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A NUMERICAL SIMULATION OF THE DISPERSAL OF AERIAL SPRAYS

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NOMENCLATURE

A	Aircraft aspect ratio
b	Aircraft semispan, m
C	Concentration, volume/semispan^2
C_D	Drag coefficient, D/qs
C_L	Lift coefficient, L/qs
D_V	Diffusivity, cm^2/sec
F	Propeller thrust, N
F_r	Froude number, $U/\sqrt{bg}$
g	Gravitational constant, m/sec^2
h	Aircraft altitude, semispans
K	Inertia parameter, $\sigma\delta^2 U/18b\mu$
M_m	Mean molecular weight of gas mixture in transfer path
M_V	Mean molecular weight of evaporating material
m	Mass, Kg
P	Pressure, Kg/m^2 (lb/in^2)
P_f	Partial pressure of air, N/m^2
P_V	Vapor pressure of air, N/m^2
PK1 to PK4	Propeller constants
Q	Nozzle flow rate, volume/semispan along flight path
Q_p	Propeller torque, N-m
r	Radial coordinate, in propeller radii
R	Droplet Reynolds number $\rho\delta U\lvert\bar{u} - \dot{\bar{\eta}}\rvert/\mu$
R_U	Droplet free stream Reynolds number, $\rho\delta U/\mu$
R_P	Propeller radius, m
S_c	Schmidt number, $\rho D_V/\mu$
T	Temperature, K(^{o}R)
t	Time, secs
U	Free stream velocity, m/sec
u	Local flowfield velocity, dimensionless with U
V	Cummulative volume percent
V_{cw}	Crosswind velocity component, m/sec
x, y, z	Cartesian coordinates
x_o, y_o, z_o	Initial droplet position (nozzle location), semispans
σ	Droplet density, Kg/m^3
σ_s	Standard deviation, microns
Γ	Aircraft circulation strength, m^2/sec
δ	Droplet diameter, microns
δ_m	Volume median droplet diameter, microns
η	Droplet position, dimensionless with b
μ	Air absolute viscosity, Kg/m-sec
ρ	Air density, Kg/m^3
τ	Dimensionless time, Ut/b

Superscripts

$\dot{}$	Derivative with respect to τ
$\bar{}$	Vector quantity

Subscripts

g	Final value at ground plane
wb	Wet bulb condition
db	Dry bulb condition

I. INTRODUCTION

The use of aerospace technology to improve aerial applications promises to yield significant improvements in the efficiency of operation, the environmental acceptability, and many other areas. One area of study is the interaction of the spray droplet with the aircraft wake. This interaction improves the overall efficiency of the operation by increasing the swath width, but also results in the drift of particles suspended in the wake to off target sites. The propeller slipstream and other nonuniform portions the wake also lead to nonuniform deposits of material inside the swath. This research uses an analytical approach to study this wake-particle interaction. Ultimately the goal of such a research effort will be to tailor the aircraft wake and dispersal system to produce a wide uniform distribution of material with minimum drift.

Reed[1] in 1954 presented a two-dimensional analysis of aerial applications. This report, aided by the techniques for trajectory analysis developed in the aircraft icing program, established the fundamentals of the method. This work was hampered by the limited computational capabilities of the time and Reed presents only a limited number of trajectories for his simple model. Bragg[2] improved this model by performing a three dimensional analysis including propeller slipstream effects Trayford and Welch[3] have made similar improvements including the effect of crosswind on the distribution. The present method is based on reference 2 but includes many improvements which have been developed by the author since the publication of reference 2.

The goal of this research was to document a method, and develop a computer code to simulate the dispersal of liquid sprays from agricultural aircraft. The program was to require small computation times so mathematical models and numerical procedures were kept as simple as possible while still modelling the fundamental physical phenomena. The program was written in such a way that a user could modify the wake model easily, while still using the particle dynamics model and the distribution and drift numerical procedures. The user may provide a flowfield code which can be inserted into this program by use of the USERV subroutine. This allows for the analysis of more complicated flowfields which may contain fuselage vortices, vortices off of flaps due to variable span loading, winglets, or more complicated flowfields due to unconventional aircraft configurations

The computer code consists of three main parts; the droplet dynamics and evaporation models, the aircraft wake models, and the distribution and drift prediction method. The theoretical basis for these models is derived in Section II and the method is compared to other results in Section III. Section IV is the computer program users' manual containing a description of the code and the input, output, and error messages. In the Appendices are sample cases and a complete listing of the code.

II. THEORETICAL DEVELOPMENT

In this section the mathematical models used for the droplet dynamics and the wake flowfield will be described. The numerical procedures used to solve these equation will also be presented.

Droplet Dynamics

By application of Newton's Second Law of Motion to a water droplet the differential equation describing the particle trajectory may be derived. Here particles in the 100 to 500 micron size range are considered. These particles are nearly spherical in shape[4] permitting the use of standard sphere drag data. In addition the analysis does not include the effect on the trajectory of atmospheric and aircraft induced turbulence, liquid droplet deformation and internal circulation, magnus forces, multiple particle interaction, and electric charge. For the aerial application problem these forces are considered negligible.

The equation of motion for a non-evaporating single particle moving in the wake of an aircraft can then be written as

$$m\left(\frac{d^2\bar{X}}{dt^2}\right) = \bar{D} + \bar{P} + \bar{M}_a + \bar{B} + m\bar{g} \qquad (1)$$

The apparent mass, $\bar{M}_a$, the pressure gradient term, $\bar{P}$, and the Bassett force, $\bar{B}$, become important only if the density of the particle is of lower, or similar order of magnitude as that of air[5]. In addition, the apparent mass and Bassett force terms could also become significant if the particle experiences a large acceleration. The particle could experience a sizeable acceleration when initially injected into the flow. This acceleration

is, however, of short duration and in the streamwise direction so as to have little effect on the final spanwise location of the particle. Therefore, noting that the density of water is much greater than that of air, and ignoring the initial acceleration effects; the apparent mass, the pressure gradient, and the Bassett force terms may be dropped from equation (1).

Now writing this equation in nondimensional form,

$$K\ddot{\bar{\eta}} = \frac{C_D R}{24}(\bar{u} - \dot{\bar{\eta}}) + \frac{1}{F_r^2}\,\frac{\bar{g}}{g} \tag{2}$$

where the nondimensional numbers K, the inertia parameter, and F_r, the Froude number are

$$K = \frac{\sigma \delta^2 U}{18 b \mu} \quad ; \qquad F_r = \frac{U}{\sqrt{bg}} \tag{3a,b}$$

An additional nondimensional number, R_U, the free stream droplet Reynolds number

$$R_U = \frac{\rho \delta U}{\mu} \tag{4}$$

results from the $\frac{C_D R}{24}$ term in equation (2). The droplets studied here experience relatively low Reynolds numbers well within the range of zero to one thousand. Several curve fits to the standard sphere drag curve are available in this range and all yield similar results. Here the equation by Langmuir[6]

$$\frac{C_D R}{24} = 1. + 0.19R^{0.63} + 2.6 \times 10^{-4} R^{1.38} \tag{5}$$

is used to calculate the sphere drag when computing the particle trajectories. Note that here R is the Reynolds number experienced

by the droplet based on the particle velocity relative to the surrounding fluid

$$R = \frac{\rho \delta U |\bar{u} - \dot{\bar{\eta}}|}{\mu} \tag{6}$$

The trajectory of a particle is then governed by equation (2) which is a non-linear, second order, ordinary differential equation which must in general be solved numerically The equation may be reduced to first order and separated into its three components to form a system of six simultaneous differential equations Given the six initial conditions of particle position and velocity when first injected into the aircraft flowfield, the trajectory may be calculated using a step integration method. The program uses a variable step size, predictor-corrector scheme suitable for stiff systems[7,8]. When compared against non-stiff methods this scheme shows a considerable decrease in computational time to achieve the same accuracy. The trajectory is terminated when the particle intersects the ground plane or becomes entrained in a vortex.

Evaporation Model

For small liquid droplets under roughly 150 microns in diameter evaporation effects often become significant As a result of evaporation the ground distribution of material is reduced and the material lost due to drift is greatly increased. To include the effect of evaporation, the analysis of Goering[9] is used.

Since the mass of the particle is no longer constant the differential equation (1) must be modified. Having already

incorporated the assumptions described early it becomes

$$m\left(\frac{d^2\bar{x}}{dt^2}\right) + \left(\frac{d\bar{x}}{dt}\right)\frac{dm}{dt} = \bar{D} + m\bar{g} \tag{7}$$

Nondimensionalizing, this equation becomes

$$K\left(\frac{d^2\eta}{d\tau^2}\right) = \left(\frac{C_D R}{24}\right)(\bar{u} - \dot{\bar{\eta}}) - \frac{3\dot{\bar{\eta}}K}{(\delta/b)}\left(\frac{d(\delta/b)}{d\tau}\right) + \frac{1}{Fr^2}\left(\frac{g}{g}\right) \tag{8}$$

Equation (8) is identical to equation (2) except for the addition of the second term on the right hand side which is due to the $\frac{dm}{dt}$ term in equation (7). An additional variable, δ, the particle diameter is introduced in equation (8) and another equation must be added to the system to allow a solution.

The expression for the rate of change of the particle diameter with respect to time is[9]

$$\left(\frac{d(\delta/b)}{d\tau}\right) = -\left(\frac{2}{\bar{U}}\right)\left(\frac{M_V}{M_m}\right)\left(\frac{D_V}{\delta}\right)\left(\frac{\rho}{\sigma}\right)\left(\frac{\Delta P}{P_f}\right)(2 + 0\ 6\ S_c^{1/3} R^{1/2}) \tag{9}$$

The terms on the right hand side may be evaluated in the following way.

It is assumed that the water droplet is diffusing into the air, therefore, the molecular weights are $M_m = 29\ 0$ and $M_V = 18.0$. The diffusion coefficient for water vapor into air is given as a function of temperature[9]

$$D_V = 5.28 \times 10^{-6}\ T_K^{1.88} \tag{10}$$

The term $\Delta P/P_f$ is shown by Goering[9] to be

$$\frac{\Delta P}{P_f} = \frac{P_{swb} - P_V}{P_{atm} - P_V} \tag{11}$$

Brooker[10] has developed a mathematical model for the psychrometric chart which is useful in evaluating equation (11). Input to the computer code are the atmospheric pressure, P_{atm}, and the wet and dry bulb temperatures, T_{wb} and T_{db} The saturation vapor pressure, P_{swb}, at wet bulb temperature, T_{wb}, is given by

$$P_{swb} = e^{54.6329 - \frac{12301.688}{T_{wb}} - 5.16923 \ln(T_{wb})} \tag{12}$$

and the vapor pressure, P_V, is

$$P_V = P_{swb} + \frac{0.2405(P_{swb} - P_{atm})}{0.62194(1075.8965 - 0.56983(T_{wb} - 491.69))}(T_{db}-T_{wb}) \tag{13}$$

In equation (12) and (13) the temperatures are in ^{o}R and the pressures are in psi. Equation (12) is valid only for temperatures above $32^{o}F$. Note that by definition $RH = P_V/P_s$, if the relative hunidity, RH, is available when T_{wb} is not.

The particle trajectory including the evaporation effect is calculated in the same manner as before, here using the differential equation (8) and adding to the system equation (9). Additional complications due to droplet evaporation which arise in the distribution and drift calculations will be discussed latter

Wake Flowfield

The flowfield model incorporated in the computer code is a horseshoe vortex system in ground effect. This simple model in either its 2-D or 3-D forms provides the wake velocities with a minimum of computer time, allowing for the small execution times characteristic of this program. In addition, a simple propeller, crosswind, and tunnel flowfield models are included in the code.

If these simple models are inadequate, the user may supply an alternate flowfield model by providing the proper subroutine. Here the flowfield models included in the code are discussed.

Basic Wake Model: The wake of an aircraft in ground effect may be modelled in three dimensions using a horse shoe vortex system. This model is reasonably accurate provided that, the wake roll-up occurs in a time much less than that of the particle trajectory, the particle trajectory intersects the ground before this system decays appreciably, and the particle remain outside of the viscous vortex cores and in the potential flow region. A two dimensional model can be formed consisting of only two doubly infinite straight trailing vortices and their reflection through the ground plane, figure 1. The strength of these vortices is calculated assuming an elliptical loading

$$\Gamma = \frac{4C_L Ub}{\pi A} \tag{14}$$

The motion of these vortices is given by Bragg[2] and the velocity can be calculated using the Biot-Savart law[1]. This model can be extended to three dimensions by adding a bound vortex of strength Γ on the aircraft quarter chord line, figure 2. The Biot-Savart Law is used to calculate the velocity induced in the x direction[2] and the y and z velocities are the same as in the two dimensional model.

It should be noted that the two dimensional model uses Reed's[1] correction for the bound vortex. If the user inputs zero for the initial droplet velocity, the program assigns to the droplet an initial velocity equal to the velocity the particle would have if

falling in free air in a constant flowfield with the velocity components equal to that existing in the 2-D model at the point of particle injection. This correction is ignored if instead non-zero initial droplet velocities are input to the computer program.

