in each size band at the start of the increment prior to the one under consideration (#/m^3)

RFS(I) - Roughness factor for the corona wires in the different linear electrical sections

START1(I) - Specified initial current density at which the calculation of a voltage-current curve starts in a given electrical section and the initial current density increment size (A/m^2)

START2(I) - Specified increment in current density which is used in place of START1(I) when the JI1-th point on the voltage-current curve is reached (A/m^2)

START3(I) - Specified increment in current density which is used in place of START2(I) when the JI2-th point on the voltage-current curve is reached (A/m^2)

VSTAR(I) - Estimate of the applied voltage corresponding to the first point on the voltage-current curve as defined by START1(I) (V)

XDC(J,K) - Charge on each particle size at the end of each increment (coul)

EAVG(N) - Average electric fields for particle charging in subincremental lengths (V/m)

CHFID(N) - Average free ion densities for particle charging in subincremental lengths ($\#/m^3$)

ECOLL(N) - Average electric fields at the plate in subincremental lengths (V/m)

ECLEAN(N) - Average electric fields at the plate for clean gas in subincremental lengths (V/m)

ENDPT(L) - Particle diameters in the inlet cumulative percent by mass distribution (μm and m)

NENDPT - Number of particle diameters in the inlet cumulative percent by mass distribution

ARD50(II) - Rapping puff mass median diameters (μm)

ARSIGM(II) - Rapping puff geometric standard deviations

ASNUCK(JJ) - Fractions of gas sneakage and/or particle reentrainment without rapping

AZNUMS(JJ) - Number of stages over which gas sneakage and/or particle reentrainment without rapping occur

AZIGGY(JJ) - Normalized standard deviations of the gas velocity distribution

VCOOP(KK,LL) - Values at different grid points of the electric potential in a wire-plate geometry under conditions of no space charge (V)

TMFP - Ionic mean free path multiplied by a factor (m)

NVI - Indicator which specifies whether to base the electrical calculation on known voltages and currents or on calculated voltage-current characteristics

NPRINT - Indicator which designates when to print certain sectionalized data

NSECT - Indicator which keeps track of which electrical section the calculation is in

SLNGTH - Length of a particular electrical section (m)

A - Collection plate area of a particular linear electrical section (m^2)

VO - Applied voltage in a particular linear electrical section (V)

TC - Total current in a particular linear electrical section (A)

B - Wire-to-plate spacing in a particular linear electrical section (m)

AC - Corona wire radius in a particular linear electrical section (m)

WL - Total wire length in a particular linear electrical section (m)

CL - Total current per length of corona wire in a particular linear electrical section (A/m)

CD - Average current density at the plate in a particular linear electrical section (A/m^2)

ET - Average electric field in the deposited particulate layer in a particular linear electrical section (V/m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section (m)

VGAS - Gas velocity in a particular linear electrical section (m/sec)

P - Gas pressure in a particular linear electrical section (atm)

VIS - Gas viscosity in a particular linear electrical section (kg/m-sec)

W - Total weight of particles per second passing into a particular linear electrical section (kg/sec)

XPI - Overall mass collection efficiency per increment based on the estimated or design efficiency (%)

RIOVR - Ratio of the ionic space charge density to the total space charge density

EPLT - Absolute value of the average electric field at the plate in a particular length increment (V/m)

AFID - Average reduced free ion density for particle charging in a particular length increment (#/m^3)

XCD - Average current density at the plate in a particular length increment (nA/cm^2)

ZMD - Interpolated mass median diameter of the collected particulate layer (m)

WT - Total weight of material per cubic meter of gas removed in all particle size bands in a given length increment (kg/m^3)

I - Index which runs over the different incremental lengths in its major usage

ROVRI - Ratio of the total space charge density to the ionic space charge density

NCALC - Indicator which determines whether to use equation (12)* for particle charging or the sum of the classical field and diffusion charges

NI - Number of subincremental lengths into which the incremental length is divided

VRATIO - Ratio of the peak applied voltage to the average for use in particle charging

NF - Number of increments taken along the length of the precipitator

NREAD - Indicator which specifies the unit number of the input device for reading data into the program

---

*Equation numbers which are superscripted by this symbol refer to equations contained in reference 2.

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

SCOREF - Overall mass collection efficiency under no-rap + rap conditions (%)

CZMDL - Fitted log-normal mass median diameter of the outlet particle size distribution under no-rap + rap conditions (μm)

CSIGMO - Fitted log-normal geometric standard deviation of the outlet particle size distribution under no-rap + rap conditions

NRUN - Indicator that specifies which set of nonideal conditions is under consideration

SNUCK - Particular value of ASNUCK(JJ)

ZIGGY - Particular value of AZIGGY(JJ)

RMMD - Particular value of ARD50(II) [μm]

RSIGMA - Particular value of ARSIGM(II)

LK - Indicator which determines whether or not the input data are printed at a certain location in the program

DV - Total volume per cubic meter of gas occupied by particles [m^3(particles)/m^3(gas)]

NN - Number of increments in the Runge-Kutta integration of equation (12)*

NUMINC - Number of increments in the Simpson's Rule integration over Θ in equation (12)*

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

NDATA - Indicator which determines the type of data set that is to be read into the program

NEST - Indicator which specifies whether to use extensive calculations or estimation procedures in determining precipitator performance

NDIST - Indicator which specifies whether the user is to supply the inlet particle size distribution or the program is to calculate a log-normal distribution

NITER - Indicator which determines the maximum number of iterations over a loop that converges on overall mass efficiency or the number of iterations that will be performed over each incremental length of the precipitator in order to obtain self-consistent solutions for the electrical conditions

IFINAL - Indicator which causes the calculation of successive points on the voltage-current curve to cease after IFINAL points

JI1 - Indicator which allows the initial increment size on current density in the calculation of the voltage-current curve to be changed after JI1-1 points are determined on the curve

JI2 - Indicator which allows the second increment size on current density in the calculation of the voltage-current curve to be changed after JI2-1 points are determined on the curve

US - Ion mobility at standard temperature and pressure (reduced ion mobility)

FPATH - Factor which scales the ion mean free path

EBD - Electrical breakdown strength of the gas near the collection electrode or the collected particulate layer (V/m)

NDSET - Counter which keeps track of the number of the particular set of nonideal conditions which is under consideration

D50 - Same as ZMMDI (μm)

SIGMAP - Same as SIGMI

SCHARG - Saturation charge number from the field charging equation

CHRFID - Average free ion density for particle charging ($\#/m^3$)

TIMEI - Initial value of time for particle charging (sec)

TIMEF - Final value of time for particle charging (sec)

V - Value of the quantity $[e^2/4\pi\varepsilon_0 akT]$ found in equation (12)*

FACTRE - Value of the quantity $[\pi\tilde{v}a^2/2]$ found in equation (12)* $[m^3/sec]$

RSIZE - Radius of a particular particle (m)

CNUMBR - Charge number of a particular particle at time TIMEF

J - Index which runs over different particle size bands

II - Index which runs over subincremental lengths

ITER - Counter which keeps track of the number of iterations which is limited by NITER

OLDQF(K) - Value of field charge on the different particle sizes at the end of a given increment or subincrement (coul)

OLDQT(K) - Value of diffusion charge on the different particle sizes at the end of a given increment or subincrement (coul)

SOLDQF(K) - Value of field charge on the different particle sizes at the start of an increment which must be saved for the iteration procedure over subincrements in a given increment (coul)

SOLDQT(K) - Value of diffusion charge on the different particle sizes at the start of an increment which must be saved for the iteration procedure over subincrements in a given increment (coul)

CMKS - Value of the quantity $[4\pi\varepsilon_0]$ found in equation (12)* $[coul^2/nt\text{-}m^2]$

KA - Index which runs over the different linear electrical sections

ZWT - Total weight of material per cubic meter of gas removed up to a given increment (kg/m^3)

RATIO - Value of the quantity [(K-1)/(K+2)] found in the particle charging equations

G - Value of the quantity [K+2] found in the particle charging equations

INDEX - Indicator which keeps track of how many increments the calculation is into a particular linear electrical section

NCOOP - Indicator which allows certain calculations to be made only at the start of a new linear electrical section

SX - Wire-to-plate spacing in a particular linear electrical section (m)

RF - Roughness factor for the discharge wires in a particular linear electrical section

START - Particular value of START1(I) [A/m^2]

DSTART - Particular value of START2(I) [A/m^2]

CSTART - Particular value of START3(I) [A/m^2]

VSTART - Particular value of VSTAR(I) [V]

ZMFP - Ionic mean free path (m)

VAVG - Root mean square velocity of the ions (cm/sec)

VC - Value of the quantity [e^2/kT] found in the charging equations (coul/V)

FACTRC - Value of the quantity [$\pi\tilde{v}/2$] found in the charging equations (m/sec)

COEFFC - Value of the quantity [$e\pi b$] found in the charging equations (coul-m^2/V-sec)

TINC - Time interval for the gas to travel one increment (sec)

DTINC - Time interval for the gas to travel one subincrement (sec)

L - Index which runs over the different particle size bands

R - Value of the quantity [$eE_0/kT(K+2)$] found in equation (12)* [m^{-1}]

RR - Value of the quantity [eE_0/kT] found in equation (12)* [m^{-1}]

RG - Same as RR

VW - Operating applied voltage corresponding to a specified current density (V)

UEQ - Effective charge carrier mobility (m^2/V-sec)

NEC - Indicator which determines whether or not the average current density, average electric field, and average electric field at the plate are to be calculated in the subincremental lengths

AEPLT - Average electric field at the plate in a particular increment (V/m)

ACDNTY - Average current density at the plate in a particular increment (A/m^2)

NZ - Index which runs over subincremental lengths

CDCLN - Average current density at the plate when the gas is clean (A/m^2)

USUM - Sum of effective charge carrier mobilities over the subincremental lengths in a particular incremental length (m^2/V-sec)

WSSUM - Total weight of material per cubic meter of gas removed in a particular size band in a particular subincrement (kg/m^3)

RHOSUM - Sum of the ratio of the ionic space charge to the total space charge over the subincremental lengths in a particular incremental length

SW - Cumulative sum of estimated amount of material removed per second in successive length increments (kg/sec)

OROVRI - Ratio of total charge density to ionic charge density in increment prior to the one the calculation is in

XS - Computed value of the exponential argument in the Deutsch equation for the estimated or design overall mass collection efficiency

ETAPF - Overall mass collection fraction per increment based on the estimated or design efficiency

FID - Average free ion density ($\#/m^3$)

AVGFID - Average reduced free ion density for particle charging ($\#/cm^3$)

PROT - Total charge density due to particles that remain after passing through a given increment ($coul/m^3$)

SERAVG - Average electric field in a particular increment (V/m).