Tunnel Model· The two dimensional model of reference 2 has been included in this program. This permits the calculation of droplet trajectories from an aircraft model in a wind tunnel to evaluate the influence of the tunnel walls and the floor. The tunnel ceiling is assumed to have a negligible effect on the droplet trajectories since a model in ground effect will be in close proximity to the tunnel floor. The simple geometry of this model is shown in figure 3. A conformal mapping method is used to determine the velocity at a point in the tunnel due to the two dimensional vortex system. The complex function describing the velocity potential and stream function in free air is transformed to the plane with infinite reflections of this vortex system in the y direction by using a complex sine mapping function. The vortex position is determined by step integration using a truncated series to express the induced velocities on a vortex filament. The derivative of this complex function with respect to the complex particle position, yields the y and z velocities at any point in the tunnel.

Propeller Model: A propeller slipstream is characterized by a rotation in the y-z plane due to the torque and an increased axial velocity due to the generated thrust. Functional forms for the axial and rotational velocities as a function of radial

distance from the propeller hub have been assumed. These equations are of a form compatible with existing data on the thrust and torque loadings on general aviation propeller blades. The equation for the axial velocity is

$$V_{axial} = PK1(1. - r) + PK2(r)\ \sin(\pi r) \tag{15}$$

and the rotational velocity is given by

$$V_{rot} = PK3(1. - r) + PK4(r)\ \sin(\pi r) \tag{16}$$

Figure 4 shows the velocity distributions for a typical propeller model. PK1 and PK3 govern the velocities at the centerline while PK2 and PK4 control primarily the maximum velocities. For most applications PK3 = 0 and PK1 is set equal to some small fraction of PK2. Using equations (15) and (16) the slipstream can be integrated to determine the thrust, F, and the torque, Q_p. The thrust is

$$\begin{aligned} F = (RP)^2\pi\rho\Big[&2U(0.166667PK1 + 0.189304PK2) \\ &+ 0.0833333(PK1)^2 + 0.129006(PK1)(PK2) \\ &+ 0.0870040(PK2)^2\Big] \end{aligned} \tag{17}$$

and for the torque,

$$\begin{aligned} Q_p = 2\pi\rho(RP)^3\Big[&0.033333(PK1)(PK3) + 0.036657\Big[(PK1)(PK4) \\ &+ (PK2)(PK3)\Big] + 0.0507039(PK2)(PK4) + 0\ 083333U(PK3) \\ &+ 0.124801U(PK4)\Big] \end{aligned} \tag{18}$$

Equations (17) and (18) are then used to determine the constants PK1, PK2, PK3, and PK4 knowing the propeller thrust and torque This method assumes that the propeller slipstream extends downstream from the propeller disc plane to infinity with no dissipation.

In reality the rotational velocities are noticeably reduced due to viscous dissipation and the straighting effects of the main wing, fuselage, landing gear, horizontal, and vertical stabilizers. This reduction in rotational velocity is strongly dependent on the particular aircraft being modelled. It is recommended therefore that V_{rot}, that is PK3 and Pk4, be reduced from those calculated from equation (16). Although little experimental data is available on which to base this, a reduction to 75 percent of the calculated values seems reasonable from preliminary studies of conventional low wing monoplanes.

Crosswind Model: The component of the wind perpendicular to the flight path and parallel to the ground plane is modelled by the equation[11]

$$V_{cw} = VCW(z)^{0.25} \tag{19}$$

Here VCW is the crosswind component in m/sec 1 meter above the ground and z is the height above the ground plane in meters. The crosswind not only contributes a velocity in the y direction, but also causes a lateral translation of the entire aircraft wake system. This is modelled in the program by including the first order differential equations for the positions of the trailing vortices and propeller slipstream with the system of equations for the droplet trajectory and solving this enlarged system by the same step integration technique.

Distribution and Drift Model

By combining several droplet trajectories from a single nozzle location the ground deposition from the nozzle can be calculated

and the drift estimated. This procedure is straight forward for the case of no crosswind, evaporation, or propeller and was first developed for the aerial spray problem by Reed[1]. Here an improved form of Reed's analysis is used for the simple case and major changes are made to handle the more difficult case of the unsymmetric and often double valued distributions.

The concentration, C, from a single nozzle can be written as

$$C = Q \frac{dV}{d\delta} \frac{d\delta}{dy_g} \tag{20}$$

By superposition the concentration from any number of nozzles can be found The derivative $d\delta/dy_g$ can be found from the plot of the particle diameter as a function of the final lateral position where the particle intersects the ground plane. These points are cubic splined to obtain $d\delta/dy_g$. This value must then be multiplied by $dV/d\delta$, a function of δ and the particular nozzle used, which represents the volume of material released by the nozzle as a function of particle diameter. Here a normal distribution of material about some volume median diameter, δ_m, is assumed which gives

$$\frac{dV}{d\delta} = \frac{1}{\sqrt{2\pi}\ \sigma_s} \quad e^{-\frac{1}{2}\left(\frac{\delta - \delta_m}{\sigma_s}\right)^2} \tag{21}$$

where σ_s is the standard deviation The Q in equation (20) is the volume flow rate of the nozzle The concentration of material on the ground is then given by equation (20) and all that remains is to determine the drift.

The drift is estimated by an extrapolation procedure which finds the smallest particle, within some maximum allowable error, which reaches the ground. The amount of material in the distribution from particles smaller than this drifted particle is found by integration of the normal distribution function. The allowable error is a function of the number of standard deviations the particle size is from δ_m to control the error in terms of volume of material. Particles which encircle the wing-tip vortices are considered as drift and their trajectory calculations are terminated. In addition, off target distribution is also considered drift The user can select a lateral semispan distance beyond which the material is considered to be drift.

This procedure must be modified for unsymmetrical distributions or cases including droplet evaporation. As a result of the propeller slipstream effects or the crosswind model the calculation of $d\delta/dy_g$ can become more difficult. Here it is not uncommon for several particle sizes to intersect the ground at the same y_g location, thus making the function double valued The double valued and often erratic behavior of the curve makes the use of the cubic spline very difficult. Many points would be required to obtain a reasonable fit When these complications arise the program abandons the cubic spline and instead uses linear interpolation between the calculated trajectory points. In regions of large changes in slope the program automatically inserts additional particle trajectories using again an error parameter weighted from the volume median diameter. This method provides good results in a minimum of computer time. Here the drift is estimated in the same manner as before.

When the droplet evaporation is considered the mass lost through evaporation must be accounted for. This results in an increase in material lost due to drift and a decrease in the ground deposition. The final droplet diameter, δ_f, is determined as a function of the initial diameter, δ_o, by using a cubic spline on the results of the trajectory calculations. The distribution is then reduced by the ratio of δ_f^3/δ_o^3. In addition to the material which does not reach the ground or lies outside the target area, the amount of material which evaporates is determined by integration and included in the total drift. By using this procedure accurate drift and distributions are determined from the calculated particle trajectories.

III. CODE VALIDATION

Initial validation of the computer code was conducted by comparing the results of this method to the early analytical work of Reed[1]. Reed's method uses a two dimensional wake model without propeller, evaporation, or crosswind effects. The distribution is calculated using a least-squares fit of a second order polynomial to the trajectory data. A comparison of the two methods is shown in figure 5. Here the circulation, Γ, has been matched since the early work assumed a rectangular lift distribution. The comparison is quite good considering that modern digital computers were not available for Reed to make his trajectory calculations.

Comparisons of the code to experimental data is difficult because of the number of variables involved which are difficult to control or measure. Recent small scale model tests of agricultural aircraft dispensing scaled particles have generated some distribution data which may be used for comparison[12,13]. Figure 6 shows the measured distributions from three nozzles and the corresponding calculated distributions. The model used was unpowered with a wing semispan of 0.914m moving at 20.6 m/sec at an altitude of 0.51 semispans. The particles used were glass microbeads with a mean diameter of 125 microns and a density of 2.42 g/m^3. Since the test program was designed only to validate the scaling laws, no measurements of particle size distribution or nozzle volumetric flow rate was made. These parameters were estimated for this comparison. Note also that the concentration reported in reference 12 is in terms of the numbers of particles per unit area where this

method calculates concentration in terms of volume of material per unit area. This accounts for the difference in the areas under the curve and also for the larger measured concentrations to the right of the peak concentration where the particles are smaller in diameter. The difference in the distributions at the y_o = 0.30 nozzle location is due in part to the fuselage vortex not accounted for in the present flowfield model. The comparison in figure 5 is however, quite good overall and supports the analysis.

In figure 7, the present method is again compared to data from reference 12. Here the same model is used as in figure 5 but the altitude is 0.35 semispans. The lateral position of the nozzle is at 0.40 semispans and the particles have a mean diameter of 140 microns and a density of 0.58 g/m^3. These particles scaled to a 200 micron water droplet for the full scale aircraft. Here again the comparison is quite good considering the differences in the definition of concentration. The amount of lateral transport of the material and the general shape and magnitude of the concentration curves compare quite well.

The present method was also compared qualitatively to the powered test conducted in reference 12. Again considering the influence of the fuselage vortex the comparisons were encouraging. The amount of lateral transport due to the propeller was approximately the same if the calculated swirl velocity was reduced by 25% as discussed earlier to account for straighting effects. Sufficient data were not available to make a detailed comparison of the distributions.

Detailed comparisons of this method have been conducted with both analytical and experimental data. The method has

performed well over the range of parameters tested The code appears to do a good job of predicting the lateral transport of droplets in the wake of aircraft in ground effect.

IV. COMPUTER PROGRAM MANUAL

A computer program has been developed to predict the ground deposition resulting from the dispersal of water droplets into the wake of an aircraft in ground effect. A complete listing of this program has been provided in Appendix B. After a general description of the program, the input, output, error messages, and test cases will be presented in this section.

General Description

The computer code has been written in FORTRAN and developed on the AARL Harris Computer System. The code is in single precision and should execute on CDC systems with only minor changes. Conversion of the code to execute on IBM type machines should involve little more than a conversion to double precision and modifying the Hollerith codes. The code is approximately 2500 card images in length and requires 15 to 45 seconds of execution time per single nozzle deposition on the Harris SLASH 6 Computer. The Harris /6 is slightly slower than a CDC Cyber 73 and about 6 times slower than an IBM 370/168. Additional storage must be supplied to the program on octal file 10.

A plot package has been provided which is completely contained in subroutine PLOT1. A single call to this subroutine occurs as the last executable statement in the main program. Since the plot subroutine used here may not be compatible to those available on other systems, the program was written to allow for easy modification of the plot package.

Certain limitations on the size of the analysis that can be conducted considering the present DO loop parameters and array

dimensions should be discussed. The maximum swath width that can be used is ±10 semispans and the number of nozzles input can not exceed 100. The program is limited to 15 particle trajectories per nozzle including those determined internally to estimate the drift and improve accuracy in a region of a large change in lateral transport. Therefore no more than 10 particle diameters should ever be input and in general 5 to 7 is usually sufficient. No more than 1000 steps can be taken in the calculation of a single particle trajectory. The number of particles calculated and the number of steps can be controlled by use of the user input error parameters.

A flow chart including the major subroutines is shown in figure 8.

Input Data

The program reads the input from device 5 in the manner described below. Several options are available to the user with the acceptable combination of options shown in figure 9. In addition the user may supply the wake flowfield to be used by the inclusion of a subroutine USERV. This allows the present particle dynamics, including evaporation effects distribution, and drift models to be used with a different or more sophisticated wake model. USERV is described by comment statements in the listing. It may use by inclusion of the proper COMMON statements or subroutine calls use other variables and sections of the code as desired.

The inputs to the program are primarily physical variables in SI units. Some variables have been nondimensionalized where it

seemed the most logical approach It is hoped that this type of input will make the code more useful. It should be noted however, that the problem can be nondimensionalized as in reference 11. The number of independent parameters is much less than the number of physical variables input to this code. The inputs could have been in terms of completely nondimensional numbers such as $R_{\bar{U}}$, K, and F_r as discussed earlier. The use of this code for sensitivity analysis can, therefore, be greatly simplified by considering the nondimensional parameters.

Card 1· (Format 13A6) Title

Card 2: (Format I5)
NDROPS Number of trajectories to be run.
Set = 1 if NDIST = 1

Cards 3-8 repeated NDROPS times

Card 3: (Format 9I2, 2X, E15.6)

N2D = 0 For a 3D run
1 For a 2D run
2 For a 2D run using the user supplied USERV subroutine

N3D = 0 For a 2D run
1 For a 3D run
2 For a 3D run using the user supplied USERV subroutine

NEVAP = 0 No droplet evaporation
1 Droplet evaporation included

NPROP2 = 0 No propeller effects
1 Propeller slipstream model included

NCW = 0 No crosswind effects (set VCW = 0)
1 Crosswind effects included

NTUN = 0 No tunnel model
1 Tunnel model included

NDIST = 0 Single particle trajectory run
1 Ground depositions calculated

NPRINT = 0 Short output option
1 Long output option

NPLOT = 0 No plotting
1 Plot distribution of trajectories

EPS Step integration error control parameter, usually set equal to 1.E-5.