XIPC - Initial value of charge number on a given particle size at the start of a new increment

H - Increment size for the Runge-Kutta integration of equation (12)* [sec]

DCONST - Value of the quantity $[(K-1)a^3/(K+2)]$ found in equation (12)* $[m^3]$

CONST - Value of the quantity $[2(K-1)a^3E_0/(K+2)]$ found in equation (12)* $[V\text{-}m^2]$

S - Value of the quantity [3a] found in equation (12)* [m]

ECONST - Value of the quantity $[3eE_0a/kT(K+2)]$ found in equation (12)*

FCONST - Value of the quantity $[(K-1)eE_0a^3/kT(K+2)]$ found in equation (12)* $[m^2]$

COEFF - Value of the quantity $[bqs/4\varepsilon_0]$ found in equation (12)* $[m^3/sec]$

CTIME - Time at the end of a given increment (sec)

EMV(K) - Unadjusted, ideal migration velocities for the different particle sizes in a given increment (m/sec)

X - Exponent used in the Deutsch equation to determine the unadjusted, ideal collection fractions for the different particle sizes in a given increment

EFF - Unadjusted, ideal collection fraction for a given particle size band in a given increment

DXNO - Number of particles per cubic meter of gas removed from a given particle size band in a given increment $(\#/m^3)$

DNSION - Ion density in the absence of particles $(\#/m^3)$

DELTNP - Number density of charges transferred from ions to particles in a given subincremental length $(\#/m^3)$

SUMMOB - Weighted summation of particle mobilities $(m^2/V\text{-}sec/m^3)$

PNUM - Total number of particles per unit volume of gas entering a given subincremental length $(\#/m^3)$

RHOP - Total average particulate charge density in a given subincremental length $(coul/m^3)$

TCHRG - Average particle charge density for a given particle size in a given subincremental length $(coul/m^3)$

PMOB - Weighted particulate mobility in a given subincremental length (m^2/V-sec)

TDNSP - Total average particulate charge number density in a given subincremental length (#/m^3)

RDNSI - Average reduced ion density in a given subincremental length (#/m^3)

SUMCD - Sum of the average current densities at the plate from the different increments in a particular linear electrical section (A/m^2)

SUMVO - Sum of the applied voltages from the different increments in a particular linear electrical section (V)

SKIP - Electric field at the plate in the increment prior to the one the calculation is in (V/m)

SIGMA - Difference between the ratio of the total space charge density to the ionic space charge density in the (I+1)-th and I-th increments

VERGE - Initial estimate of the space charge density at the corona wire to start the calculation of the electric field at the plate (coul/m^3)

CVERGE - Converged value of the space charge density at the wire in calculating the electric field at the plate (coul/m^3)

ZTM - Cumulative sum of the weight of material per cubic meter of gas collected up to a given particle size in a given increment (kg/m^3)

CZA - Ratio of the partial sum of the weight of dust removed per cubic meter of gas up the K-th particle size in a given increment to the total weight of dust removed per cubic meter of gas in a given increment

CZB - Ratio of the partial sum of the weight of dust removed per cubic meter of gas up to the (K-1)-th particle size in a given increment to the total weight of dust removed per cubic meter of gas in a given increment

TL1 - Difference between CZA and CZB for use in interpolating to find the mass median diameter of the collected dust

TL2 - Difference between 0.50 and CZB for use in interpolating to find the mass median diameter of the collected dust

KJ - Index which runs simultaneously with the index which runs over the different particle sizes and keeps track of the (K-1)-th particle size

ETC - Ideal, unadjusted overall mass collection efficiency for the entire precipitator (%)

DIFF - Difference between the calculated ideal, unadjusted overall mass collection efficiency and the estimated value

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE PRTINP USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

LK - Indicator which determines whether or not the input data are printed at a certain location in the program

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

NDSET - Counter which keeps track of the number of the particular set of nonideal conditions which is under consideration

DL - Inlet mass loading (kg/m^3)

DLB - Inlet mass loading ($grains/ft^3$)

PL - Total electrical length of the precipitator (m)

PLB - Total electrical length of the precipitator (ft)

RHO - Resistivity of the collected particulate layer (ohm-m)

RHOCGS - Resistivity of the collected particulate layer (ohm-cm)

NCARD - Counter which keeps track of the number of each successive imput data card

NENDPT - Number of particle diameters in the inlet cumulative percent by mass distribution

NDATA - Indicator which determines the type of data set that is to be read into the program

ITL(M) - Identifying label for the calculations

NEST - Indicator which specifies whether to use extensive calculations or estimation procedures in determining precipitator performance

NDIST - Indicator which specifies whether the user is to supply the inlet particle size distribution or the program is to calculate a log-normal distribution

NVI - Indicator which specifies whether to base the electrical calculation on known voltages and currents or on calculated voltage-current characteristics

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

NITER - Indicator which determines the maximum number of iterations over a loop that converges on overall mass efficiency or the number of iterations that will be performed over each incremental length of the precipitator in order to obtain self-consistent solutions for the electrical conditions

NCALC - Indicator which determines whether to use equation (12)* for particle charging or the sum of the classical field and diffusion charges

NRAPD - Number of rapping puff particle size distributions to be considered

NEFF - Indicator which determines whether the unadjusted, ideal or adjusted, no-rap efficiency is used to determine the mass reentrained due to rapping

NTEMP - Indicator which specifies whether the precipitator is cold or hot side

NONID - Number of nonideal conditions of gas velocity nonuniformity and gas sneakage and/or particle reentrainment without rapping to be considered

NN - Number of increments in the Runge-Kutta integration of equation (12)*

NUMINC - Number of increments in the Simpson's Rule integration over Θ in equation (12)*

IFINAL - Indicator which causes the calculation of successive points on the voltage-current curve to cease after IFINAL points

JI1 - Indicator which allows the initial increment size on current density in the calculation of the voltage-current curve to be changed after JI1-1 points are determined on the curve

JI2 - Indicator which allows the second increment size on current density in the calculation of the voltage-current curve to be changed after JI2-1 points are determined on the curve

VISKIP - Indicator which determines whether or not a dirty-gas voltage-current curve is calculated in each increment of length

VISAME - Indicator which determines whether or not a clean-gas voltage-current curve is calculated for each of the electrical sections or just the first electrical section

ETAO - Estimated or design overall mass collection efficiency (%)

DD - Mass density of the particles (kg/m^3)

EPS - Relative dielectric constant of the particles

VRATIO - Ratio of the peak applied voltage to the average for use in particle charging

US - Ion mobility at standard temperature and pressure (reduced ion mobility)

FPATH - Factor which scales the ion mean free path

EBD - Electrical breakdown strength of the gas near the collection electrode or the collected particulate layer (V/m)

ARD50(II) - Rapping puff mass median diameters (μm)

ARSIGM(II) - Rapping puff geometric standard deviations

ASNUCK(JJ) - Fractions of gas sneakage and/or particle reentrainment without rapping

AZIGGY(JJ) - Normalized standard deviations of the gas velocity distribution

AZNUMS(JJ) - Number of stages over which gas sneakage and/or particle reentrainment without rapping occur

NDCARD - Indicator which determines how the arrays ENDPT(L) and PRCU(L) should be printed

ENDPT(L) - Particle diameters in the inlet cumulative percent by mass distribution (μm and m)

D50 - Specified or fitted mass median diameter of the inlet particle size distribution based on a log-normal distribution (μm)

SIGMAP - Specified or fitted geometric standard deviation of the inlet particle size distribution based on a log-normal distribution

PRCU(L) - Cumulative percent by mass up to each particle size in the inlet particle size distribution (%)

NUMSEC - Number of linear electrical sections in the precipitator

LSECT(I) - Number of length increments in the different linear electrical sections

AS(I) - Collection plate areas for the different linear electrical sections (m^2)

VOS(I) - Applied voltages for the different linear electrical sections (V)

TCS(I) - Total current for the different linear electrical sections (A)

WLS(I) - Total wire length for the different linear electrical sections (ft^2)

ACS(I) - Corona wire radii for the different linear electrical sections (in.)

BS(I) - Wire-to-plate spacing for the different linear electrical sections (in.)

NWS(I) - Number of wires per electrical section per gas passage for the different linear electrical sections

SYS(I) - One-half the wire-to-wire spacing for the different linear electrical sections (in.)

VGS(I) - Gas volume flow rate for the different linear electrical sections (ft^3/min)

VGASS(I) - Gas velocity for the different linear electrical sections (ft/sec)

TEMPS(I) - Gas temperature for the different linear electrical sections (°F)

PS(I) - Gas pressure in the different electrical sections (atm)

VISS(I) - Gas viscosity for the different linear electrical sections (kg/m-sec)

LINCS(I) - Lengths of the increments taken in the different linear electrical sections (ft)

RFS(I) - Roughness factor for the corona wires in the different linear electrical sections

START1(I) - Specified initial current density at which the calculation of a voltage-current curve starts in a given electrical section and the initial current density increment size (A/m^2)

START2(I) - Specified increment in current density which is used in place of START1(I) when the JI1-th point on the voltage-current curve is reached (A/m^2)

START3(I) - Specified increment in current density which is used in place of START2(I) when the JI2-th point on the voltage-current curve is reached (A/m^2)

VSTAR(I) - Estimate of the applied voltage corresponding to the first point on the voltage-current curve as defined by START1(I) (V)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE SPCHG1 USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

I - Index which runs over the incremental lengths

SW - Cumulative sum of estimated amount of material removed per second in successive length increments (kg/sec)

ROVRI - Ratio of the total space charge density to the ionic space charge density

OROVRI - Ratio of total charge density to ionic charge density in increment prior to the one the calculation is in

ETAO - Estimated overall mass collection efficiency (%)

XS - Computed value of the exponential argument in the Deutsch equation for the estimated overall mass collection efficiency

LINC - Length of the increments taken in a particular linear electrical section (m)

PL - Total electrical length of the precipitator (m)

ETAPF - Overall mass collection fraction per increment based on the estimated efficiency

W - Total weight of particles per second passing into a particular linear electrical section (kg/sec)

DW(J) - Amount of material removed per increment on a total weight basis (kg)

CD - Average current density at the plate in a particular linear electrical section (A/m^2)

E - Elementary charge unit (coul)

U - Ion mobility adjusted for temperature and pressure (m^2/V-sec)

ERAVG - Average electric field used for particle charging (V/m)

FID - Average free ion density (#/m^3)

SUM - Total particulate charge density in a given increment based on saturation charges (coul/m^3)

NS - Number of different particle size bands in the inlet particle size distribution

L - Index which runs over the different particle size bands

QSAT(L) - Saturation charge for the different particle sizes (coul)

XNO(L) - Number of particles per cubic meter of gas in each size band at the start of each increment (#/m^3)

LSECT(I) - Number of length increments in the different linear electrical sections

NSECT - Indicator which keeps track of which electrical section the calculation is in

TC - Total current in a particular linear electrical section (A)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

ZC - Ratio of the particulate charge density to the ionic charge density (ratio of 200 times the particulate current to the total current)

AFID - Average reduced free ion density for particle charging in a particular length increment (#/m^3)

AVGFID - Average reduced free ion density for particle charging (#/cm^3)

XCD - Average current density at the plate in a particular length increment (nA/cm^2)

UEQ - Effective charge carrier mobility (m^2/V-sec)

XPI - Overall mass collection efficiency per increment based on the estimated efficiency (%)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE SPCHG2 USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

I - Index which runs over the incremental lengths

ETAO - Design overall mass collection efficiency (%)

XS - Computed value of the exponential argument in the Deutsch equation for the design overall mass collection efficiency

LINC - Length of the increments taken in a particular linear electrical section (m)

PL - Total electrical length of the precipitator (m)

ETAPF - Overall mass collection fraction per increment based on the design efficiency

DELTNP - Number density of charges transferred from ions to particles in a given subincremental length (#/m^3)

SUMMOB - Weighted summation of particle mobilities (m^2/V-sec/m^3)

PNUM - Total number of particles per unit volume of gas entering a given subincremental length (#/m^3)

RHOP - Total average particulate charge density in a given subincremental length (coul/m^3)

J - Index which runs over the different particle size bands

XNO(J) - Number of particles per cubic meter of gas in each size band at the start of each increment (#/m^3)

XDC(I,J) - Charge on each particle size at the end of each increment (coul)

TCHRG - Average particle charge density for a given particle size in a given subincremental length (coul/m^3)

CCF(J) - Cunningham correction factor for the different particle sizes

VIS - Gas viscosity in a particular linear electrical section (kg/m-sec)

RAD(J) - Radii of the different particle sizes (m)

DIFF - Difference between the charge on a given particle size in the (I+1)-th and I-th increments (coul)

II - Index which runs over the subincremental lengths

Q(J) - Charge on each particle size at the end of a particular increment (coul)

OLDQ(J) - Charge on the different particle sizes in the increment prior to the one under consideration (coul)

PMOB - Weighted particulate mobility in a given subincremental length (m^2/V-sec)

TDNSP - Total average particulate charge number density in a given subincremental length (#/m^3)

CHFID(II) - Average free ion densities for particle charging in subincremental lengths (#/m^3)

DNSION - Ion density in the absence of particles (#/m^3)

RDNSI - Average reduced ion density in a given subincremental length (#/m^3)

PIR - Ratio of the total charge density which can be accepted by particles in a given subincrement to the available free ion density

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

AFID - Average reduced free ion density for particle charging in a particular length increment (#/m^3)

AVGFID - Average reduced free ion density for particle charging (#/cm^3)

U - Ion mobility adjusted for temperature and pressure (m^2/V-sec)

E - Elementary charge unit (coul)

UEQ - Effective charge carrier mobility (m^2/V-sec)

RIOVR - Ratio of the ionic space charge density to the total space charge density

XPI - Overall mass collection efficiency per increment based on the design efficiency (%)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE EFLD1 USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

VO - Applied voltage (negative value used in calculations) [V]

PI - Value of the constant π

EPSO - Permittivity of free space ($coul^2/nt\text{-}m^2$)

AC - Radius of the corona wires (m)

RO - Radius of the corona wires (m)

ROC - Radius of the corona wires (cm)

RF - Roughness factor for the corona wires

TDK - Temperature of the gas stream (°K)

P - Pressure in the gas stream (atm)

RELD - Relative air density [$\delta = (T_0/T)(P/P_0)$]

EORO - Product of the corona starting electric field and the wire radius

CD - Average current density at the plate (A/m^2)

UEQ - Effective charge carrier mobility ($m^2/V\text{-}sec$)

VERGE - Initial estimate of the space charge density at the corona wire to start the calculation of the electric field at the plate ($coul/m^3$)

QZERO - Space charge density at the corona wire ($coul/m^3$)

I - Index which runs over grid points in the x-direction

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

J - Index which runs over grid points in the y-direction

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

MOBILT(I,J) - Array containing the values of effective charge carrier mobility at the different grid points (m^2/V-sec)

MAXJ - Upper limit that the calculated average current density at the plate cannot exceed (A/m^2)

MINJ - Lower limit that the calculated average current density at the plate cannot fall below (A/m^2)

NX1 - Number of grid intervals in the x-direction for the numerical calculations of electrical conditions

NY1 - Number of grid intervals in the y-direction for the numerical calculations of electrical conditions

SX - Wire-to-plate spacing in a particular linear electrical section (m)

AX - Interval size in the x-direction (m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section (m)

AY - Interval size in the y-direction (m)

AXS - Value of the quantity $[a_x^2]$ (m^2)

AYS - Value of the quantity $[a_y^2]$ (m^2)

ASP - Value of the quantity $[(a_x^2+a_y^2)/\varepsilon_0]$ (m^4-nt/coul^2)

ASS - Value of the quantity $[1/2(a_x^2+a_y^2)]$ (m^{-2})

Z - Counter which keeps track of the number of times the calculation iterates due to lack of convergence in the average current density at the plate

VCOOP(I,J) - Array containing the values of electric potential given equation (26)* at the different grid points (V)

V(I,J) - Array containing the value of the electric potential at each point in the grid during an iteration (V)

IZ - Same as Z

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

LL - Counter which keeps track of the number of times the calculation iterates due to lack of convergence in the electric potential at each point in the grid

RHO(I,J) - Array containing the value of the space charge density at each point in the grid during an iteration (coul/m^3)

EX(I,J) - Array containing the value of the component of the electric field intensity perpendicular to the plates at each point in the grid during an iteration (V/m)

EY(I,J) - Array containing the value of the component of the electric field intensity parallel to the plates at each point in the grid during an iteration (V/m)

Q1 - Value of the quantity $[2b_{i,1}]$ along the line AD where $b_{i,j}$ is the effective charge carrier mobility which is a function of position (m^2/V-sec)

Q2 - Value of the quantity $[2b_{i,1}a_x]$ along the line AD (m^3/V-sec)

Q3 - Value of the quantity $[2b_{i,1}a_y]$ along the line AD (m^3/V-sec)

Q4 - Value of the quantity $[2b_{i,1}a_xa_y]$ along the line AD (m^4/V-sec)

Q5 - Value of the quantity $[-\varepsilon_0E_x(2b_{i,1}a_y-a_yb_{i-1,1})]$ along the line AD ($coul^2$/nt-sec)

Q6 - Value of the quantity $[\varepsilon_0{}^2E_x{}^2(2b_{i,1}a_y-a_yb_{i-1,1})^2]$ along the line AD ($coul^4/nt^2$-sec^2)

Q7 - Value of the quantity $[4b^2_{i,1}a_xa_y{}^2\varepsilon_0E_x\rho_{i-1,1}]$ along the line AD where $\rho_{i,j}$ is the space charge density at the different grid points ($coul^2$-m^2/V^2-sec^2)

Q8 - Value of the quantity $[-\sqrt{Q6+Q7}]$ along the line AD (coul-m/V-sec)

P1 - Value of the quantity $[2b_{i,j}]$ along the line AB (m^2/V-sec)

P2 - Value of the quantity $[2b_{i,j}a_x]$ along the line AB (m^3/V-sec)

P3 - Value of the quantity $[2b_{1,j}a_y]$ along the line AB (m^3/V-sec)

P4 - Value of the quantity $[2b_{1,j}a_xa_y]$ along the line AB (m^4/V-sec)

P5 - Value of the quantity $[-\varepsilon_0E_y(2b_{1,j}a_x-a_xb_{1,j-1})]$ along the line AB ($coul^2$/nt-sec)

P6 - Value of the quantity $[\varepsilon_0{}^2E_y{}^2(2b_{1,j}a_x-a_xb_{1,j-1})^2]$ along the line AB ($coul^4/nt^2$-sec^2)

P7 - Value of the quantity $[4b^2_{1,j}a_x{}^2a_y\varepsilon_0E_y\rho_{1,j-1}]$ along the line AB ($coul^2$-m^2/V^2-sec^2)

P8 - Value of the quantity $[-\sqrt{P6+P7}]$ along the line AB (coul-m/V-sec)

R1 - Value of the quantity $[2b_{i,NY}]$ along the line BC (m^2/V-sec)

R2 - Value of the quantity $[2b_{i,NY}a_x]$ along the line BC (m^3/V-sec)

R3 - Value of the quantity $[2b_{i,NY}a_y]$ along the line BC (m^3/V-sec)

R4 - Value of the quantity $[2b_{i,NY}a_xa_y]$ along the line BC (m^4/V-sec)

R5 - Value of the quantity $[-\varepsilon_0E_x(2b_{i,NY}a_y-a_yb_{i-1,NY})]$ along the line BC ($coul^2$/nt-sec)

R6 - Value of the quantity $[\varepsilon_0{}^2E_x{}^2(2b_{i,NY}a_y-a_yb_{i-1,NY})]$ along the line BC ($coul^4/nt^2$-sec^2)

R7 - Value of the quantity $[4b^2_{i,NY}a_xa^2_y\varepsilon_0E_x\rho_{i-1,NY}]$ along the line BC ($coul^2$-m^2/V^2-sec^2)

R8 - Value of the quantity $[-\sqrt{R6+R7}]$ along the line BC (coul-m/V-sec)

D1 - Value of the quantity $[2b_{i,j}]$ for interior points in the grid (m^2/V-sec)

D2 - Value of the quantity $[2a_xb_{i,j}]$ for interior points in the grid (m^3/V-sec)

D3 - Value of the quantity $[2a_y b_{i,j}]$ for interior points in the grid (m^3/V-sec)

D4 - Value of the quantity $[2a_x a_y b_{i,j}]$ for interior points in the grid (m^4/V-sec)

D5 - Value of the quantity $[-\varepsilon_0(E_x(2a_y b_{i,j}-a_y b_{i-1,j}) + E_y(2a_x b_{i,j}-a_x b_{i,j-1}))]$ for interior points in the grid (coul^2/nt-sec)

D6 - Value of the quantity [D5·D5] (coul^4/nt^2-sec^2)

D7 - Value of the quantity $[4b^2_{i,j} a_x a_y \varepsilon_0(a_y E_x \rho_{i-1,j} + a_x E_y \rho_{i,j-1})]$ for interior points in the grid (coul^2-m^2/V^2-sec^2)

D8 - Value of the quantity $[-\sqrt{D6+D7}]$ for interior points in the grid (coul-m/V-sec)

OLDV(I,J) - Array containing the value of the electric potential at each point in the grid during the previous iteration (V)

OLDRO(I,J) - Array containing the value of the space charge density at each point in the grid during the previous iteration (coul/m^3)

CDNSTY(I,J) - Array containing the value of current density at each point in the grid (A/m^2)

ACDNTY - Average current density at the plate (A/m^2)

EPLT - Sum of the values of the electric field intensity at the plate (V/m)

AEPLT - Average electric field at the plate (V/m)

CVERGE - Converged value of the space charge density at the wire in calculating the electric field at the plate (coul/m^3)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE EFLD2 USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

IVCK - Indicator which terminates the calculation of points on the voltage-current whenever the specified applied voltage is reached and interpolated upon

VO - Specified operating applied voltage (V)

VSTART - Particular value of VSTAR(I) [V]

VW - Operating applied voltage corresponding to a specified current density (V)

AC - Radius of the corona wires (m)

RO - Radius of the corona wires (m)

TDK - Temperature of the gas stream (°K)

P - Pressure of the gas stream (atm)

RELD - Relative air density [$\delta = (T_0/T)(P/P_0)$]

ROC - Radius of the corona wires (cm)

RF - Roughness factor for the corona wires

EORO - Product of the corona starting electric field and the wire radius (V)

I - Index which runs over grid points in the x-direction

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

J - Index which runs over grid points in the y-direction

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

UEQ - Effective charge carrier mobility (m^2/V-sec)