Card 4 included only if NEVAP = 1

Card 4: (Format 3F10.6)

PA Atomspheric pressure, N/m^2

TDB Dry bulb temperature, ^oC

TWB Wet bulb temperature, ^oC

Card 5 included only if NPROP2=1

Card 5: (Format 6F10.4)

ZPROP2 Z coordinate of propeller hub, semispans

PK1 to 4 Propeller slipstream constants as defined in Section II

RP Slipstream radius (usually equal to propeller radius), semispans

Card 6 (Format 7F10.4)

A Aircraft aspect ratio

CL Aircraft lift coefficient

B Aircraft semispan, m

U Aircraft speed, m/sec

G Gravitational constant, m/sec^2

ZYO Initial Y coordinate of trailing vortex, semispans

ZZO Initial Z coordinate of trailing vortex, semispans

Card 7: (Format 2E20.6, 2F10.4)

DA	Air Density (ignored if NEVAP = 1), Kg/m^3
VIS	Absolute air viscosity (ignored if NEVAP = 1), Kg/m-sec
VCW	Crosswind velocity (=0. if NCW = 0), m/sec
D	Tunnel width (ignored if NTUN = 0), m

Card 8 included only if NDIST = 0

Card 8: (Format 8F10.5)

DIA	Particle diameter, microns
DD	Particle density, Kg/m^3
X, Y, Z	Initial particle position, semispans
UD, VD, WD	Initial particle velocity relative to the aircraft fixed coordinate system, nondimensional with respect to U

Cards 9 to 16 included if NDIST = 1

Card 9: (Format 6I5)

NCOL	Number of nozzles
NROW	Number of initial particle sizes input
NDIAMN =	0 All nozzles the same DIAMN 1 DIAMN input for each nozzle
NSTDEV =	0 All nozzle have the same STDEV 1 STDEV input for each nozzle
NQ =	0 All nozzles have the same Q 1 Q input for each nozzle
NZNOZ =	0 All nozzles have same Z coordinates 1 Z input for each nozzle

Card 10: (Format 8F10 5)

DD	Particle density, Kg/m^3
XO	Nozzle X coordinate (ignored if N2D = 1), semispans
UDO, VDO, WDO	Initial particle velocity relative to the aircraft fixed coordinate system, nondimensional with respect to U
SWIDTH	One-half the swadth width calculated, semispans

DERR — Constant by which default error limits are multiplied, normally set equal to one

DWIDTH — Material landing beyond ± this value are considered drift, semispans

Card 11: (Formant 8F10.5)

YNOZ — Y coordinate of each nozzle (NCOL values), semispans

Card 12. (Format 8F10.5)

SIZE — Particle sizes input to represent distribution (NROW values), microns

Card 13: (Format 8F10.5)

DIAMN — Median particle diameter, microns
Input one value if NDIAMN = 0
Input NCOL values if NDIAMN = 1

Card 14: (Format 8F10 5)

STDEV — Standard deviation of particle size distribution, microns
Input one value if NSTDEV = 0
Input NCOL values if NSTDEV = 1

Card 15. (Format 8F10.5)

Q — Nozzle flow rate, unit volume/semispan along flight path
Input one value if NQ = 0
Input NCOL values if NQ = 1

Card 16 (Format 8F10 5)

ZNOZ — Z coordinate of nozzle, semispan
Input one value if NZNOZ = 0
Input NCOL values if NZNOZ = 1

Cards 1-16 may be repeated to run several cases simultaneously.

Output

The program first outputs all the basic input data. The variables output are all in the same units as the corresponding inputs. After this initial listing, the output depends primarily on only the choice of NDIST and NPRINT. The program's calculated output is all dimensionless unless indicated otherwise.

For the NDIST = 1 case and NPRINT = 1, the distribution from each individual nozzle is listed. The output is self explanatory, note that concentration has units of volume per semispan squared. If more than one particle size lands at the same lateral position, YG, the diameter, DIA, column is omitted. The rest of the output is the same for both the NPRINT = 0 and 1 options A table including the input values for each nozzle is output along with the drift in percent of total for each nozzle. Next a trajectory summary listing all the trajectories calculated is included before the final distribution The final distribution is a compilation of the distributions from all nozzles and is output in 0.01 semi-span increments. The total drift given is in percent of total material and is weighted by the volume flow rate of each nozzle. As a check, the total material reaching the tarjet area is also given. This is determined by a simple trapezoidal integration of the final integration and is meant only as a check. The accuracy of this estimate will be low for complicated distributions.

For the single particle trajectory calculations of NDIST = 0 the output is simple for NPRINT = 0. Here the initial inputs are output as before, followed by the final value of the variables in their normal units. The final values include particle position, velocity, droplet diameter for NEVAP = 1, and the nondimensional time, τ, required for the trajectory. This output is repeated for each particle trajectory.

If the user selects NPRINT = 1, all the dependent variables and the independent variable, τ, are output at each time step in the integration process. This can result in a great many lines

in some cases. Since so many combinations of variables are possible depending of the user options selected, no header is provided for this output. The variables are output in the following manner. Column 1 is always the step number and 2 the nondimensional time, τ. Columns 3-6 always contain, the lateral position, Y, the lateral velocity, VD, the vertical position, Z, and the vertical velocity, WD If the run is 3-D, columns 7 and 8 contain the streamwise position, X, and the corresponding velocity, UD. If NEVAP = 1 the last column always contains the current droplet diameter. The columns between WD or UD and the droplet diameter contain the vortex and propeller slipstream position. If options are selected making the entire flowfield transport laterally, the columns will be Y and Z coordinate of the left, then right trailing vortex and then the Y and Z position of the propeller slipstream. If all these variables are not present, the initial values make it clear which one is being output.

Error Messages

The program provides several internal error messages and warnings. These messages and the most likely user actions needed to correct the problem are given here

MESSAGE	COMMENT
Max Number of Runs Exceeded Before Drift Calculation Completed (E)	Number of Particle Trajectories Exceeds 15, Reduce NROW or Increase DERR
Trajectory Terminated, Propeller Slipstream Entrainment (W)	Particle Considered Drift

MESSAGE	COMMENT
DO Loop Parameter Exceeded in SUB2D (E)	Number of Steps Exceeds 1000, Increase EPS
Trajectory Completed, Z less Than Zero	Normal Trajectory Termination
Trajectory Terminated, Vortex Entrainment (W)	Particle Considered Drift
DO Loop Parameter Exceeded in SUB3D (E)	Number of Steps Exceeds 1000, Reduce EPS
NVAR Incorrect (E)	Illegal Combination of Options
Cubic Spline Problem Nozzle No DIA = (E)	Cubic Spline Provides Poor Fit to Trajectory Data, Change Error Parameters or Input Particle Diameters
Insufficient Data To Calculate Distribution (E)	Not Enough Trajectories to Cubic Spline Particle Diameters for NEVAP = 1 Case, Change Input Particle Diameter
Insufficient Data To Estimate Drift, Nozzle No. Drift Set Equal To Zero (E)	(Same as Above)
WDR Exceeded DO Loop in INCON (E)	Error in 2D Initial Droplet Velocity Calculation, Input Non Zero Initial Velocity, Often Due to Illegal Input
Right Endpoint in INCON Incorrect (E)	(Same as Above)
DO Loop Parameter in INCON Exceeded (E)	(Same as Above)

(E) ERROR (W) WARNING

Sample Cases

Five sample cases have been provided in Appendix A. These cases are intended both as examples and as check cases after the program has been installed on a new system. The complete input, output, and plots are given for each of the cases. With the use of the input and output descriptions in this section, the cases should be self explanatory.

V SUMMARY

A method has been developed and a computer program written to predict the dispersal of aerial sprays from agricultural aircraft. The method has been compared to early analytical results and recent experimental studies and found to compare well with these results A user's manual for the program including sample cases and FORTRAN program listing have been provided The code was written to allow the flexibility to install a more sophisticated wake model to increase the usefullness of the program. The computer program provides a useful tool to aid in agricultural aircraft and dispersal system design as well as for aerial applications research

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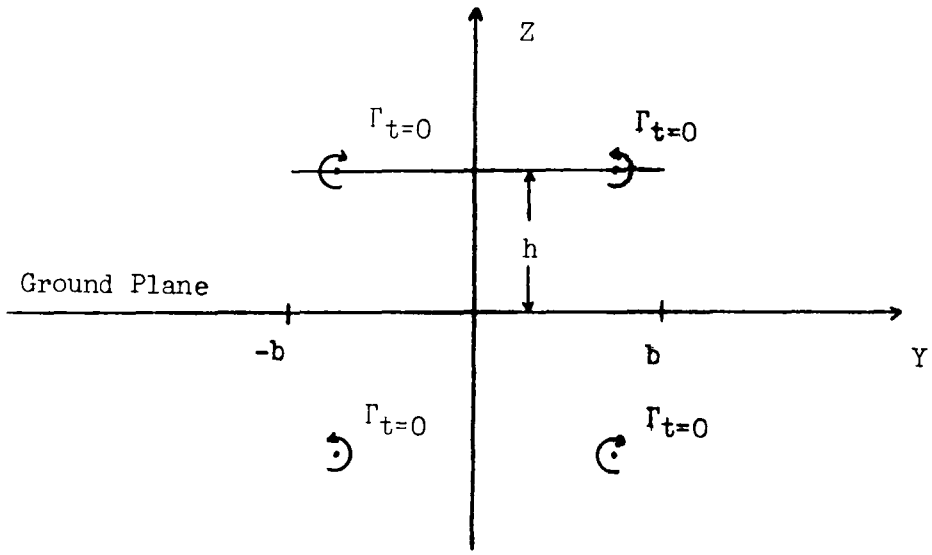