MOBILT(I,J) - Array containing the values of effective charge carrier mobility at the different grid points (m^2/V-sec)

PI - Value of the constant π

EPSO - Permittivity of free space ($coul^2/nt\text{-}m^2$)

START - Particular value of START1(I) [A/m^2]

SSTART - Initial value of START which is saved (A/m^2)

MINJ - Lower limit that the calculated average current density at the plate cannot fall below (A/m^2)

MAXS - Particular value of current density on the voltage-current curve (A/m^2)

NX1 - Number of grid intervals in the x-direction for the numerical calculations of electrical conditions

NY1 - Number of grid intervals in the y-direction for the numerical calculations of electrical conditions

SX - Wire-to-plate spacing in a particular linear electrical section (m)

AX - Interval size in the x-direction (m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section

AY - Interval size in the y-direction (m)

AXS - Value of the quantity [a_x^2] (m^2)

AYS - Value of the quantity [a_y^2] (m^2)

ASP - Value of the quantity [$(a_x^2+a_y^2)/\varepsilon_0$] ($m^4$-nt/$coul^2$)

ASS - Value of the quantity [$1/2(a_x^2+a_y^2)$] (m^{-2})

IFINAL - Indicator which causes the calculation of successive points on the voltage-current curve to cease after IFINAL points

II - Index which runs over the different current densities to be used on the voltage-current curve

JI1 - Indicator which allows the initial increment size on current density in the calculation of the voltage-current curve to be changed after JI1-1 points are determined on the curve

DSTART - Particular value of START2(I) [A/m^2]

JI2 - Indicator which allows the second increment size on current density in the calculation of the voltage-current curve to be changed after JI2-1 points are determined on the curve

CSTART - Particular value of START3(I) [A/m^2]

MAXJ - Upper limit that the calculated average current density at the plate cannot exceed (A/m^2)

QZERO - Space charge density at the corona wire ($coul/m^3$)

NWIRE - Number of wires per electrical section per gas passage in a particular electrical section

Z - Counter which keeps track of the number of times the calculation iterates due to lack of convergence in the average current density at the plate

VCOOP(I,J) - Array containing the values of electric potential given equation (26)* at the different grid points (V)

V(I,J) - Array containing the value of the electric potential at each point in the grid during an iteration (V)

IZ - Same as Z

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

LL - Counter which keeps track of the number of times the calculation iterates due to lack of convergence in the electric potential at each point in the grid

RHO(I,J) - Array containing the value of the space charge density at each point in the grid during an iteration ($coul/m^3$)

EX(I,J) - Array containing the value of the component of the electric field intensity perpendicular to the plates at each point in the grid during an iteration (V/m)

EY(I,J) - Array containing the value of the component of the electric field intensity parallel to the plates at each point in the grid during an iteration (V/m)

Q1 - Value of the quantity $[2b_{i,1}]$ along the line AD where $b_{i,j}$ is the effective charge carrier mobility which is a function of position (m^2/V-sec)

Q2 - Value of the quantity $[2b_{i,1}a_x]$ along the line AD (m^2/V-sec)

Q3 - Value of the quantity $[2b_{i,1}a_y]$ along the line AD (m^3/V-sec)

Q4 - Value of the quantity $[2b_{i,1}a_xa_y]$ along the line AD (m^4/V-sec)

Q5 - Value of the quantity $[-\varepsilon_0E_x(2b_{i,1}a_y-a_yb_{i-1,1})]$ along the line AD ($coul^2$/nt-sec)

Q6 - Value of the quantity $[\varepsilon_0{}^2E_x{}^2(2b_{i,1}a_y-a_yb_{i-1,1})^2]$ along the line AD ($coul^4/nt^2$-sec^2)

Q7 - Value of the quantity $[4b_{i,1}^2a_xa_y{}^2\varepsilon_0E_x\rho_{i-1,1}]$ along the line AD where $\rho_{i,j}$ is the space charge density at the different grid points ($coul^2$-m^2/V^2-sec^2)

Q8 - Value of the quantity $[-\sqrt{Q6+Q7}]$ along the line AD (coul-m/V-sec)

P1 - Value of the quantity $[2b_{1,j}]$ along the line AB (m^2/V-sec)

P2 - Value of the quantity $[2b_{1,j}a_x]$ along the line AB (m^3/V-sec)

P3 - Value of the quantity $[2b_{1,j}a_y]$ along the line AB (m^3/V-sec)

P4 - Value of the quantity $[2b_{1,j}a_xa_y]$ along the line AB (m^4/V-sec)

P5 - Value of the quantity $[-\varepsilon_0E_y(2b_{1,j}a_x-a_xb_{1,j-1})]$ along the line AB ($coul^2$/nt-sec)

P6 - Value of the quantity $[\varepsilon_0{}^2E_y{}^2(2b_{1,j}a_x-a_xb_{1,j-1})^2]$ along the line AB ($coul^4/nt^2$-sec^2)

P7 - Value of the quantity $[4b_{1,j}^2a_x{}^2a_y\varepsilon_0E_y\rho_{1,j-1}]$ along the line AB ($coul^2$-m^2/V^2-sec^2)

P8 - Value of the quantity $[-\sqrt{P6+P7}]$ along the line AB (coul-m/V-sec)

R1 - Value of the quantity $[2b_{i,NY}]$ along the line BC (m^2/V-sec)

R2 - Value of the quantity $[2b_{i,NY}a_x]$ along the line BC (m^3/V-sec)

R3 - Value of the quantity $[2b_{i,NY}a_y]$ along the line BC (m^3/V-sec)

R4 - Value of the quantity $[2b_{i,NY}a_xa_y]$ along the line BC (m^4/V-sec)

R5 - Value of the quantity $[-\varepsilon_0E_x(2b_{i,NY}a_y-a_yb_{i-1,NY}]$ along the line BC ($coul^2$/nt-sec)

R6 - Value of the quantity $[\varepsilon_0{}^2E_x^2(2b_{i,NY}a_y-a_yb_{i-1,NY}]$ along the line BC ($coul^4/nt^2$-sec^2)

R7 - Value of the quantity $[4b_{i,NY}^2a_xa_y^2\varepsilon_0E_x\rho_{i-1,NY}]$ along the line BC ($coul^2$-m^2/V^2-sec^2)

R8 - Value of the quantity $[-\sqrt{R6+R7}]$ along the line BC (coul-m/V-sec)

D1 - Value of the quantity $[2b_{i,j}]$ for interior points in the grid (m^2/V-sec)

D2 - Value of the quantity $[2a_xb_{i,j}]$ for interior points in the grid (m^3/V-sec)

D3 - Value of the quantity $[2a_yb_{i,j}]$ for interior points in the grid (m^3/V-sec)

D4 - Value of the quantity $[2a_xa_yb_{i,j}]$ for interior points in the grid (m^4/V-sec)

D5 - Value of the quantity $[-\varepsilon_0(E_x(2a_yb_{i,j}-a_yb_{i-1,j}) + E_y(2a_xb_{i,j}-a_xb_{i,j-1}))]$ for interior points in the grid ($coul^2$/nt-sec)

D6 - Value of the quantity [D5·D5] ($coul^4/nt^2$-sec^2)

D7 - Value of the quantity $[4b_{i,j}^2a_xa_y\varepsilon_0(a_yE_x\rho_{i-1,j} + a_xE_y\rho_{i,j-1})]$ for interior points in the grid ($coul^2$-m^2/V^2-sec^2)

D8 - Value of the quantity $[-\sqrt{D6+D7}]$ for interior points in the grid (coul-m/V-sec)

OLDV(I,J) - Array containing the value of the electric potential at each point in the grid during the previous iteration (V)

OLDRO(I,J) - Array containing the value of the space charge density at each point in the grid during the previous iteration (coul/m^3)

CDNSTY(I,J) - Array containing the value of current density at each point in the grid (A/m^2)

ACDNTY - Average current density at the plate (A/m^2)

TEST - Absolute value of the difference between the calculated average current density at the plate and the specified value (A/m^2)

TEST1 - One percent of the calculated average current density at the plate (A/m^2)

EPLT - Sum of the values of the electric field intensity at the plate (V/m)

AEPLT - Average electric field at the plate (V/m)

EBD - Electrical breakdown strength of the gas near the collection electrode or the collected particulate layer (V/m)

OLDVW - The value of applied voltage at the point prior to the one under consideration (V)

OLDCD - The value of average current density at the plate at the point prior to the one under consideration (A/m^2)

NEC - Indicator which determines whether or not the average current density, average electric field, and average electric field at the plate are to be calculated in the subincremental lengths

K - Index which sequences the grid strips in the basic area for which the calculations are performed

RSUM - Average charge number density in a particular grid strip (#/m^3)

ESUM - Average electric field intensity in a particular grid strip (V/m)

EAVGS(K) - Array containing the average electric field intensities in the different grid strips in the basic area for which the calculations are performed (V/m)

CHFIDS(K) - Array containing the average charge number densities in the different grid strips in the basic area for which the calculations are performed (#/m^3)

NYY - Index which renumbers the grid strips so that by symmetry the area covered by the half-wire spacing which was not considered in the calculations can be taken into account

EAVG(L) - Array containing the average electric field intensities in the different grid strips which cover an area between successive wires (V/m)

CHFID(L) - Array containing the average charge number densities in the different grid strips which cover an area between successive wires (#/m^3)

L - Index which runs over and numbers the first (NY-1) grid strips in a given wire-to-wire spacing

KK - Index which runs over the different grid strips in the basic area for which the calculations are performed

M1 - Number of the first grid strip in the last (NY-1) grid strips in a given wire-to-wire spacing

M2 - Number of the last grid strip in a given wire-to-wire spacing

M - Index which runs over and numbers the last (NY-1) grid strips in a given wire-to-wire spacing

LL - Index which sequences the grid strips in the basic area for which the calculations are performed

NN - Index which runs over points in the y-direction

ECOLLS(LL) - Array containing the average electric field intensity at the plate in the different grid strips in the basic area for which the calculations are performed (V/m)

L1 - Index which renumbers the grid strips so that by symmetry the area covered by the half-wire spacing which was not considered in the calculations can be taken into account

ECOLL(L) - Array containing the average electric field intensity at the plate in the different grid strips which cover an area between successive wires (V/m)

L2 - Index which runs over the different grid strips in the basic area for which the calculations are performed

I1 - Number of the first grid strip in the last (NY-1) grid strips in a given wire-to-wire spacing

I2 - Number of the last grid strip in a given wire-to-wire spacing

I - Index which runs over and numbers the last (NY-1) grid strips in a given wire-to-wire spacing

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE CHARGN USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

H - Increment size used in the Runge-Kutta scheme (sec)

H2 - One-half the increment size chosen for the Runge-Kutta scheme (sec)

YI - Time at the start of a given increment or subincrement of the precipitator (sec)

Y - Time at the end of a given increment or subincrement of the precipitator (sec)

XI - Number of charges on a given particle size at the start of a given increment or subincrement of the precipitator

X - Number of charges on a given particle size at the end of a given increment or subincrement of the precipitator

I - Index which runs over the different points specified for use in the Runge-Kutta scheme

NN - Number of points specified for use in the Runge-Kutta scheme

ECHARG - Elementary charge unit (coul)

SCHARG - Saturation charge number from the field charging equation

NUMINC - Number of increments in the Simpson's Rule integration over Θ in equation (12)*

CONST - Value of the quantity $[2(K-1)a^3E_0/(K+2)]$ found in equation (12)* $[V\text{-}m^2]$

EZERO - Average electric field used for particle charging (V/m)

V - Value of the quantity $[e^2/4\pi\varepsilon_0 akT]$ found in equation (12)*

RSIZE - Radius of a particular particle (m)

ECONST - Value of the quantity $[3eE_0a/kT(K+2)]$ found in equation (12)*

CMKS - Value of the quantity $[4\pi\varepsilon_0]$ found in equation (12)* $[coul^2/nt\text{-}m^2]$

RR - Value of the quantity $[eE_0/kT]$ found in equation (12)* $[m^{-1}]$

FCONST - Value of the quantity $[(K-1)eE_0a^3/kT(K+2)]$ found in equation (12)* $[m^2]$

FACTOR - Value of the quantity $[\pi\tilde{v}a^2/2]$ found in equation (12)* $[m^3/sec]$

COEFF - Value of the quantity $[bqs/4\varepsilon_0]$ found in equation (12)* $[m^3/sec]$

AFID - Average reduced free ion density for particle charging in a particular length increment $(\#/m^3)$

T1 - Value of the charge-number rate to the particle surface at the point (XI,YI) multiplied by the stepsize H for use in the Runge-Kutta scheme

T2 - Value of the charge-number rate to the particle surface at the point (XI+H2, YI+T1/2) multiplied by the stepsize H for use in the Runge-Kutta scheme

T3 - Value of the charge-number rate to the particle surface at the point (XI+H2, YI+T2/2) multiplied by the stepsize H for use in the Runge-Kutta scheme

T4 - Value of the charge-number rate to the particle surface at the point (XI+H, YI+T3) multiplied by the stepsize H for use in the Runge-Kutta scheme

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR FUNCTION SUBPROGRAM RATE USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

ECHARG - Elementary charge unit (coul)

SCHARG - Saturation charge number from the field charging equation

NUMINC - Number of increments in the Simpson's Rule integration over θ (not used)

CONST - Value of quantity $[2(K-1)a^3E_0/(K+2)]$ found in equation (45) $[V\text{-}m^2]$

EZERO - Average electric field used for particle charging (V/m)

V - Value of the quantity $[e^2/4\pi\varepsilon_0 akT]$ found in equation (45)

RSIZE - Radius of a particular particle (m)

ECONST - Value of the quantity $[3eE_0a/kT(K+2)]$ found in equation (45) $[V\text{-}m^2]$

CMKS - Value of the quantity $[4\pi\varepsilon_0]$ found in equation (45) $[coul^2/nt\text{-}m^2]$

RR - Value of the quantity $[eE_0/kT]$ found in equation (45) $[m^{-1}]$

FCONST - Value of the quantity $[(K-1)eE_0a^3/kT(K+2)]$ found in equation (45) $[m^2]$

FACTOR - Value of the quantity $[\pi\tilde{v}a^2/2]$ found in equation (45) $[m^3/sec]$

COEFF - Value of the quantity $[bqs/4\varepsilon_0]$ found in equation (45) $[m^3/sec]$

AFID - Average reduced free ion density for particle charging in a particular length increment $(\#/m^3)$

NTIME - Instantaneous charging time (sec)

NUMBER - Instantaneous number of charges on a given particle size

INTGRL - Value of the integral appearing in equation (45)

NE - Negative of the instantaneous charge on a given particle size (coul)

T(I) - Roots of the Legendre polynomials of third order

A(I) - Gaussian weighting functions

THZERO - Maximum angle (θ_0) for field charging in radians

YFUC - The quadrature being computed

THETA - Values of the angle θ taken for the integration over θ in equation (45)

CTHETA - Value of the quantity [cos θ]

TCONST - Value of the quantity $[2(K-1)a^3E_0\cos\theta/(K+2)]$ (m^2-V)

ECOS - Value of the quantity [E_0 cos θ] (V/m)

C1 - Value of the quantity $[q/4\pi\varepsilon_0E_0\cos\theta]$

CO - Value of the quantity $[(K-1)a^3/(K+2)]$

RZERO - Radial distance from the center of a given particle at which the total radial component of the electric field is zero (m)

ARG1 - Argument of the exponential function inside the integral in equation (45)

YVAL - Integrand of the integral in equation (45)

RATE1 - Contribtuion to the particle charging rate due to the second term in equation (45) [#/sec]

ARG3 - Argument of the exponential function in the third term in equation (45)

RATE2 - Contribution to the particle charging rate due to the third term in equation (45)

RATE3 - Contribution to the particle charging rate due to the first term in equation (45) [#/sec]

RATE - Total instantaneous charging rate to the entire surface of a given particle (#/sec)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE ARCCOS USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

A - Numerator of the ratio A/B whose inverse cosine is to be determined

B - Denominator of the ratio A/B whose inverse cosine is to be determined

ACOS - Value of the quantity $[\cos^{-1}(A/B)]$ (radians)

RATIO - Value of the ratio A/B

T - Variable used to generate the different numerical coefficients in the series representation of the inverse cosine function

SUM - Sum of successive terms in the series representation of the inverse cosine function

TERM - A particular term in the series representation of the inverse cosine function

U - Variable used in the generation of the numerical coefficients in the series representation of the inverse cosine function

V - Variable used in the generation of the numerical coefficients in the series representation of the inverse cosine function

W - Variable used in the generation of the numerical coefficients in the series representation of the inverse cosine function

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE ZERO USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

C1 - Value of the quantity $[q/4\pi\epsilon_0 E_0 \cos\theta]$ found in equation (52)*

C0 - Value of the quantity $[(K-1)a^3/(K+2)]$ found in equation (52)* $[m^3]$

RZERO - Radial distance from the center of a given particle at which the total radial component of the electric field is zero (m)

B - Value of the argument of the inverse cosine function found in equation (55)*

C - Value of the inverse cosine function found in equation (55)*

D - Factor multiplying the cosine function found in equation (12)*

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE CHGSUM USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NVI - Indicator which specifies whether to base the electrical calculation on known voltages and currents or on calculated voltage-current characteristics

I - Index which runs over incremental lengths

II - Index which runs over subincremental lengths

OLDQF(J) - Value of field charge on the different particle sizes at the end of a given increment or subincrement (coul)

OLDQT(J) - Value of diffusion charge on the different particle sizes at the end of a given increment or subincrement (coul)

ITER - Counter which keeps track of the number of iterations which is limited by NITER

SOLDQF(J) - Value of field charge on the different particle sizes at the start of an increment which must be saved for the iteration procedure over subincrements in a given increment (coul)

SOLDQT(J) - Value of diffusion charge on the different particle sizes at the start of an increment which must be saved for the iteration procedure over subincrements in a given increment (coul)

E - Elementary charge unit (coul)

SCHARG - Saturation charge number from the field charging equation

SATCHG - Saturation charge for a given particle size from field charging theory (coul)

CHRFID - Average free ion density for particle charging ($\#/m^3$)

U - Ion mobility adjusted for temperature and pressure (m^2/V-sec)

EPSO - Permittivity of free space ($coul^2/nt\text{-}m^2$)

TIMEF - Final value of time for particle charging (sec)

TIMEI - Initial value of time for particle charging (sec)

CF1 - Value of the quantity $[(N_0be/4\varepsilon_0)(t_f-t_i)]$ found in equation (15)*

CF2 - Value of the quantity $[1/(1-q_i/q_s)]$ found in equation (15)*

QF - Charge on a given particle size in a given increment or subincrement due to field charging (coul)

V - Value of the quantity $[e^2/4\pi\varepsilon_0 akT]$ found in equation (15)*

ARG - Value of the quantity $[q_i e/4\pi\varepsilon_0 akT]$ found in equation (15)*

RSIZE - Radius of a particular particle (m)

VAVC - Root mean square velocity of the ions (m/sec)

BC - Boltzmann's constant (J/°K)

TDK - Temperature of the gas in a given electrical section (°K)

QT - Charge on a given particle size in a given increment or subincrement due to diffusion charging (coul)

CNUMBR - Total charge number on a given particle size in a given increment or subincrement

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE PRTINC USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NPRINT - Indicator which designates when to print certain sectionalized data

NSECT - Indicator which keeps track of which electrical section the calculation is in

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

ITL - Identifying label for the calculations

SLNGTH - Length of a particular electrical section (m)

A - Collection plate area of a particular linear electrical section (m^2)

VO - Applied voltage in a particular linear electrical section (V)

TC - Total current in a particular linear electrical section (A)

B - Wire-to-plate spacing in a particular linear electrical section (m)

AC - Corona wire radius in a particular linear electrical section (m)

WL - Total wire length in a particular linear electrical section (m)

CL - Total current per length of corona wire in a particular linear electrical section (A/m)

CD - Average current density at the plate in a particular linear electrical section (A/m^2)

ET - Average electric field in the deposited particulate layer in a particular linear electrical section (V/m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section (m)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

VGAS - Gas velocity in a particular linear electrical section (m/sec)

TDK - Temperature of the gas in a given electrical section (°K)

P - Gas pressure in a particular linear electrical section (atm)

VIS - Gas viscosity in a particular linear electrical section (kg/m-sec)

U - Ion mobility adjusted for temperature and pressure (m^2/V-sec)

VAVC - Root mean square velocity of the ions (m/sec)

TMFP - Ionic mean free path multiplied by a factor (m)

W - Total weight of particles per second passing into a particular linear electrical section (kg/sec)

LINC - Length of the increments taken in a particular linear electrical section (m)

XPI - Overall mass collection efficiency per increment based on the estimated or design efficiency (%)

NVI - Indicator which specifies whether to base the electrical calculation on known voltages and currents or on calculated voltage-current characteristics

RIOVR - Ratio of the ionic space charge density to the total space charge density

ERAVG - Average electric field used for particle charging (V/m)

EPLT - Absolute value of the average electric field at the plate in a particular length increment (V/m)

AFID - Average reduced free ion density for particle charging in a particular length increment (#/m^3)

XCD - Average current density at the plate in a particular length increment (nA/cm^2)

ZMD - Interpolated mass median diameter of the collected particulate layer (m)

WT - Total weight of material per cubic meter of gas removed in all particle size bands in a given length increment (kg/m^3)

LTHICK - Thickness of the collected particulate layer in a particular increment of length (mm/min)

JPART - Current density due to particles in a particular increment of length (A/m^2)

JION - Current density due to ions in a particular increment of length (A/m^2)

I - Index which runs over incremental lengths

ROVRI - Ratio of the total space charge density to the ionic space charge density

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE PRTCHG USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

NCALC - Indicator which determines whether to use equation (12)* for particle charging or the sum of the classical field and diffusion charges

NEST - Indicator which specifies whether to use extensive calculations or estimation procedures in determining precipitator performance

JS - Index which is utilized in dividing the output data for particle charging into sets of eight columns each with a column for each particle size band

KS - Index which is utilized in dividing the output data for particle charging into sets of eight columns each with a column for each particle size band