Figure 1. Two Dimensional Wake Vortex Model

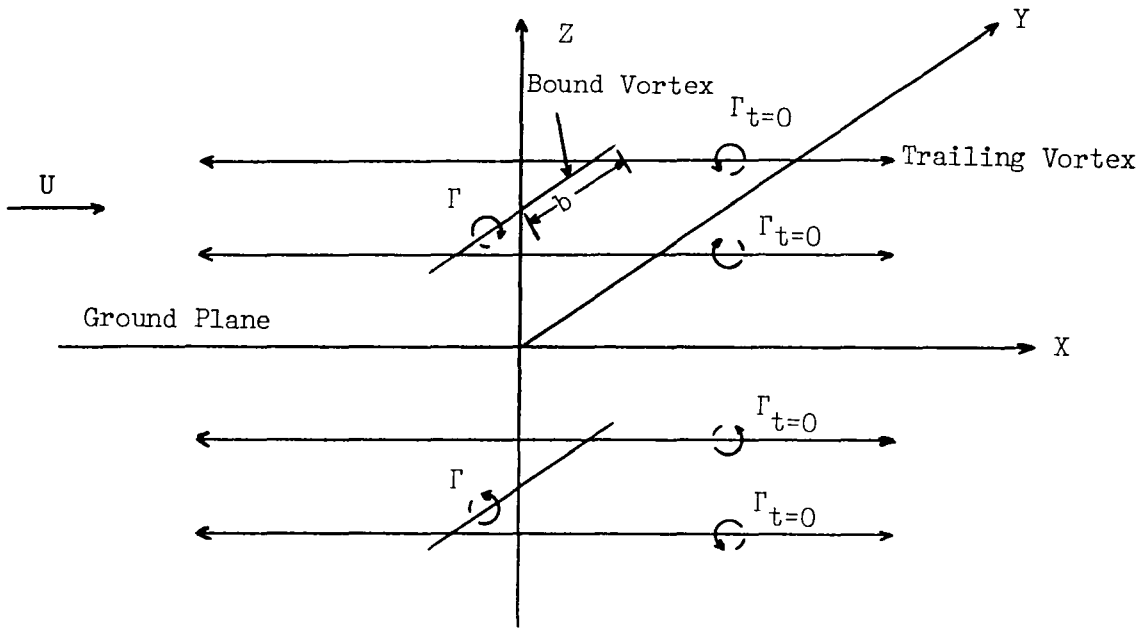

Figure 2. Three Dimensional Wake Vortex Model

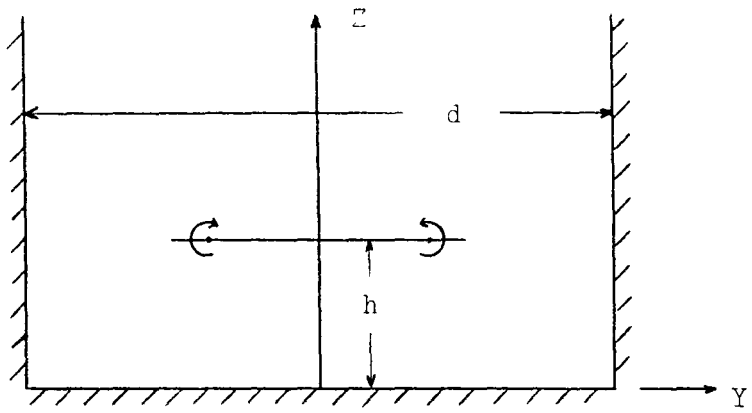

Figure 3 Two Dimensional Tunnel Model

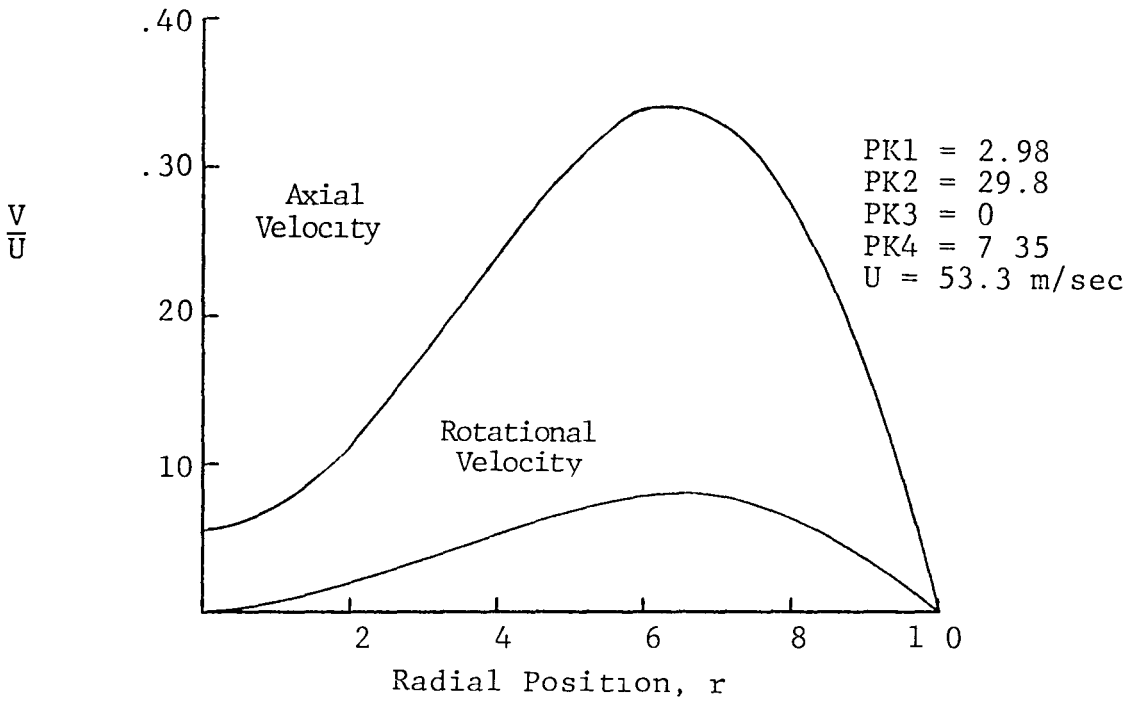

Figure 4. Typical Velocities for the Propeller Model

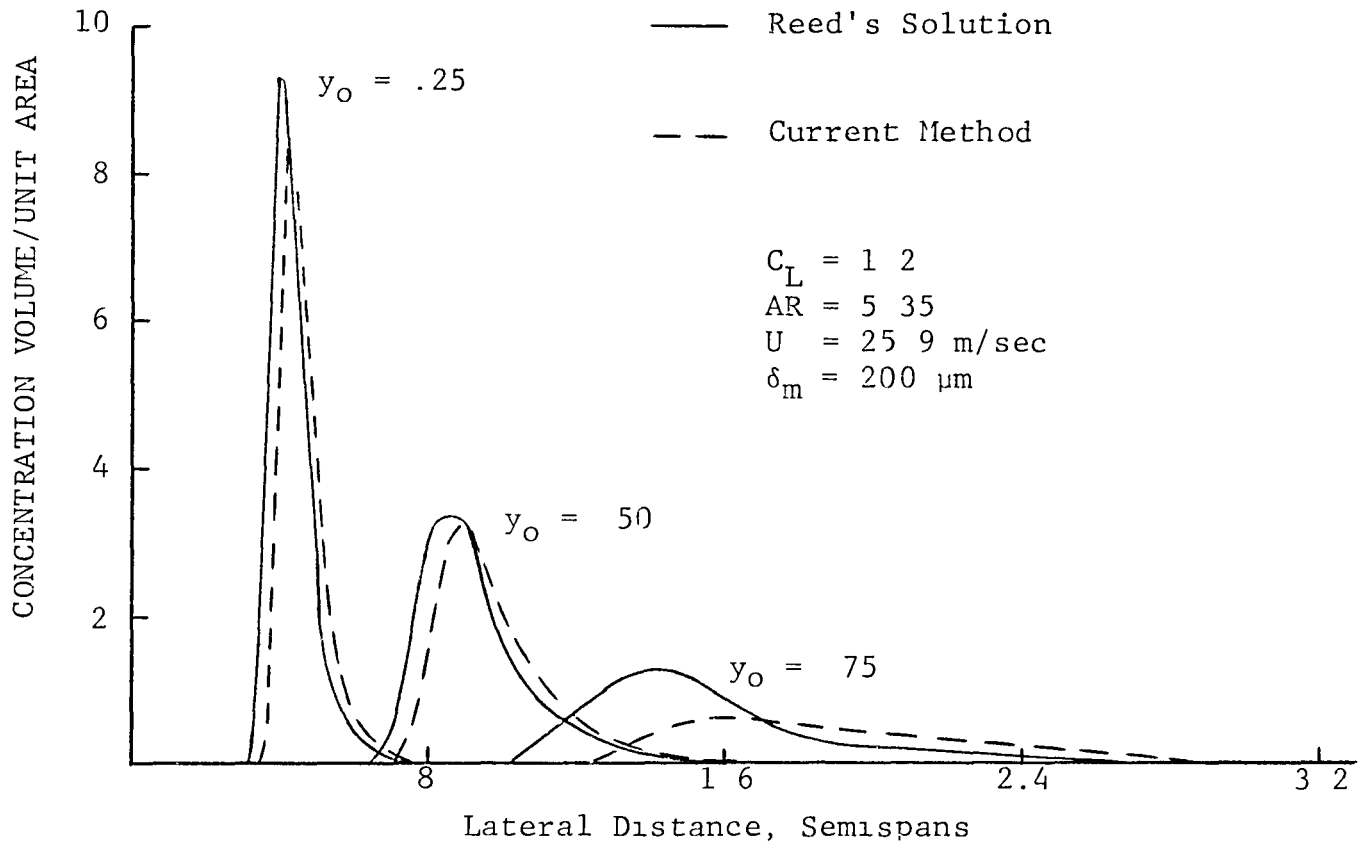

Figure 5. Present Method Compared to that of Reed

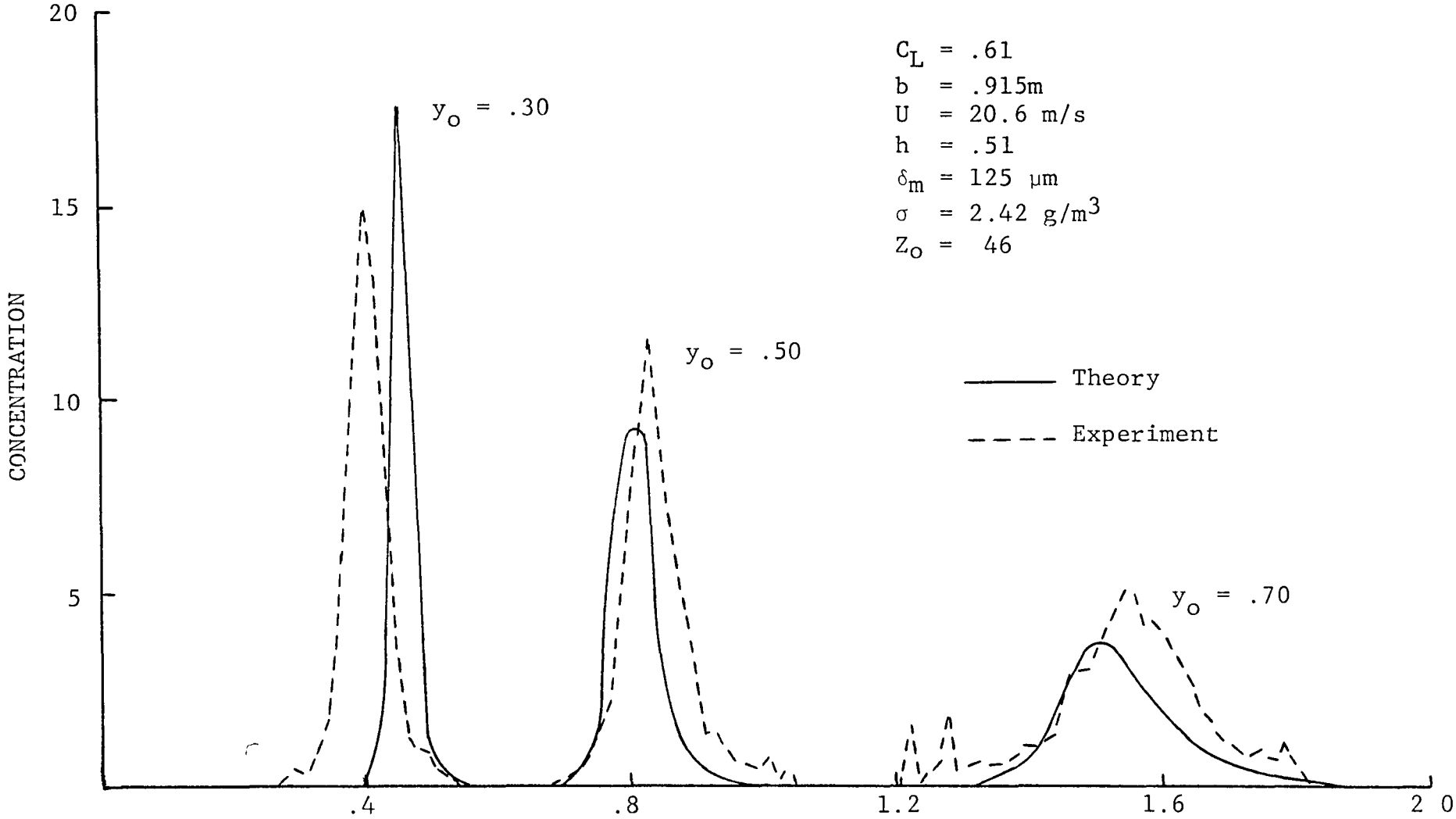

Figure 6. Comparison of Theory to Experiment for Three Nozzle Locations

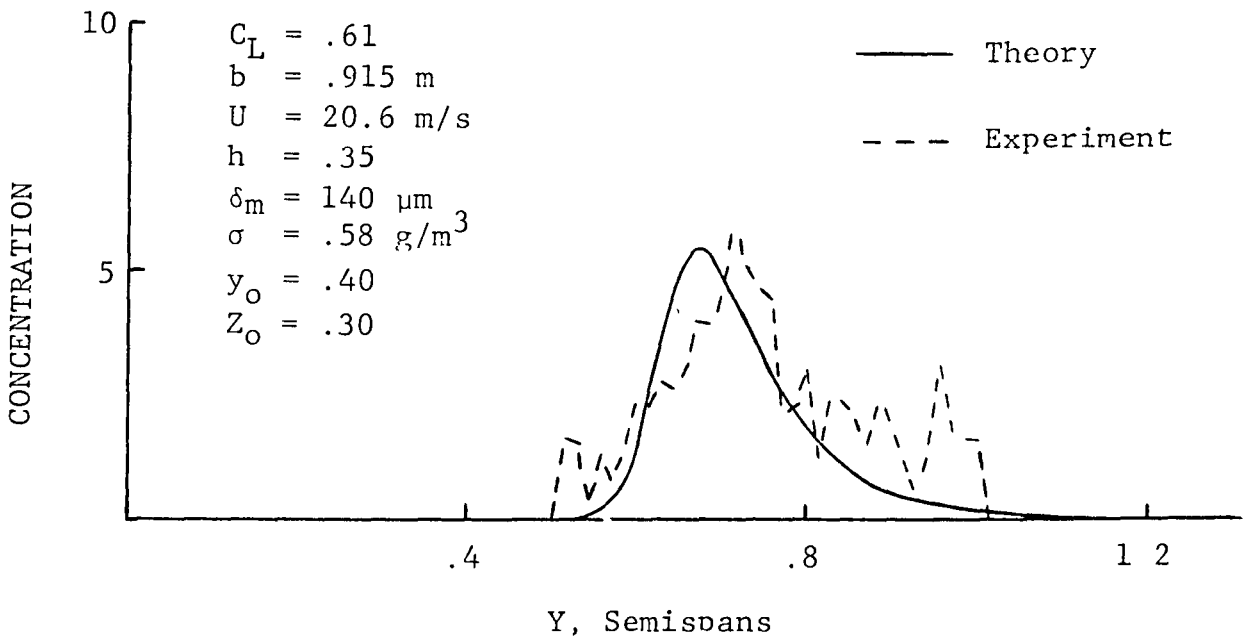

Figure 7 Comparison of Theory to Experiment

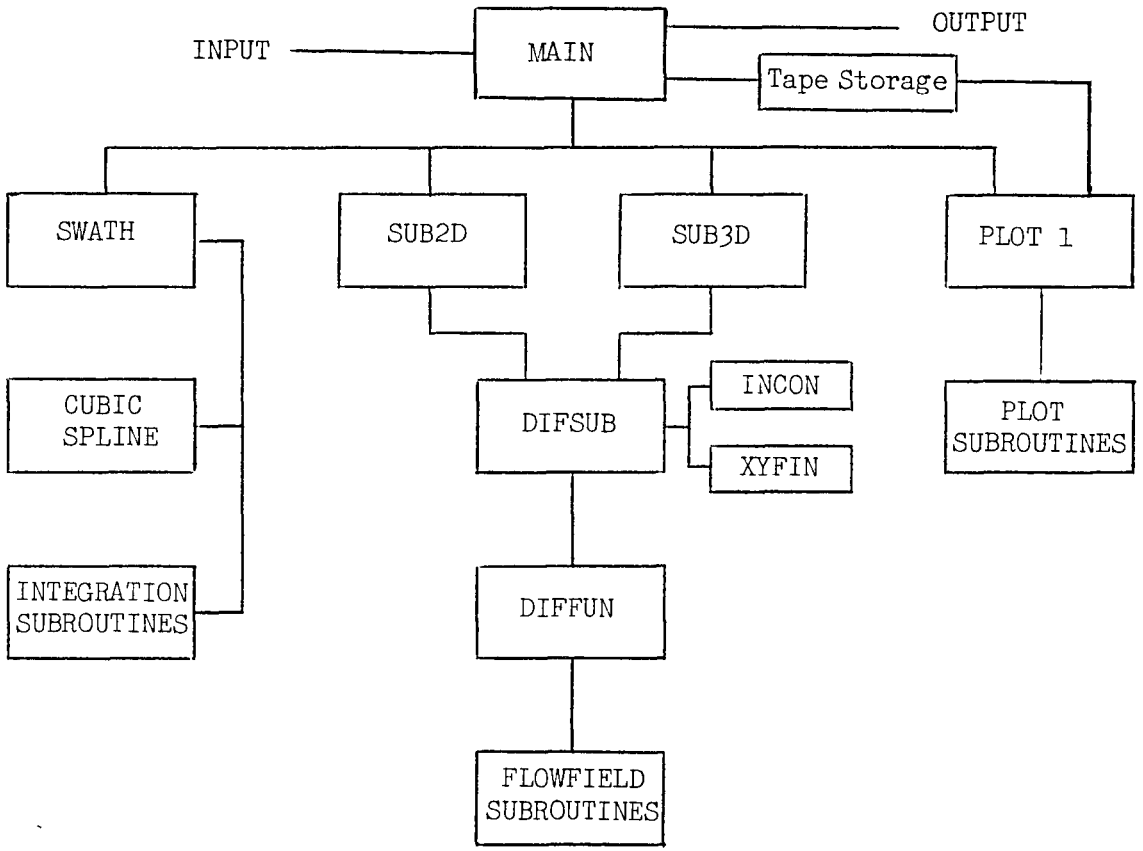

Figure 8. Computer Program Flow Chart

	N2D=1	N2D=2	N3D=1	N3D=2	NEVAP	NPROP2	NCW	NTUN	NDIST	NPLOT	NPRINT
N2D=1	X	-	-	-	X	X	X	X	X	X	X
N2D=2	-	X	-	-	X	-	-	-	X	X	X
N3D=1	-	-	X	-	X	X	X	-	X	X	X
N3D=2	-	-	-	X	X	-	-	-	X	X	X
NEVAP	X	X	X	X	X	X	X	X	X	X	X
NPROP2	X	-	X	-	X	X	X	X	X	X	X
NCW	X	-	X	-	X	X	X	-	X	X	X
NTUN	X	-	-	-	X	X	-	X	X	X	X
NDIST	X	X	X	X	X	X	X	X	X	X	X
NPRINT	X	X	X	X	X	X	X	X	X	X	X
NPLOT	X	X	X	X	X	X	X	X	X	X	X

X Allowable Option
- Unacceptable Option

Figure 9. Program Option Available

APPENDIX A

FIVE SAMPLE CASES

All five sets of input data are listed first, then each sample output including the plot.

```
ASP TEST CASE 1
1
 0 1 0 1 1 0 0 1 1              1.E-5
.50         1.793       17.93       0.          6.029       0.20
6.          .6          6.096       53.035      9.8066      .8          .5
              1.225F00                1.7932E-5 2.5         0.
200.        1000.       0.          .10         .40         0.          0.          0.
$EOJ
```

```
ASP TEST CASE 2
1
 1 0 0 0 0 0 1 1 1              1.E-5
6.          .6          6.096       53.035      9.8066      .8          .5
              1.225E00                1.7932E-5 0.          0.
1    6      1    1      1    1
1000.       0.          0.          0.          0.          4.0         1.          5.
.40
600.        300.        250.        200.        150.        100.
200.
50.
1.
.4
```

```
ASP TEST CASE 3
1
 1 0 1 0 0 0 1 0 1              1.E-5
101352.1    23.8889     18.3333
6.          .6          6.096       53.035      9.8066      .8          .5
              1.225F00                1.7932E-5 0.          0.
1    6      1    1      1    1
1000.       0.          0.          0.          0.          4.0         1.          5.
.40
600.        300.        250.        200.        150.        100.
200.
50.
1.
.4
```

```
ASP TEST CASE 4
1
 1 0 0 0 0 1 1 0 1                1.E-5
6.          .6          6.096     53.035    9.8066    .8          .5
              1.225E00               1.7932E-5 0.        36.576
1     6     1     1     1     1
1000.       0.          0.        0.        0.        4.0       1.        5.
.40
600.        300.        250.      200.      150.      100.
200.
50.
1.
.4
```

```
ASP TEST CASE 5
1
 0 1 1 1 1 0 1 0 1                1.E-5
101352.1    23.8889     18.3333
.50         1.793       17.93     0.        6.029     .20
6.          .6          6.096     53.035    9.8066    .8          .5
              1.225E00               1.7932E-5 1.0       0.
3     6     1     1     1     1
1000.       0.          0.        0.        0.        4.0       1.        5.