NS - Number of different particle size bands in the inlet particle size distribution

DIAM(J) - Diameters of the different particle sizes (μm and m)

J - Index which runs over the different particle size bands

I - Index which runs over incremental lengths

NF - Number of increments taken along the length of the precipitator

NVI - Indicator which specifies whether to base the electrical calculation on known voltages and currents or on calculated voltage-current characteristics

NI - Number of subincremental lengths into which the incremental length is divided

N - Number of the subincremental strip having the maximum values of average electric field and current density

PI - Value of the constant π

EPSO - Permittivity of free space ($coul^2/nt\text{-}m^2$)

RAD(J) - Radii of the different particle sizes (m)

TMFP - Ionic mean free path multiplied by a factor (m)

EAVG(N) - Average electric fields for particle charging in subincremental lengths (V/m)

EPS - Relative dielectric constant of the particles

VRATIO - Ratio of the peak applied voltage to the average for use in particle charging

XDC(I,J) - Charge on each particle size at the end of each increment (coul)

QSATM - Saturation charge for a given particle size based on the last electrical section and the subincremental strip containing the largest values of average electric field and current density (coul)

YY(J) - Array containing the ratio of the charge on a given particle size to the saturation charge in the last electrical section for a given increment

QSAT(J) - Saturation charge for a given particle size based on the last electrical section and the average electric field for the entire section (coul)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE ADJUST USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NRUN - Indicator that specifies which set of nonideal conditions is under consideration

NS - Number of different particle size bands in the inlet particle size distribution

NS1 - Number of particle size bands plus one

NUMSEC - Number of linear electrical sections in the precipitator

NUMS1 - Number of electrical sections less one

TDK - Temperature of the gas stream in the last electrical section (°K)

PS(NUMSEC) - Pressure of the gas stream in the last electrical section (atm)

CONVF - Conversion factor which converts kg/ACM to mg/DSCM

NRAPDC - Counter which keeps track of the number of rapping puff particle size distributions that have been considered

X - Ideal, unadjusted overall mass collection fraction (or efficiency) [no units or %]

I - Index which runs over the different particle size bands

DXS(I) - Total number of particles removed per cubic meter of gas in each particle size band under ideal conditions and with no empirical corrections (#/m^3)

ONO(I) - Initial number of particles per cubic meter of gas in each particle size band (#/m^3)

EFESR - Ideal, unadjusted mass collection fraction for a given particle size

PCNT(I) - Percentage or fraction by mass in the inlet particle size distribution of the different size bands (% and decimal)

ARD50(J) - Rapping puff mass median diameters (μm)

ARSIGM(J) - Rapping puff geometric standard deviations

RMMD - Particular value of ARD50(J) [μm]

RSIGMA - Particular value of ARSIGM(J)

RPRCU(I) - Cumulative fraction by mass as a function of particle size for the rapping puff

RPCNT(I) - Percentages by mass in the different particle size bands for the rapping puff (%)

NONCK - Counter which keeps track of the number of sets of nonideal conditions of nonuniform velocity distribution and gas sneakage and/or particle reentrainment without rapping that have been considered

ASNUCK(K) - Fractions of gas sneakage and/or particle reentrainment without rapping

SNUCK - Particular value of ASNUCK(K)

AZIGGY(K) - Normalized standard deviations of the gas velocity distribution

ZIGGY - Particular value of AZIGGY(K)

AZNUMS(K) - Number of stages over which gas sneakage and/or particle reentrainment without rapping occur

ZNUMS - Number of stages over which gas sneakage and/or particle reentrainment without rapping occur for a particular case

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

Y - Adjusted overall mass collection fraction (or efficiency) under no-rap conditions (no units or %)

XEP - Adjusted mass collection fraction for a given particle size band under no-rap conditions

XMV(I) - Effective migration velocities for the different particle sizes under ideal conditions and with no empirical corrections (m/sec)

WY - Adjusted migration velocity for a given particle size under no-rap conditions (cm/sec)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

ATOTAL - Total collection plate area of the precipitator (m^2)

F1 - Correction factor for the migration velocity of a given particle size in order to account for non-uniform velocity distribution

F2 - Correction factor for the migration velocity of a given particle size in order to account for gas sneakage and/or particle reentrainment without rapping

WYS - Migration velocity of a given particle size corrected only for gas sneakage and/or particle reentrainment without rapping (cm/sec)

WYV - Migration velocity of a given particle size corrected only for nonuniform velocity distribution (cm/sec)

ZNLFF - Combined correction factor for nonuniform velocity distribution and gas sneakage and/or particle reentrainment without rapping

WYSV - Migration velocity of a given particle size corrected only for nonuniform gas velocity distribution and gas sneakage and/or particle reentrainment without rapping (cm/sec)

WUNCOR(I) - Unadjusted, ideal migration velocities for the different particle sizes (cm/sec)

EUNCOR(I) - Unadjusted, ideal mass collection efficiencies for the different particle sizes (%)

DIAM(I) - Diameters of the different particle sizes (μm and m)

PXS(I) - Number of particles per cubic meter of gas for a given particle size that are removed by the precipitator under adjusted, no-rap conditions (#/m^3)

IDC - Indicator which controls when the summation of outlet emissions over the different particle size bands will be performed

SPO - Total outlet emissions under adjusted, no-rap conditions (#/m^3)

SCPO - Total outlet emissions under rap + no-rap conditions (#/m^3)

IX - Indicator which determines when the total electrical length up to the last electrical section will be calculated

SCOREF - Overall mass collection efficiency under no-rap + rap conditions (%)

XY - Percentage by mass in a given particle size in the inlet particle size distribution (%)

PENTR - Percentage by mass of a given particle size that penetrates through the precipitator under adjusted, no-rap conditions (%)

PCTOT(I) - Percentage by mass in a given particle size band in the no-rap outlet emissions (%)

CLPTLS - Total electrical length of the precipitator excluding the last electrical section (m)

IS - Index which runs over the different linear electrical sections

LSECT(IS) - Number of length increments in the different linear electrical sections

LINCS(IS) - Lengths of the increments taken in the different linear electrical sections (ft)

NYX - Index which starts and terminates a loop in which the mass loss due to rapping and the mass leaving the precipitator under no-rap conditions are determined

XEFF - Overall mass collection fraction for either unadjusted, ideal or adjusted, no-rap conditions

NEFF - Indicator which determines whether the unadjusted, ideal or adjusted, no-rap efficiency is used to determine the mass reentrained due to rapping

EXPONT - Argument of the exponential function in equation (2) for either the unadjusted, ideal efficiency or the adjusted, no-rap efficiency

DL - Inlet mass loading (kg/m^3)

PL - Total electrical length of the precipitator (m)

XMELS - Mass entering the last section of the precipitator from either unadjusted, ideal or adjusted, no-rap calculations (kg/m^3)

XMCLS - Mass collected in the last section of the precipitator from either unadjusted, ideal or adjusted, no-rap calculations (kg/m^3 or mg/DSCM)

XMLLS - Mass leaving the last section of the precipitator from either unadjusted, ideal, or adjusted, no-rap calculations (kg/m^3)

NTEMP - Indicator which specifies whether the precipitator is cold or hot side

RAPLOS - Mass contained in the outlet emissions due to rapping (mg/DSCM)

YMELS - Mass entering the last section of the precipitator from adjusted, no-rap calculations (kg/m^3)

YMCLS - Mass collected in the last section of the precipitator from adjusted, no-rap calculations (kg/m^3 or mg/DSCM)

YMLLS - Mass leaving the last section of the precipitator from adjusted, no-rap calculations (kg/m^3)

DD - Mass density of the particles (kg/m^3)

RNS - Number of particles per cubic meter of gas in a given size band that are contained in the emissions due to rapping ($\#/m^3$)

EFFWR - Mass collection fraction for a given particle size containing all corrections and adjustments

CRNP - Number of particles per cubic meter of gas in a given size band that are collected after rapping ($\#/m^3$)

COREFF - Mass collection efficiency for a given particle size containing all corrections and adjustments (%)

WYP - Migration velocity for a given particle size containing all corrections and adjustments (cm/sec)

CPENTR - Percent penetration of a given particle size containing all corrections and adjustments (%)

CPCTOT(I) - Percentage by mass in a given size band contained in the no-rap + rap emissions (%)

SL - Number of particles per cubic meter of gas of a given particle size band exiting the precipitator under no-rap conditions (#/m^3)

RAD(I) - Radii of the different particle sizes (m)

WSL(I) - Weight per cubic meter of gas of particles in a given size band exiting the precipitator under no-rap conditions (kg/m^3)

ENDPT(I) - Particle diameters in the inlet cumulative percent by mass distribution (μm and m)

DLD - Value of the quantity [$\Delta \log_{10} D$] for a given particle size band in the size distribution histogram

DMDLD(I) - Value of the quantity [$\Delta M/\Delta \log_{10} D$] for the different particle size bands in the outlet emissions under no-rap conditions (mg/DSCM)

RDMDLD(I) - Value of the quantity [$\Delta M/\Delta \log_{10} D$] for the different particle size bands in the outlet emissions due to rapping only (mg/DSCM)

CDMDLD(I) - Value of the quantity [$\Delta M/\Delta \log_{10} D$] for the different particle size bands in the outlet emissions under no-rap + rap conditions (mg/DSCM)

CCF(I) - Cunningham correction factor for the different particle sizes

ETAO - Estimated or design overall mass collection efficiency (%)

ZMMDI - Specified or fitted mass median diameter of the inlet particle size distribution based on a log-normal distribution (μm)

SIGMI - Specified or fitted geometric standard deviation of the inlet particle size distribution based on a log-normal distribution

NDIST - Indicator which specifies whether the user is to

supply the inlet particle size distribution or the program is to calculate a log-normal distribution

GFIT - Linear-correlation coefficient obtained in the log-normal fit of the inlet particle size distribution

PRCUNR(I) - Cumulative percentage by mass as a function of particle size for the outlet emissions under no-rap conditions (%)

SUMNR - Summation over the different particle size bands of the percentage by mass contained in each size band for the outlet emissions under no-rap conditions (%)

ZMDL - Fitted mass median diameter of the outlet no-rap emissions based on a log-normal distribution (μm)

SIGMO - Fitted geometric standard deviation of the outlet no-rap emissions based on a log-normal distribution

ZGFIT - Linear-correlation coefficient obtained in the log-normal fit of the outlet no-rap emissions

COREFW - Precipitation rate parameter under no-rap + rap conditions (cm/sec)

WZ - Precipitation rate parameter under no-rap conditions (cm/sec)

PRCUC(I) - Cumulative percentage by mass as a function of particle size for the outlet emissions under no-rap + rap conditions (%)

SUMC - Summation over the different particle size bands of the percentage by mass contained in each size band for the outlet emissions under no-rap + rap conditions (%)

CZMDL - Fitted mass median diameter of the outlet no-rap + rap emissions based on a log-normal distribution (μm)

CSIGMO - Fitted geometric standard deviation of the outlet no-rap + rap emissions based on a log-normal distribution

CGFIT - Linear-correlation coefficient obtained in the log-normal fit of the outlet no-rap + rap emissions

M - Index which runs over the different particle size bands

NONID - Number of nonideal conditions of gas velocity non-uniformity and gas sneakage and/or particle reen-trainment without rapping to be considered

NRAPD - Number of rapping puff particle size distributions to be considered

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE WADJST USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

DIAM(I) - Diameters of the different particle sizes (μm and m)

I - Index which runs over the different particle size bands

WY - Enters the subroutine as the unadjusted, no-rap migration velocity for a given particle size and leaves as the adjusted, no-rap migration velocity (cm/sec)

ONO(I) - Initial number of particles per cubic meter of gas in each particle size band (#/m^3)

PXS(I) - Number of particles per cubic meter of gas for a given particle size that are removed by the precipitator under adjusted, no-rap conditions (#/m^3)

ATOTAL - Total collection plate area of the precipitator (m^2)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

EFESR - Mass collection fraction for a given particle size under adjusted, no-rap conditions

CFACT(L) - Correction factors for the no-rap migration velocities of the different particle sizes

DCHECK(L) - Particle diameters corresponding to the different correction factors given by CFACT(L) [m]

L - Index which runs over the different values of CFACT(L) and DCHECK(L)

WFACT - Interpolated correction factor for the unadjusted, no-rap migration velocity of a given particle size

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE LNDIST USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

D50 - Specified or fitted mass median diameter of the inlet particle size distribution based on a log-normal distribution (μm)

SIGMAP - Specified or fitted geometric standard deviation of the inlet particle size distribution based on a log-normal distribution

PRCU(I) - Cumulative fractions by mass up to specified particle sizes

PCNT(J) - Fractions by mass contained in specified particle size bands

Y(K) - Values of the log-normal distribution function at different values of the independent variable for use in integrating the function over the specified size bands

Z(K) - Cumulative integrals resulting from the integration of the log-normal distribution function over a specified particle size band

AREA(J) - Amount of the distribution accumulated in a given particle size band

NS - Number of particle size bands

ENDPT(I) - Particle diameters specified for use in constructing the log-normal distribution histogram (μm)

NENDPT - Number of particle diameters specified for use in constructing the log-normal distribution histogram

PI - Value of the constant π

SIGMAZ - Value of the quantity [$\ln \sigma_p$]

N - Total number of particle size bands used in constructing the log normal distribution histogram

NINC - Number of points used in the Trapezoidal Rule integrations over the different particle size bands

ASUM - Value of the integration of the log-normal distribution function over the entire distribution

K - Index which runs over the NS different particle size bands specified by the user

J - Index which runs over the N different particle size bands used in the construction of the log-normal distribution histogram

X2 - Upper limit of integration for a given particle size band

X1 - Lower limit of integration for a given particle size band

DX - Stepsize taken for the Trapezoidal Rule integration of the log-normal distribution function over the different particle size bands

D - Value of the integration variable at different points in a given particle size band

SGT1 - Value of the quantity $[1/\sigma_z\sqrt{2\pi}]$

SGT2 - Value of the quantity $[2\sigma_z^2]$

I - Index which runs over the different points in a given particle size band in performing the Trapezodial Rule integration of the log-normal distribution function

SUM - Total fraction by mass contained in the histogram specified by the user

CHECK1 - Difference between 1 and the calculated total mass fraction contained in the histogram specified by the user

CHECK2 - Difference between 1 and the calculated cumulative fraction by mass up to the largest particle size specified by the user

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE QTFE USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

DX - Stepsize used in the Trapezoidal Rule integration scheme

Y(I) - Function values used in the integration scheme

Z(I) - Cumulative integrals resulting from the integration scheme

NINC - Number of points used in the integration scheme

SUM2 - Cumulative integral up to a given point in the integration scheme

DDX - One-half of the specified stepsize

I - Index which runs over the different points in the integration scheme

SUM1 - Cumulative integral up to the point prior to the point under consideration

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE LNFIT USED IN THE ELECTRISTATIC PRECIPITATOR PERFORMANCE MODEL

PRCU(I) - Known or calculated cumulative percentages supplied by the user (%)

D50 - Fitted mass median diameter based on a log-normal distribution (μm)

SIGMAP - Fitted geometric standard deviation based on a log-normal distribution

GFIT - Linear-correlation coefficient obtained in the log-normal fit

Z(I) - Natural logarithm of the actual particle diameters corresponding to the known or calculated cumulative percentages

Y(I) - Calculated natural logarithm of the particle diameters corresponding to the known or calculated cumulative percentages based on a true log-normal distribution

ENDPT(I) - Actual particle diameters corresponding to the known or calculated cumulative percentages (μm)

NENDPT - Number of particle diameters corresponding to the known or calculated cumulative percentages

NSTAG - Number of points used in the log-normal fit procedure

I - Index which runs over the different particle diameters corresponding to the known or calculated cumulative percentages

J - Index which sequences the points which are actually used in the log-normal fit

XY - Cumulative mass fraction less than a given particle size

XYY - Square root of the natural logarithm of the square of the reciprocal of XY

A - Y-intercept of the fitted straight line

B - Slope of the fitted straight line

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE CFIT USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

A - Y-intercept of the fitted straight line

B - Slope of the fitted straight line

R - Linear-correlation coefficient for the straight line fit

NSTAG - Number of data points that are fitted to the straight line

Z(I) - Values of the independent variable

Y(I) - Values of the dependent variable

XN - Running sum over the number of data points

SUMX - Summation over all data points of the values of the independent variable

SUMY - Summation over all data points of the values of the dependent variable

SUMXY - Summation over all data points of the values of the product of the independent and dependent variables

SUMXX - Summation over all data points of the values of the square of the independent variable

SUMYY - Summation over all data points of the values of the square of the dependent variables

I - Index which runs over the different data points

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE PRTSUM USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

ATOTAL - Total collection plate area of the precipitator (m^2)

VG - Gas volume flow rate in a particular electrical section (m^3/sec)

SCA - Specific collection area of the precipitator (m^2/m^3/sec)

VOSUM - Sum of the applied voltages in the different linear electrical sections (V)

CDSUM - Sum of the current densities in the different linear electrical sections (nA/cm^2)

NUMSEC - Number of linear electrical sections in the precipitator

LSECT(I) - Number of length increments in the different linear electrical sections

LINCS(I) - Lengths of the increments taken in the different linear electrical sections (ft)

I - Index which runs over the different linear electrical sections

VOS(I) - Applied voltages for the different linear electrical sections (V)

TCS(I) - Total current for the different linear electrical sections (A)

AS(I) - Collection plate areas for the different linear electrical sections (m^2)

AVO - Average applied voltage over the entire precipitator (V)

PL - Total electrical length of the precipitator (ft and m)

ACD - Average current density over the entire precipitator (nA/cm^2)

RHO - Resistivity of the collected particulate layer (ohm-m)

RHOCGS - Resistivity of the collected particulate layer (ohm-cm)

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

NRUN - Indicator that specifies which set of nonideal conditions is under consideration

SCOREF - Overall mass collection efficiency under no-rap + rap conditions (%)

ZMMDI - Specified or fitted mass median diameter of the inlet particle size distribution based on a log-normal distribution (μm)

SIGMI - Specified or fitted geometric standard deviation of the inlet particle size distribution based on a log-normal distribution

CZMDL - Fitted log-normal mass median diameter of the outlet particle size distribution under no-rap + rap conditions (μm)

CSIGMO - Fitted log-normal geometric standard deviation of the outlet particle size distribution under no-rap + rap conditions

SNUCK - Particular value of ASNUCK(JJ)

ZIGGY - Particular value of AZIGGY(JJ)

RMMD - Particular value of ARD50(II) [μm]

RSIGMA - Particular value of ARSIGM(II)

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE CMAN USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

NX1 - Number of grid intervals in the x-direction for the numerical calculations of electrical conditions

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

NY1 - Number of grid intervals in the y-direction for the numerical calculations of electrical conditions

SX - Wire-to-plate spacing in a particular linear electrical section (m)

AX - Interval size in the x-direction (m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section (m)

AY - Interval size in the y-direction (m)

I - Index which runs over grid points in the x-direction

J - Index which runs over grid points in the y-direction

X - Value of x representing grid points (m)

Y - Value of y representing grid points (m)

VW - Electrical potential at the wire (V)

VCOOP(I,J) - Array containing the values of static potential at the different grid points (V)

NWIRE - Number of wires per electrical section per gas passage in a particular electrical section

M - Series sum in equation (1) is taken from -M to M

SUMX - Term in the sum for x-component of static electric field

SUMY - Term in the sum for y-component of static electric field

S1 - Parameter used in computing x-component of field at wire

S2 - Parameter used in computing y-component of field at wire

EXSUM - Parameter used in computing x-component of static field

EYSUM - Parameter used in computing y-component of static field

H3 - Sine function in equation (2)

F3 - Sine function in equation (1)

NUM - Sum in equation (1)

DENOM - Sum in the denominator of equation (2)

PI - Value of the constant π

E1 - Arguments for the hyperbolic cosine functions in equation (1)

F1 - Arguments for the cosine functions in equation (1)

G1 - Arguments for the hyperbolic cosine functions in the denominator of equation (2)

H1 - Arguments for the cosine functions in the denominator of equation (2)

E2 - Hyperbolic cosine functions in the denominator of equation (2)

F2 - Cosine functions in the denominator of equation (2)

G2 - Hyperbolic cosine functions in the denominator of equation (2)

H2 - Cosine functions in the denominator of equation (2)

TT - Argument for the logarithmic function in equation (1)

TB - Argument for the logarithmic function in the denominator of equation (2)

F - Logarithmic function in equation (1)

G - Logarithmic function in the denominator of equation (2)

E3 - Hyperbolic sine function in equation (1)

G3 - Hyperbolic sine function in equation (2)

ECX(I,J) - Array containing values of the x-component of the static field

ECY(I,J) - Array containing values of the y-component of the static field

X1(I) - Array containing x-components of grid points

Y1(J) - Array containing y-components of grid points

LTEST - Logical variable which determines when to use X1&Y1

NVII - Integer which determines when the approximations are used

EXO - Parameter used to compute x-component of field at wire

EYO - Parameter used to compute y-component of field at wire

LIST OF NECESSARY VARIABLES, DEFINITIONS, AND UNITS FOR SUBROUTINE EFLD3 USED IN THE ELECTROSTATIC PRECIPITATOR PERFORMANCE MODEL

IVCK - Indicator which terminates the calculation of points on the voltage-current whenever the specified applied voltage is reached and interpolated upon

VO - Specified operating applied voltage (V)

VSTART - Particular value of VSTAR(I) [V]

VW - Operating applied voltage corresponding to a specified current density (V)

AC - Radius of the corona wires (m)

RO - Radius of the corona wires (m)

TDK - Temperature of the gas stream (°K)

P - Pressure of the gas stream (atm)

RELD - Relative air density [$\delta = (T_0/T)(P/P_0)$]

ROC - Radius of the corona wires (cm)

RF - Roughness factor for the corona wires

EORO - Product of the corona starting electric field and the wire radius (V)

I - Index which runs over grid points in the x-direction

NX - Number of grid points in the x-direction for the numerical calculations of electrical conditions

J - Index which runs over grid points in the y-direction

NY - Number of grid points in the y-direction for the numerical calculations of electrical conditions