-.30        0.          .30
600.        300.        250.      200.      150.      100.
200.        200.        200.
50.         50.         50.
1.          1.          1.
.4          .4          .4
```

OSU / AARL

AERIAL SPRAY PROGRAM

LAST UPDATE 2/1/81

ASP TEST CASE 1

PROGRAM CONTROL

N2D= 0	N3D= 1	NEVAP= 0	NPROP2= 1	NCW= 1
NTUN= 0	NDIST= 0	NPRINT= 1	NPLOT= 1	EPS= 0.100000E-04

PARAMETER VALUES

A= 6.0000	CL= 0.6000	B= 6.0960	U= 53.0350	G= 9.8066
ZY0= 0.8000	ZZ0= 0.5000	DA= 0.122500E+01	VIS= 0.179320E-04	VCW= 2.5000
D= 0.0000	DD= 1000.0000			

PROP2 INPUTS

ZPROP2= 0.5000	PK1= 1.7930	PK2= 17.9300	PK3= 0.0000	PK4= 6.0290
RP= 0.2000				

INITIAL VALUES

X= 0.000000	Y= 0.100000	Z= 0.400000	UD= 0.000000	VD= 0.000000
WD= 0.000000	DIA= 200.0000			

1	0.00010	0.10000	0.00003	0.40000	-0.00011	0.00000	0.00142	0.80001	0.50000	-0.80000	0.50000	0.00001	0.50000
2	0.00020	0.10000	0.00005	0.40000	-0.00022	0.00000	0.00283	0.80002	0.50000	-0.79999	0.50000	0.00001	0.49999
3	0.00116	0.10000	0.00030	0.40000	-0.00124	0.00001	0.01625	0.80009	0.50000	-0.79994	0.50000	0.00007	0.49996
4	0.00212	0.10000	0.00054	0.40000	-0.00225	0.00003	0.02937	0.80016	0.49999	-0.79990	0.49999	0.00013	0.49993
5	0.00308	0.10000	0.00077	0.39999	-0.00323	0.00007	0.04219	0.80024	0.49999	-0.79985	0.49999	0.00019	0.49990
6	0.00472	0.10000	0.00116	0.39999	-0.00487	0.00015	0.06347	0.80036	0.49998	-0.79977	0.49998	0.00029	0.49985
7	0.00636	0.10001	0.00153	0.39998	-0.00644	0.00027	0.08395	0.80049	0.49998	-0.79970	0.49998	0.00040	0.49980
8	0.00801	0.10001	0.00189	0.39997	-0.00797	0.00043	0.10368	0.80062	0.49997	-0.79962	0.49997	0.00050	0.49975
9	0.00965	0.10001	0.00224	0.39995	-0.00945	0.00061	0.12269	0.80074	0.49997	-0.79954	0.49997	0.00060	0.49970
10	0.01185	0.10002	0.00268	0.39993	-0.01136	0.00091	0.14711	0.80091	0.49996	-0.79943	0.49996	0.00074	0.49963
11	0.01405	0.10002	0.00310	0.39990	-0.01321	0.00126	0.17040	0.80108	0.49995	-0.79933	0.49995	0.00088	0.49957
12	0.01625	0.10003	0.00350	0.39987	-0.01499	0.00166	0.19263	0.80125	0.49994	-0.79922	0.49994	0.00101	0.49950
13	0.01845	0.10004	0.00388	0.39984	-0.01671	0.00211	0.21387	0.80142	0.49993	-0.79912	0.49993	0.00115	0.49943
14	0.02225	0.10005	0.00449	0.39977	-0.01957	0.00299	0.24838	0.80171	0.49992	-0.79894	0.49992	0.00139	0.49931
15	0.02605	0.10007	0.00505	0.39969	-0.02231	0.00399	0.28043	0.80200	0.49991	-0.79876	0.49991	0.00162	0.49920
16	0.02986	0.10009	0.00557	0.39960	-0.02494	0.00512	0.31025	0.80229	0.49989	-0.79858	0.49989	0.00186	0.49908
17	0.03366	0.10011	0.00606	0.39950	-0.02749	0.00635	0.33808	0.80259	0.49988	-0.79839	0.49988	0.00210	0.49896
18	0.03746	0.10014	0.00650	0.39939	-0.02998	0.00768	0.36411	0.80288	0.49987	-0.79821	0.49987	0.00233	0.49884
19	0.04210	0.10017	0.00701	0.39924	-0.03294	0.00944	0.39372	0.80324	0.49985	-0.79799	0.49985	0.00262	0.49870
20	0.04674	0.10020	0.00747	0.39908	-0.03584	0.01134	0.42117	0.80359	0.49983	-0.79777	0.49983	0.00291	0.49856
21	0.05139	0.10024	0.00789	0.39891	-0.03870	0.01335	0.44670	0.80395	0.49982	-0.79755	0.49982	0.00320	0.49842
22	0.05603	0.10028	0.00828	0.39872	-0.04152	0.01548	0.47052	0.80431	0.49980	-0.79733	0.49980	0.00349	0.49827
23	0.06067	0.10032	0.00864	0.39853	-0.04432	0.01772	0.49281	0.80466	0.49978	-0.79711	0.49978	0.00378	0.49813

25	0.07287	0.10043	0.00945	0.39794	-0.05157	0.02406	0.54516	0.80560	0.49974	-0.79652	0.49974	0.00454	0.49775
26	0.07897	0.10049	0.00980	0.39761	-0.05516	0.02745	0.56851	0.80607	0.49972	-0.79623	0.49972	0.00492	0.49757
27	0.08506	0.10055	0.01011	0.39727	-0.05873	0.03099	0.59031	0.80654	0.49970	-0.79594	0.49970	0.00529	0.49738
28	0.09116	0.10061	0.01040	0.39690	-0.06228	0.03465	0.61073	0.80701	0.49968	-0.79565	0.49968	0.00567	0.49719
29	0.09726	0.10067	0.01065	0.39651	-0.06579	0.03843	0.62994	0.80748	0.49965	-0.79536	0.49965	0.00605	0.49700
30	0.10709	0.10078	0.01102	0.39583	-0.07136	0.04477	0.65870	0.80823	0.49962	-0.79489	0.49962	0.00666	0.49670
31	0.11692	0.10089	0.01133	0.39511	-0.07679	0.05137	0.68515	0.80899	0.49959	-0.79442	0.49959	0.00728	0.49640
32	0.12675	0.10100	0.01159	0.39433	-0.08203	0.05823	0.70963	0.80974	0.49955	-0.79396	0.49955	0.00789	0.49610
33	0.13658	0.10112	0.01181	0.39349	-0.08705	0.06532	0.73244	0.81050	0.49952	-0.79349	0.49952	0.00850	0.49580
34	0.14641	0.10123	0.01199	0.39261	-0.09179	0.07262	0.75378	0.81125	0.49948	-0.79302	0.49948	0.00911	0.49550
35	0.15623	0.10135	0.01214	0.39169	-0.09624	0.08013	0.77381	0.81201	0.49945	-0.79255	0.49945	0.00972	0.49520
36	0.17090	0.10153	0.01231	0.39023	-0.10229	0.09169	0.80153	0.81314	0.49939	-0.79185	0.49939	0.01063	0.49475
37	0.18556	0.10171	0.01242	0.38869	-0.10758	0.10363	0.82692	0.81427	0.49934	-0.79115	0.49934	0.01154	0.49430
38	0.20023	0.10190	0.01249	0.38708	-0.11213	0.11593	0.85024	0.81539	0.49929	-0.79045	0.49929	0.01245	0.49385
39	0.21489	0.10208	0.01251	0.38541	-0.11596	0.12856	0.87167	0.81652	0.49924	-0.78976	0.49924	0.01336	0.49340
40	0.22956	0.10226	0.01251	0.38368	-0.11910	0.14149	0.89137	0.81765	0.49919	-0.78906	0.49919	0.01427	0.49296
41	0.24422	0.10245	0.01247	0.38192	-0.12163	0.15470	0.90948	0.81878	0.49914	-0.78836	0.49914	0.01518	0.49251
42	0.26215	0.10267	0.01240	0.37972	-0.12396	0.17119	0.92965	0.82016	0.49907	-0.78751	0.49907	0.01630	0.49197
43	0.28008	0.10289	0.01231	0.37748	-0.12557	0.18802	0.94785	0.82153	0.49901	-0.78665	0.49901	0.01741	0.49142
44	0.29801	0.10311	0.01220	0.37522	-0.12656	0.20516	0.96427	0.82291	0.49895	-0.78580	0.49895	0.01852	0.49088
45	0.31594	0.10333	0.01207	0.37294	-0.12704	0.22259	0.97911	0.82429	0.49889	-0.78495	0.49889	0.01963	0.49033
46	0.33387	0.10354	0.01194	0.37066	-0.12709	0.24026	0.99252	0.82567	0.49882	-0.78409	0.49882	0.02074	0.48979
47	0.35180	0.10376	0.01181	0.36839	-0.12679	0.25817	1.00464	0.82705	0.49876	-0.78324	0.49876	0.02185	0.48925
48	0.37972	0.10408	0.01160	0.36486	-0.12575	0.28646	1.02126	0.82920	0.49866	-0.78191	0.49866	0.02358	0.48840
49	0.40764	0.10440	0.01141	0.36137	-0.12420	0.31517	1.03552	0.83135	0.49857	-0.78059	0.49857	0.02531	0.48755
50	0.43556	0.10472	0.01123	0.35793	-0.12229	0.34426	1.04777	0.83349	0.49847	-0.77926	0.49847	0.02704	0.48672
51	0.46348	0.10503	0.01109	0.35454	-0.12012	0.37366	1.05830	0.83564	0.49837	-0.77793	0.49837	0.02876	0.48588
52	0.49140	0.10534	0.01097	0.35122	-0.11778	0.40334	1.06737	0.83779	0.49828	-0.77660	0.49828	0.03049	0.48504
53	0.51932	0.10564	0.01088	0.34797	-0.11534	0.43325	1.07518	0.83994	0.49818	-0.77528	0.49818	0.03222	0.48421
54	0.55757	0.10606	0.01082	0.34362	-0.11190	0.47457	1.08415	0.84288	0.49805	-0.77346	0.49805	0.03458	0.48306
55	0.59583	0.10647	0.01082	0.33941	-0.10843	0.51619	1.09145	0.84583	0.49791	-0.77165	0.49791	0.03694	0.48192
56	0.63409	0.10689	0.01089	0.33532	-0.10500	0.55806	1.09736	0.84877	0.49778	-0.76983	0.49778	0.03930	0.48078
57	0.67235	0.10731	0.01102	0.33137	-0.10162	0.60014	1.10212	0.85172	0.49765	-0.76802	0.49765	0.04166	0.47965
58	0.71060	0.10773	0.01121	0.32755	-0.09832	0.64238	1.10590	0.85466	0.49752	-0.76620	0.49752	0.04402	0.47852
59	0.74886	0.10817	0.01147	0.32385	-0.09512	0.68474	1.10885	0.85761	0.49739	-0.76439	0.49739	0.04637	0.47739
60	0.80074	0.10877	0.01190	0.31902	-0.09093	0.74235	1.11175	0.86161	0.49721	-0.76193	0.49721	0.04956	0.47586
61	0.85263	0.10940	0.01243	0.31441	-0.08690	0.80009	1.11358	0.86560	0.49704	-0.75947	0.49704	0.05275	0.47433
62	0.90451	0.11006	0.01306	0.31000	-0.08302	0.85789	1.11452	0.86960	0.49686	-0.75701	0.49686	0.05594	0.47282
63	0.95639	0.11076	0.01377	0.30579	-0.07929	0.91573	1.11469	0.87360	0.49668	-0.75456	0.49668	0.05913	0.47130
64	1.00828	0.11149	0.01457	0.30177	-0.07570	0.97355	1.11420	0.87759	0.49651	-0.75210	0.49651	0.06231	0.46980
65	1.06016	0.11227	0.01545	0.29793	-0.07226	1.03133	1.11315	0.88159	0.49634	-0.74965	0.49634	0.06549	0.46829
66	1.13080	0.11341	0.01675	0.29299	-0.06780	1.10990	1.11092	0.88704	0.49610	-0.74631	0.49610	0.06981	0.46625
67	1.20144	0.11464	0.01814	0.28835	-0.06363	1.18827	1.10797	0.89248	0.49586	-0.74298	0.49586	0.07413	0.46423
68	1.27209	0.11597	0.01959	0.28399	-0.05978	1.26642	1.10446	0.89793	0.49563	-0.73964	0.49563	0.07845	0.46221
69	1.34273	0.11741	0.02108	0.27990	-0.05624	1.34431	1.10055	0.90338	0.49539	-0.73631	0.49539	0.08276	0.46020
70	1.41337	0.11895	0.02257	0.27604	-0.05303	1.42191	1.09639	0.90883	0.49516	-0.73298	0.49516	0.08707	0.45820
71	1.48401	0.12060	0.02404	0.27240	-0.05013	1.49921	1.09209	0.91428	0.49493	-0.72965	0.49493	0.09137	0.45621
72	1.57953	0.12299	0.02596	0.26778	-0.04669	1.60324	1.08624	0.92165	0.49462	-0.72515	0.49462	0.09717	0.45353
73	1.67504	0.12555	0.02777	0.26346	-0.04374	1.70671	1.08048	0.92902	0.49431	-0.72066	0.49431	0.10297	0.45087
74	1.77055	0.12829	0.02946	0.25941	-0.04123	1.80964	1.07496	0.93639	0.49400	-0.71617	0.49400	0.10876	0.44823
75	1.86606	0.13118	0.03102	0.25557	-0.03911	1.91206	1.06973	0.94377	0.49369	-0.71168	0.49369	0.11454	0.44560
76	1.96158	0.13421	0.03244	0.25193	-0.03730	2.01399	1.06482	0.95114	0.49338	-0.70720	0.49338	0.12031	0.44299
77	2.08133	0.13819	0.03404	0.24757	-0.03542	2.14116	1.05915	0.96039	0.49300	-0.70159	0.49300	0.12753	0.43975
78	2.20108	0.14235	0.03545	0.24343	-0.03389	2.26768	1.05397	0.96965	0.49262	-0.69598	0.49262	0.13474	0.43653
79	2.32083	0.14668	0.03671	0.23945	-0.03263	2.39361	1.04925	0.97890	0.49225	-0.69037	0.49225	0.14194	0.43334
80	2.44058	0.15114	0.03782	0.23560	-0.03159	2.51900	1.04494	0.98816	0.49187	-0.68478	0.49187	0.14912	0.43017
81	2.56033	0.15573	0.03881	0.23187	-0.03072	2.64389	1.04098	0.99743	0.49150	-0.67918	0.49150	0.15628	0.42703
82	2.68008	0.16043	0.03970	0.22824	-0.02999	2.76832	1.03732	1.00669	0.49113	-0.67360	0.49113	0.16343	0.42392
83	2.83746	0.16676	0.04074	0.22358	-0.02919	2.93123	1.03288	1.01887	0.49065	-0.66626	0.49065	0.17281	0.41987
84	2.99485	0.17325	0.04167	0.21904	-0.02852	3.09346	1.02877	1.03106	0.49017	-0.65894	0.49017	0.18216	0.41587
85	3.15224	0.17987	0.04252	0.21460	-0.02796	3.25507	1.02491	1.04325	0.48970	-0.65162	0.48970	0.19149	0.41192
86	3.30962	0.18663	0.04331	0.21024	-0.02748	3.41609	1.02123	1.05545	0.48923	-0.64432	0.48923	0.20079	0.40800
87	3.46701	0.19350	0.04405	0.20595	-0.02705	3.57653	1.01769	1.06765	0.48877	-0.63702	0.48877	0.21007	0.40414
88	3.62439	0.20049	0.04476	0.20172	-0.02667	3.73643	1.01424	1.07985	0.48831	-0.62973	0.48831	0.21932	0.40032
89	3.75188	0.20623	0.04533	0.19834	-0.02640	3.86556	1.01149	1.08974	0.48793	-0.62384	0.48793	0.22679	0.39726

90	3.77187	0.20714	0.04541	0.19781	-0.02636	3.88377	1.01107	1.09429	0.48788	-0.62271	0.48788	0.22496	0.39378
91	3.79186	0.20805	0.04549	0.19729	-0.02632	3.90597	1.01067	1.09284	0.48782	-0.62199	0.48782	0.22913	0.39630
92	3.81903	0.20929	0.04559	0.19657	-0.02627	3.93342	1.01014	1.09495	0.48774	-0.62073	0.48774	0.23072	0.39566
93	3.84620	0.21053	0.04568	0.19586	-0.02623	3.96086	1.00964	1.09706	0.48766	-0.61948	0.48766	0.23231	0.39501
94	3.87337	0.21177	0.04577	0.19515	-0.02619	3.98828	1.00917	1.09917	0.48758	-0.61822	0.48758	0.23390	0.39437
95	3.95217	0.21539	0.04597	0.19309	-0.02607	4.06776	1.00793	1.10528	0.48736	-0.61459	0.48736	0.23850	0.39251
96	4.03097	0.21901	0.04612	0.19104	-0.02598	4.14714	1.00687	1.11140	0.48713	-0.61095	0.48713	0.24310	0.39066
97	4.10977	0.22265	0.04622	0.18899	-0.02588	4.22644	1.00596	1.11752	0.48691	-0.60732	0.48691	0.24769	0.38882
98	4.18857	0.22630	0.04628	0.18696	-0.02579	4.30568	1.00517	1.12364	0.48669	-0.60369	0.48669	0.25227	0.38699
99	4.29082	0.23103	0.04630	0.18433	-0.02567	4.40842	1.00430	1.13158	0.48640	-0.59898	0.48640	0.25821	0.38464
100	4.39308	0.23577	0.04628	0.18171	-0.02554	4.51108	1.00358	1.13953	0.48611	-0.59427	0.48611	0.26413	0.38230
101	4.49533	0.24049	0.04622	0.17910	-0.02541	4.61366	1.00297	1.14747	0.48583	-0.58957	0.48583	0.27005	0.37998
102	4.59759	0.24522	0.04613	0.17651	-0.02526	4.71620	1.00246	1.15542	0.48554	-0.58488	0.48554	0.27596	0.37768
103	4.69984	0.24993	0.04600	0.17394	-0.02511	4.81868	1.00204	1.16337	0.48526	-0.58018	0.48526	0.28185	0.37540
104	4.87481	0.25795	0.04574	0.16957	-0.02483	4.99395	1.00147	1.17698	0.48478	-0.57216	0.48478	0.29191	0.37154
105	5.04977	0.26593	0.04542	0.16525	-0.02453	5.16913	1.00105	1.19059	0.48431	-0.56415	0.48431	0.30194	0.36773
106	5.22473	0.27384	0.04506	0.16098	-0.02422	5.34425	1.00075	1.20421	0.48384	-0.55615	0.48384	0.31193	0.36397
107	5.39970	0.28169	0.04466	0.15677	-0.02391	5.51933	1.00052	1.21784	0.48337	-0.54816	0.48337	0.32190	0.36026
108	5.57466	0.28947	0.04424	0.15262	-0.02359	5.69437	1.00036	1.23147	0.48291	-0.54018	0.48291	0.33183	0.35661
109	5.84230	0.30122	0.04356	0.14637	-0.02311	5.96208	1.00019	1.25233	0.48222	-0.52800	0.48222	0.34695	0.35111
110	6.10994	0.31279	0.04285	0.14025	-0.02263	6.22976	1.00009	1.27320	0.48153	-0.51584	0.48153	0.36201	0.34573
111	6.37758	0.32416	0.04211	0.13425	-0.02217	6.49741	1.00003	1.29409	0.48085	-0.50370	0.48085	0.37698	0.34047
112	6.64523	0.33533	0.04135	0.12838	-0.02171	6.76506	1.00000	1.31499	0.48019	-0.49159	0.48019	0.39188	0.33531
113	6.91287	0.34629	0.04057	0.12263	-0.02127	7.03269	0.99998	1.33590	0.47953	-0.47950	0.47953	0.40670	0.33027
114	7.18051	0.35704	0.03977	0.11699	-0.02084	7.30033	0.99996	1.35682	0.47888	-0.46744	0.47888	0.42145	0.32534
115	7.55511	0.37173	0.03863	0.10930	-0.02026	7.67491	0.99996	1.38613	0.47799	-0.45059	0.47799	0.44196	0.31861
116	7.92970	0.38598	0.03745	0.10181	-0.01971	8.04949	0.99996	1.41546	0.47712	-0.43379	0.47712	0.46231	0.31208
117	8.30430	0.39978	0.03624	0.09453	-0.01918	8.42407	0.99996	1.44481	0.47627	-0.41704	0.47627	0.48251	0.30574
118	8.67890	0.41313	0.03500	0.08744	-0.01867	8.79866	0.99997	1.47419	0.47543	-0.40033	0.47543	0.50256	0.29960
119	9.05349	0.42600	0.03371	0.08053	-0.01819	9.17324	0.99997	1.50359	0.47461	-0.38366	0.47461	0.52246	0.29364
120	9.42809	0.43838	0.03238	0.07381	-0.01773	9.54783	0.99997	1.53302	0.47380	-0.36703	0.47380	0.54220	0.28786
121	10.05584	0.45798	0.03005	0.06291	-0.01700	10.17556	0.99998	1.58237	0.47249	-0.33926	0.47249	0.57494	0.27856
122	10.68359	0.47607	0.02756	0.05246	-0.01631	10.80329	0.99998	1.63180	0.47123	-0.31161	0.47123	0.60725	0.26972
123	11.31133	0.49254	0.02486	0.04242	-0.01567	11.43103	0.99998	1.68128	0.47000	-0.28407	0.47000	0.63913	0.26131
124	11.93908	0.50723	0.02190	0.03277	-0.01506	12.05877	0.99999	1.73082	0.46882	-0.25664	0.46882	0.67058	0.25331
125	12.56683	0.51995	0.01857	0.02350	-0.01448	12.68651	0.99999	1.78042	0.46767	-0.22931	0.46767	0.70160	0.24570
126	13.19458	0.53041	0.01464	0.01459	-0.01390	13.31425	0.99999	1.83008	0.46656	-0.20209	0.46656	0.73219	0.23845
127	13.53726	0.53500	0.01209	0.00988	-0.01359	13.65693	0.99999	1.85721	0.46597	-0.18728	0.46597	0.74872	0.23463
128	13.79823	0.53786	0.00982	0.00637	-0.01333	13.91789	0.99999	1.87788	0.46553	-0.17601	0.46553	0.76127	0.23180
129	13.98649	0.53953	0.00788	0.00388	-0.01313	14.10615	0.99999	1.89280	0.46521	-0.16790	0.46521	0.77019	0.22978
130	14.09471	0.54032	0.00657	0.00247	-0.01301	14.21438	0.99999	1.90138	0.46503	-0.16324	0.46503	0.77533	0.22864
131	14.17140	0.54078	0.00548	0.00147	-0.01291	14.29106	0.99999	1.90746	0.46491	-0.15994	0.46491	0.77896	0.22783
132	14.22379	0.54104	0.00462	0.00080	-0.01282	14.34345	0.99999	1.91162	0.46482	-0.15768	0.46482	0.78144	0.22729
133	14.25067	0.54116	0.00410	0.00045	-0.01277	14.37034	0.99999	1.91375	0.46478	-0.15653	0.46478	0.78271	0.22701
134	14.26808	0.54123	0.00372	0.00023	-0.01274	14.38775	0.99999	1.91513	0.46475	-0.15578	0.46475	0.78354	0.22682
135	14.27811	0.54126	0.00347	0.00010	-0.01271	14.39778	0.99999	1.91593	0.46473	-0.15535	0.46473	0.78401	0.22672
136	14.28217	0.54128	0.00335	0.00005	-0.01270	14.40184	0.99999	1.91625	0.46473	-0.15517	0.46473	0.78420	0.22668
137	14.28461	0.54128	0.00328	0.00002	-0.01269	14.40428	0.99999	1.91644	0.46472	-0.15507	0.46472	0.78432	0.22665
138	14.28627	0.54129	0.00321	0.00000	-0.01268	14.40594	0.99999	1.91657	0.46472	-0.15500	0.46472	0.78440	0.22664
139	14.28793	0.54129	0.00314	-0.00002	-0.01268	14.40760	0.99999	1.91670	0.46472	-0.15492	0.46472	0.78447	0.22662