UEQ - Effective charge carrier mobility (m^2/V-sec)

NWIRE - Number of wires per electrical section per gas passage in a particular electrical section

VCOOP(I,J) - Array containing the values of static potential at the grid points (V)

V(I,J) - Array containing the value of the electric potential at each point in the grid during an iteration (V)

NPRNT - Indicator which specifies the unit number of the output device for printing data from the program

RHO(I,J) - Array containing the value of the space charge density at each point in the grid during an iteration (coul/m^3)

EX(I,J) - Array containing the value of the component of the electric field intensity perpendicular to the plates at each point in the grid during an iteration (V/m)

EY(I,J) - Array containing the value of the component of the electric field intensity parallel to the plates at each point in the grid during an iteration (V/m)

LTEST - Logical variable which determines whether a uniform grid spacing is used

NVII - An integer which determines whether measured operating conditions are used or a theoretical I-V curve is generated

ECX(I,J) - x-component of the static electric field

ECY(I,J) - y-component of the static electric field

X1(I) - Position of grid points in the x-direction

Y1(J) - Position of grid points in the y-direction

AX(I) - Grid point separation in the x-direction

AY(J) - Grid point separation in the y-direction

Z - Dummy arguments in statement functions COSH(Z) and SINH(Z)

R - Ratio R1/Sx

A1 - Constant = $\pi/2Sx$

B1 - Constant = $2J/b\varepsilon_0$

MOBILT(I,J) - Array containing the values of effective charge carrier mobility at the different grid points (m^2/V-sec)

PI - Value of the constant π

EPSO - Permittivity of free space ($coul^2/nt\text{-}m^2$)

START - Particular value of START1(I) [A/m^2]

SSTART - Initial value of START which is saved (A/m^2)

MAXS - Particular value of current density on the voltage-current curve (A/m^2)

NX1 - Number of grid intervals in the x-direction for the numerical calculations of electrical conditions

NY1 - Number of grid intervals in the y-direction for the numerical calculations of electrical conditions

SX - Wire-to-plate spacing in a particular linear electrical section (m)

AX - Interval size in the x-direction (m)

SY - One-half the wire-to-wire spacing in a particular linear electrical section

AY - Interval size in the y-direction (m)

IFINAL - Indicator which causes the calculation of successive points on the voltage-current curve to cease after IFINAL points

II - Index which runs over the different current densities to be used on the voltage-current curve

JI1 - Indicator which allows the initial increment size on current density in the calculation of the voltage-current curve to be changed after JI1-1 points are determined on the curve

DSTART - Particular value of START2(I) [A/m^2]

JI2 - Indicator which allows the second increment size on current density in the calculation of the voltage-current curve to be changed after JI2-1 points are determined on the curve

CSTART - Particular value of START3(I) [A/m^2]

BIR - Constant = $(B1)^{\frac{1}{2}}$

C1 - Constant = $B1Sy/\pi$

VWIR - Space charge contribution to the potential from points outside Sy

EXWIR - Space charge contribution to the x-component of the field from points outside Sy

EYWIR - Space charge contribution to the y-component of the field from points outside Sy

E1 - Independent variable associated with F1 in the method of false position

E2 - Independent variable associated with F2 in the method of false position

E3 - The latest estimate of the root of F in the method of false position

F1 - Negative value of the function in the method of false position

F2 - Positive value of the function in the method of false position

F - Function in the method of false position whose root determines when the specified operating voltage has been obtained

NW - Number of wires per electrical section per gas passage in a particular electrical section

R1 - Distance from the wire at which the analytic solutions are matched

SUM1 - A sum over the wires which contributes to the static potential at the wire

SIG1 - A sum over the wires which contributes to the static potential at the wire

RM - Floating point whole number used to avoid problems with mixed mode arithmetic

CH - Hyperbolic cosine function in the static potential expression evaluated at y = Sy

POT1 - A constant used in evaluating the static potential at the wire

SUMV - A sum over the space charge cylinders which contributes to the static potential at the wire

SUMW - Quantity = 2SUM1

SQON - A parameter to help simplify the coding of the mathematical expressions in the electrical solutions

SQOP - A parameter to help simplify the coding of the mathematical expressions in the electrical solutions

RNN - A parameter to help simplify the coding of the mathematical expressions in the electrical solutions

RNP - A parameter to help simplify the coding of the mathematical expressions in the electrical solutions

ARGR - A constant = $\pi R1/2Sx$

FAC1 - The expression represented by F in equation (22)

ACOS - The value of ARCCOS (Sy/R1) in equation (22)

DUM - The quantity shown in brackets in equation (22)

RLAM - The predicted value of static potential at the wire

RAD - A parameter used to simplify the coding of the mathematical expressions in the electrical solutions

RASX - A parameter used to simplify the coding of the mathematical expressions in the electrical solutions

RAR1 - A parameter used to simplify the coding of the mathematical expressions in the electrical solutions

RONSP - A parameter used to match the charge density profiles at x = R1

CLAM - A parameter used to match the x-components of the electric field at x = R1

WLAM - A parameter used to specify the effective value of space charge density outside the region of Sy

VNAUT - A parameter used to match the potentials at x = R1

VT - The total potential at the wire

ICOUNT - An integer which counts the number of tries to match the specified operating voltage in the method of false position

I11 - Do loop parameter which increments x over the grid points

I12 - Do loop parameter which increments y over the grid points

SQRN - Parameter which simplifies coding the mathematical expressions in the electrical solutions

SQRP - Parameter which simplifies coding the mathematical expressions in the electrical solutions

SQXN - Parameter which simplifies coding the mathematical expressions in the electrical solutions

SQXP - Parameter which simplifies coding the mathematical expressions in the electrical solutions

ARGX - Quantity = $\pi x/2Sx$

ARGY - Quantity = $\pi y/2Sy$

RAXY - Parameter which simplifies coding the mathematical expressions in the electrical solutions

RASXY - Parameter which simplifies coding the mathematical expressions in the electrical solutions

RAR1Y - Parameter which simplifies coding the mathematical expressions in the electrical solutions

COSHY - Hyperbolic cosine evaluated at $\pi y/2Sx$

SINHY - Hyperbolic sine evaluated at $\pi y/2Sx$

CX - Cosine function evaluated at $\pi x/2Sx$

VXYJ - Space charge contribution to the potential

EXJ - Space charge contribution to the x-component of the electric field

EYJ - Space charge contribution to the y-component of the electric field

RHOJ - Space charge density

SUMEX - A sum over space charge cylinders which contributes to the x-component of the electric field

SUMEY - A sum over space charge cylinders which contributes to the y-component of the electric field

COSX - Cosine function evaluated at $\pi x/2Sx$

SINX - Sine function evaluated at $\pi y/2Sy$

COSHN - The hyperbolic cosine function containing the negative sign in equations (8) - (13)

COSHP - The hyperbolic cosine function containing the positive sign in equations (8) - (13)

SINHN - The hyperbolic sine function containing the negative sign in equations (10) - (13)

SINHP - The hyperbolic sine function containing the positive sign in equation (10)

DENON - Quantity = $COSHN^2 - COSX^2$

DENOP - Quantity = $COSHP^2 - COSX^2$

TERMV - Logarithmic contributions to the potential from space charge at a point outside Sy

TEREX - Quantity used in summing the contributions to the x-component of the field from space charge outside Sy

SUMEX - The sum contributing to the x-component of the field due to space charge outside Sy

TEREY - Quantity used in summing the contributions to the y-component of the field from space charge outside Sy

SUMEY - The sum contributing to the y-component of the field due to space charge outside Sy

OLDV(I,J) - Array containing the value of the electric potential at each point in the grid during the previous iteration (V)

OLDRO(I,J) - Array containing the value of the space charge density at each point in the grid during the previous iteration (coul/m^3)

CDNSTY(I,J) - Array containing the value of current density at each point in the grid (A/m^2)

ACDNTY - Average current density at the plate (A/m^2)

EPLT - Sum of the values of the electric field intensity at the plate (V/m)

AEPLT - Average electric field at the plate (V/m)

EBD - Electrical breakdown strength of the gas near the collection electrode or the collected particulate layer (V/m)

OLDVW - The value of applied voltage at the point prior to the one under consideration (V)

OLDCD - The value of average current density at the plate at the point prior to the one under consideration (A/m^2)

NEC - Indicator which determines whether or not the average current density, average electric field, and average electric field at the plate are to be calculated in the subincremental lengths

K - Index which sequences the grid strips in the basic area for which the calculations are performed

RSUM - Average charge number density in a particular grid strip ($\#/m^3$)

ESUM - Average electric field intensity in a particular grid strip (V/m)

EAVGS(K) - Array containing the average electric field intensities in the different grid strips in the basic area for which the calculations are performed (V/m)

CHFIDS(K) - Array containing the average charge number densities in the different grid strips in the basic area for which the calculations are performed ($\#/m^3$)

NYY - Index which renumbers the grid strips so that by symmetry the area covered by the half-wire spacing which was not considered in the calculations can be taken into account

EAVG(L) - Array containing the average electric field intensities in the different grid strips which cover an area between successive wires (V/m)

CHFID(L) - Array containing the average charge number densities in the different grid strips which cover an area between successive wires ($\#/m^3$)

L - Index which runs over and numbers the first (NY-1) grid strips in a given wire-to-wire spacing

KK - Index which runs over the different grid strips in the basic area for which the calculations are performed

M1 - Number of the first grid strip in the last (NY-1) grid strips in a given wire-to-wire spacing

M2 - Number of the last grid strip in a given wire-to-wire spacing

M - Index which runs over and numbers the last (NY-1) grid strips in a given wire-to-wire spacing

LL - Index which sequences the grid strips in the basic area for which the calculations are performed

NN - Index which runs over points in the y-direction

ECOLLS(LL) - Array containing the average electric field intensity at the plate in the different grid strips in the basic area for which the calculations are performed (V/m)

L1 - Index which renumbers the grid strips so that by symmetry the area covered by the half-wire spacing which was not considered in the calculations can be taken into account

ECOLL(L) - Array containing the average electric field intensity at the plate in the different grid strips which cover an area between successive wires (V/m)

L2 - Index which runs over the different grid strips in the basic area for which the calculations are performed

I1 - Number of the first grid strip in the last (NY-1) grid strips in a given wire-to-wire spacing

I2 - Number of the last grid strip in a given wire-to-wire spacing

I - Index which runs over and numbers the last (NY-1) grid strips in a given wire-to-wire spacing

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT The report describes modifications to the EPA/Southern Research Institute computer model of electrostatic precipitation (ESP). The modifications include a new semi-empirical approximation procedure for predicting electrical conditions in an ESP. Comparisons between the results from the approximation procedure and more exact procedures are presented. A new integration procedure for calculating particle charge is also presented. Complete FORTRAN listings of the revised ESP model and the new subprograms are provided. Example problems are included. The modified model requires significantly less computer time than does the earlier model. Comparisons of results obtained using the earlier and the modified models over a wide range of possible ESP geometries and electrical operating points indicate that for practical purposes the modified model can be used in place of the more rigorous earlier model.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Control	13B
Electrostatic Precipitation	Stationary Sources	13H
Mathematical Models		12A
FORTRAN		09B

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