**** TRAJECTORY COMPLETED, 7 LESS THAN ZERO ****

FINAL VALUES

X= 14.405961 Y= 0.541290 Z= 0.000000 UD= 0.999992 VD= 0.003211
WD= -0.012684 DIA= 200.0000 T= 14.286297

BAKGND: STOP

ASP TEST CASE 1
ΔZ/B
.00
.08
.16
.24
.32
.40
.48
Y/B
.00
.08
.16
.24
.32
.40
.48
.56
.64

OSU / AARL

AERIAL SPRAY PROGRAM

LAST UPDATE 2/1/81

ASP TEST CASE 2

PROGRAM CONTROL

N2D= 1	N3D= 0	NEVAP= 0	NPROP2= 0	NCW= 0
NTUN= 0	NDIST= 1	NPRINT= 1	NPLOT= 1	EPS= 0.100000E-04

PARAMETER VALUES

A= 6.0000	CL= 0.6000	B= 6.0960	U= 53.0350	G= 9.8066
ZY0= 0.8000	ZZ0= 0.5000	DA= 0.122500E+01	VIS= 0.179320E-04	VCW= 0.0000
D= 0.0000	DD= 1000.0000			

DISTRIBUTION INPUTS

NCOL= 1	NROW= 6	NDIAMN= 1	NSTDEV= 1	NQ= 1
NZNOZ= 1	DD=1000.00000	X= 0.00000	UD= 0.00000	VD= 0.00000
WD= 0.00000	SWIDTH= 4.00000	DFRR= 1.00000	DWIDTH= 5.00000	

YNOZ=0.400

YG	DIA	CONCENTRATION	YG	DIA	CONCENTRATION	YG	DIA	CONCENTRATION
0.640000E+00	0.441061E+03	0.110564E-03	0.650000E+00	0.426213E+03	0.408700E-03	0.660000E+00	0.412488E+03	0.126168E-02
0.670000E+00	0.399762E+03	0.334558E-02	0.680000E+00	0.387928E+03	0.779777E-02	0.690000E+00	0.376A96E+03	0.162809E-01
0.700000E+00	0.3665A5E+03	0.309327E-01	0.710000E+00	0.356927E+03	0.541859E-01	0.720000E+00	0.347A61E+03	0.884828E-01
0.730000E+00	0.339334E+03	0.135946E+00	0.740000E+00	0.331299E+03	0.198073E+00	0.750000E+00	0.323714E+03	0.275513E+00
0.760000E+00	0.316543E+03	0.367965E+00	0.770000E+00	0.309752E+03	0.474192E+00	0.780000E+00	0.303311E+03	0.592145E+00
0.790000E+00	0.297195E+03	0.719134E+00	0.800000E+00	0.291380E+03	0.851925E+00	0.810000E+00	0.285844E+03	0.987170E+00
0.820000E+00	0.280570E+03	0.112161E+01	0.830000E+00	0.275540E+03	0.125221E+01	0.840000E+00	0.270738E+03	0.137634E+01
0.850000E+00	0.266150E+03	0.149180E+01	0.860000E+00	0.261762E+03	0.159689E+01	0.870000E+00	0.257562E+03	0.169039E+01
0.880000E+00	0.253538E+03	0.177154E+01	0.890000E+00	0.249681E+03	0.184000E+01	0.900000E+00	0.245979E+03	0.189559E+01
0.910000E+00	0.242426E+03	0.193848E+01	0.920000E+00	0.239012E+03	0.196920E+01	0.930000E+00	0.235731E+03	0.198850E+01
0.940000E+00	0.232576E+03	0.199723E+01	0.950000E+00	0.229539E+03	0.199634E+01	0.960000E+00	0.226616E+03	0.198681E+01
0.970000E+00	0.223799E+03	0.196964E+01	0.980000E+00	0.221084E+03	0.194580E+01	0.990000E+00	0.218467E+03	0.191622E+01
0.100000E+01	0.215941E+03	0.188178E+01	0.101000E+01	0.213502E+03	0.184330E+01	0.102000E+01	0.211147E+03	0.180153E+01
0.103000E+01	0.208872E+03	0.175716E+01	0.104000E+01	0.206672E+03	0.171079E+01	0.105000E+01	0.204544E+03	0.166297E+01
0.106000E+01	0.202495E+03	0.161418E+01	0.107000E+01	0.200492E+03	0.156483E+01	0.108000E+01	0.198561E+03	0.151536E+01
0.109000E+01	0.196691E+03	0.146626E+01	0.110000E+01	0.194877E+03	0.141774E+01	0.111000E+01	0.193117E+03	0.136998E+01
0.112000E+01	0.191409E+03	0.132313E+01	0.113000E+01	0.189751E+03	0.127730E+01	0.114000E+01	0.188139E+03	0.123259E+01
0.115000E+01	0.186572E+03	0.118905E+01	0.116000E+01	0.185048E+03	0.114675E+01	0.117000E+01	0.183566E+03	0.110572E+01
0.118000E+01	0.182122E+03	0.106597E+01	0.119000E+01	0.180717E+03	0.102752E+01	0.120000E+01	0.179347E+03	0.990365E+00
0.121000E+01	0.178013E+03	0.954498E+00	0.122000E+01	0.176711E+03	0.919905E+00	0.123000E+01	0.175442E+03	0.886566E+00
0.124000E+01	0.174204E+03	0.854457E+00	0.125000E+01	0.172995E+03	0.823551E+00	0.126000E+01	0.171815E+03	0.793816E+00
0.127000E+01	0.170662E+03	0.765222E+00	0.128000E+01	0.169536E+03	0.737734E+00	0.129000E+01	0.168436E+03	0.711317E+00
0.130000E+01	0.167360E+03	0.685937E+00	0.131000E+01	0.166308E+03	0.661557E+00	0.132000E+01	0.165279E+03	0.638143E+00
0.133000E+01	0.164272E+03	0.615658E+00	0.134000E+01	0.163286E+03	0.594069E+00	0.135000E+01	0.162322E+03	0.573341E+00
0.136000E+01	0.161377E+03	0.553441E+00	0.137000E+01	0.160452E+03	0.534334E+00	0.138000E+01	0.159546E+03	0.515991E+00
0.139000E+01	0.158657E+03	0.498379E+00	0.140000E+01	0.157787E+03	0.481469E+00	0.141000E+01	0.156934E+03	0.465232E+00
0.142000E+01	0.156097E+03	0.449639E+00	0.143000E+01	0.155276E+03	0.434664E+00	0.144000E+01	0.154471E+03	0.420280E+00
0.145000E+01	0.153681E+03	0.406463E+00	0.146000E+01	0.152906E+03	0.393188E+00	0.147000E+01	0.152146E+03	0.380433E+00
0.148000E+01	0.151399E+03	0.368174E+00	0.149000E+01	0.150665E+03	0.356392E+00	0.150000E+01	0.149945E+03	0.345064E+00
0.151000E+01	0.149238E+03	0.334066E+00	0.152000E+01	0.148543E+03	0.323321E+00	0.153000E+01	0.147861E+03	0.312838E+00
0.154000E+01	0.147192E+03	0.302624E+00	0.155000E+01	0.146536E+03	0.292683E+00	0.156000E+01	0.145893E+03	0.283019E+00
0.157000E+01	0.145262E+03	0.273632E+00	0.158000E+01	0.144644E+03	0.264523E+00	0.159000E+01	0.144038E+03	0.255689E+00
0.160000E+01	0.143445E+03	0.247128E+00	0.161000E+01	0.142864E+03	0.238838E+00	0.162000E+01	0.142295E+03	0.230813E+00
0.163000E+01	0.141738E+03	0.223049E+00	0.164000E+01	0.141192E+03	0.215542E+00	0.165000E+01	0.140659E+03	0.208284E+00
0.166000E+01	0.140136E+03	0.201271E+00	0.167000E+01	0.139626E+03	0.194496E+00	0.168000E+01	0.139126E+03	0.187953E+00
0.169000E+01	0.138637E+03	0.181636E+00	0.170000E+01	0.138159E+03	0.175537E+00	0.171000E+01	0.137691E+03	0.169650E+00
0.172000E+01	0.137234E+03	0.163969E+00	0.173000E+01	0.136788E+03	0.158487E+00	0.174000E+01	0.136351E+03	0.153197E+00
0.175000E+01	0.135924E+03	0.148094E+00	0.176000E+01	0.135507E+03	0.143170E+00	0.177000E+01	0.135100E+03	0.138419E+00
0.178000E+01	0.134701E+03	0.133837E+00	0.179000E+01	0.134312E+03	0.129415E+00	0.180000E+01	0.133932E+03	0.125150E+00
0.181000E+01	0.133561E+03	0.121034E+00	0.182000E+01	0.133199E+03	0.117063E+00	0.183000E+01	0.132845E+03	0.113232E+00
0.184000E+01	0.132499E+03	0.109534E+00	0.185000E+01	0.132162E+03	0.105966E+00	0.186000E+01	0.131833E+03	0.102522E+00
0.187000E+01	0.131511E+03	0.991974E-01	0.188000E+01	0.131197E+03	0.959882E-01	0.189000E+01	0.130891E+03	0.928897E-01
0.190000E+01	0.130592E+03	0.898979E-01	0.191000E+01	0.130300E+03	0.870086E-01	0.192000E+01	0.130016E+03	0.842382E-01
0.193000E+01	0.129738E+03	0.816006E-01	0.194000E+01	0.129466E+03	0.790880E-01	0.195000E+01	0.129201E+03	0.766933E-01
0.196000E+01	0.128942E+03	0.744098E-01	0.197000E+01	0.128689E+03	0.722311E-01	0.198000E+01	0.128442E+03	0.701514E-01
0.199000E+01	0.128200E+03	0.681652E-01	0.200000E+01	0.127963E+03	0.662675E-01	0.201000E+01	0.127731E+03	0.644532E-01
0.202000E+01	0.127503E+03	0.627181E-01	0.203000E+01	0.127281E+03	0.610577E-01	0.204000E+01	0.127063E+03	0.594682E-01
0.205000E+01	0.126849E+03	0.579458E-01	0.206000E+01	0.126639E+03	0.564870E-01	0.207000E+01	0.126433E+03	0.550886E-01
0.208000E+01	0.126231E+03	0.537473E-01	0.209000E+01	0.126033E+03	0.524604E-01	0.210000E+01	0.125839E+03	0.512251E-01
0.211000E+01	0.125647E+03	0.500387E-01	0.212000E+01	0.125460E+03	0.488990E-01	0.213000E+01	0.125275E+03	0.478034E-01
0.214000E+01	0.125093E+03	0.467509E-01	0.215000E+01	0.124915E+03	0.457366E-01	0.216000E+01	0.124739E+03	0.447614E-01
0.217000E+01	0.124567E+03	0.438225E-01	0.218000E+01	0.124397E+03	0.429181E-01	0.219000E+01	0.124229E+03	0.420468E-01
0.220000E+01	0.124064E+03	0.412068E-01	0.221000E+01	0.123902E+03	0.403969E-01	0.222000E+01	0.123742E+03	0.396155E-01
0.223000E+01	0.123584E+03	0.388614E-01	0.224000E+01	0.123429E+03	0.381334E-01	0.225000E+01	0.123275E+03	0.374303E-01
0.226000E+01	0.123124E+03	0.367510E-01	0.227000E+01	0.122975E+03	0.360944E-01	0.228000E+01	0.122828E+03	0.354595E-01
0.229000E+01	0.122682E+03	0.348454E-01	0.230000E+01	0.122539E+03	0.342512E-01	0.231000E+01	0.122397E+03	0.336761E-01
0.232000E+01	0.122257E+03	0.331191E-01	0.233000E+01	0.122119E+03	0.325796E-01	0.234000E+01	0.121983E+03	0.320569E-01
0.235000E+01	0.121848E+03	0.315501E-01	0.236000E+01	0.121714E+03	0.310587E-01	0.237000E+01	0.121582E+03	0.305821E-01

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  0.241000E+01 0.121069E+03 0.288111E-01   0.242000E+01 0.120945E+03 0.283996E-01   0.243000E+01 0.120821E+03 0.279996E-01
  0.244000E+01 0.120699E+03 0.276107E-01   0.245000E+01 0.120577E+03 0.272325E-01   0.246000E+01 0.120458E+03 0.268645E-01

DRIFT=  0.558032E+01

NOZZLE NO.        YNOZ          ZNOZ          DIAMN          STDEV          Q          DRIFT

     1          0.4000        0.4000        200.0000       50.0000        1.0000       5.5803
```



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SINGLE DROPLET LATERAL DISPLACEMENT

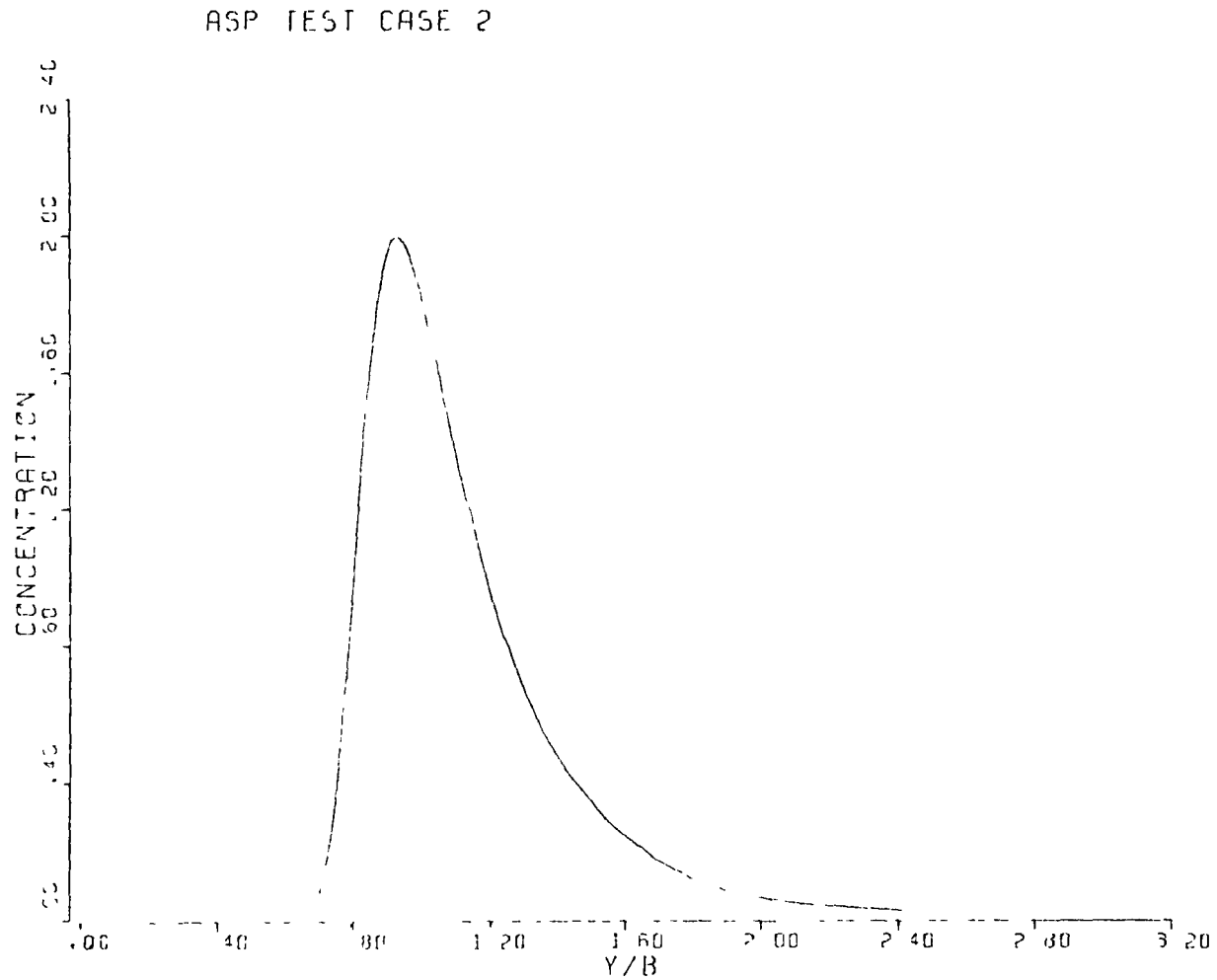

NOZZLE:      1
     YG              DIA
  0.567768E+00  0.600000E+03
  0.785351E+00  0.300000E+03
  0.889156E+00  0.250000E+03
  0.107252E+01  0.200000E+03
  0.149923E+01  0.150000E+03
  0.191002E+01  0.130300E+03
  0.246069E+01  0.120449E+03
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
  0.000000E+01  0.000000E+01
```

FINAL DISTRIBUTION

YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION
0.64	0.110564E-03	0.65	0.408700E-03	0.66	0.126168E-02	0.67	0.334558E-02	0.68	0.779777E-02
0.69	0.162809E-01	0.70	0.309327E-01	0.71	0.541859E-01	0.72	0.884828E-01	0.73	0.135946E+00
0.74	0.198073E+00	0.75	0.275513E+00	0.76	0.367965E+00	0.77	0.474192E+00	0.78	0.592145E+00
0.79	0.719134E+00	0.80	0.851925E+00	0.81	0.987170E+00	0.82	0.112161E+01	0.83	0.125221E+01
0.84	0.137634E+01	0.85	0.149180E+01	0.86	0.159689E+01	0.87	0.169039E+01	0.88	0.177154E+01
0.89	0.184000E+01	0.90	0.189559E+01	0.91	0.193848E+01	0.92	0.196920E+01	0.93	0.198850E+01
0.94	0.199723E+01	0.95	0.199634E+01	0.96	0.198681E+01	0.97	0.196964E+01	0.98	0.194580E+01
0.99	0.191622E+01	1.00	0.188178E+01	1.01	0.184330E+01	1.02	0.180153E+01	1.03	0.175716E+01
1.04	0.171079E+01	1.05	0.166297E+01	1.06	0.161418E+01	1.07	0.156483E+01	1.08	0.151536E+01
1.09	0.146626E+01	1.10	0.141774E+01	1.11	0.136998E+01	1.12	0.132313E+01	1.13	0.127730E+01
1.14	0.123259E+01	1.15	0.118905E+01	1.16	0.114675E+01	1.17	0.110572E+01	1.18	0.106597E+01
1.19	0.102752E+01	1.20	0.990365E+00	1.21	0.954498E+00	1.22	0.919905E+00	1.23	0.886566E+00
1.24	0.854457E+00	1.25	0.823551E+00	1.26	0.793816E+00	1.27	0.765222E+00	1.28	0.737734E+00
1.29	0.711317E+00	1.30	0.685937E+00	1.31	0.661557E+00	1.32	0.638143E+00	1.33	0.615658E+00
1.34	0.594069E+00	1.35	0.573341E+00	1.36	0.553441E+00	1.37	0.534334E+00	1.38	0.515991E+00
1.39	0.498379E+00	1.40	0.481469E+00	1.41	0.465232E+00	1.42	0.449639E+00	1.43	0.434664E+00
1.44	0.420280E+00	1.45	0.406463E+00	1.46	0.393188E+00	1.47	0.380433E+00	1.48	0.368174E+00
1.49	0.356392E+00	1.50	0.345064E+00	1.51	0.334066E+00	1.52	0.323321E+00	1.53	0.312838E+00
1.54	0.302624E+00	1.55	0.292683E+00	1.56	0.283019E+00	1.57	0.273632E+00	1.58	0.264523E+00
1.59	0.255689E+00	1.60	0.247128E+00	1.61	0.238838E+00	1.62	0.230813E+00	1.63	0.223049E+00
1.64	0.215542E+00	1.65	0.208284E+00	1.66	0.201271E+00	1.67	0.194496E+00	1.68	0.187953E+00
1.69	0.181636E+00	1.70	0.175537E+00	1.71	0.169650E+00	1.72	0.163969E+00	1.73	0.158487E+00
1.74	0.153197E+00	1.75	0.148094E+00	1.76	0.143170E+00	1.77	0.138419E+00	1.78	0.133837E+00
1.79	0.129415E+00	1.80	0.125150E+00	1.81	0.121034E+00	1.82	0.117063E+00	1.83	0.113232E+00
1.84	0.109534E+00	1.85	0.105966E+00	1.86	0.102522E+00	1.87	0.991974E-01	1.88	0.959882E-01
1.89	0.928897E-01	1.90	0.898979E-01	1.91	0.870086E-01	1.92	0.842382E-01	1.93	0.816006E-01
1.94	0.790880E-01	1.95	0.766933E-01	1.96	0.744098E-01	1.97	0.722311E-01	1.98	0.701514E-01
1.99	0.681652E-01	2.00	0.662675E-01	2.01	0.644532E-01	2.02	0.627181E-01	2.03	0.610577E-01
2.04	0.594682E-01	2.05	0.579458E-01	2.06	0.564870E-01	2.07	0.550886E-01	2.08	0.537473E-01
2.09	0.524604E-01	2.10	0.512251E-01	2.11	0.500387E-01	2.12	0.488990E-01	2.13	0.478034E-01
2.14	0.467500E-01	2.15	0.457366E-01	2.16	0.447614E-01	2.17	0.438225E-01	2.18	0.429181E-01
2.19	0.420468E-01	2.20	0.412068E-01	2.21	0.403969E-01	2.22	0.396155E-01	2.23	0.388614E-01
2.24	0.381334E-01	2.25	0.374303E-01	2.26	0.367510E-01	2.27	0.360944E-01	2.28	0.354595E-01
2.29	0.348454E-01	2.30	0.342512E-01	2.31	0.336761E-01	2.32	0.331191E-01	2.33	0.325796E-01
2.34	0.320569E-01	2.35	0.315501E-01	2.36	0.310587E-01	2.37	0.305821E-01	2.38	0.301195E-01
2.39	0.296705E-01	2.40	0.292346E-01	2.41	0.288111E-01	2.42	0.283996E-01	2.43	0.279996E-01
2.44	0.276107E-01	2.45	0.272325E-01	2.46	0.268645E-01				

TOTAL DRIFT= 0.558032E+01

TOTAL= 0.944312E+02
BAKGND: STOP


ASP TEST CASE 2
CONCENTRATION
.00
.40
.80
1.20
1.60
2.00
2.40
2.80
3.20
Y/B

OSU / AARL

AERIAL SPRAY PROGRAM

LAST UPDATE 2/1/81

ASP TEST CASE 3

PROGRAM CONTROL

N2D= 1	N3D= 0	NEVAP= 1	NPROP2= 0	NCW= 0
NTUN= 0	NDIST= 1	NPRINT= 0	NPLOT= 1	EPS= 0.100000E-04

PARAMETER VALUES

A= 6.0000	CL= 0.6000	B= 6.0960	U= 53.0350	G= 9.8066
ZY0= 0.8000	Z70= 0.5000	DA= 0.118901E+01	VIS= 0.181330E-04	VCW= 0.0000
D= 0.0000	DD= 1000.0000			

EVAPORATION INPUTS

PA= 101352.10 TDB= 23.888900 TWB= 18.333300

DISTRIBUTION INPUTS

NCOL= 1	NROW= 6	NDIAMN= 1	NSTDEV= 1	NQ= 1
NZNOZ= 1	DD=1000.00000	X= 0.00000	UD= 0.00000	VD= 0.00000
WD= 0.00000	SWIDTH= 4.00000	DERR= 1.00000	DWIDTH= 5.00000	

NOZZLE NO.	YNOZ	ZNOZ	DIAMN	STDEV	Q	DRIFT
1	0.4000	0.4000	200.0000	50.0000	1.0000	21.2474

SINGLE DROPLET LATERAL DISPLACEMENT

NOZZLE: 1

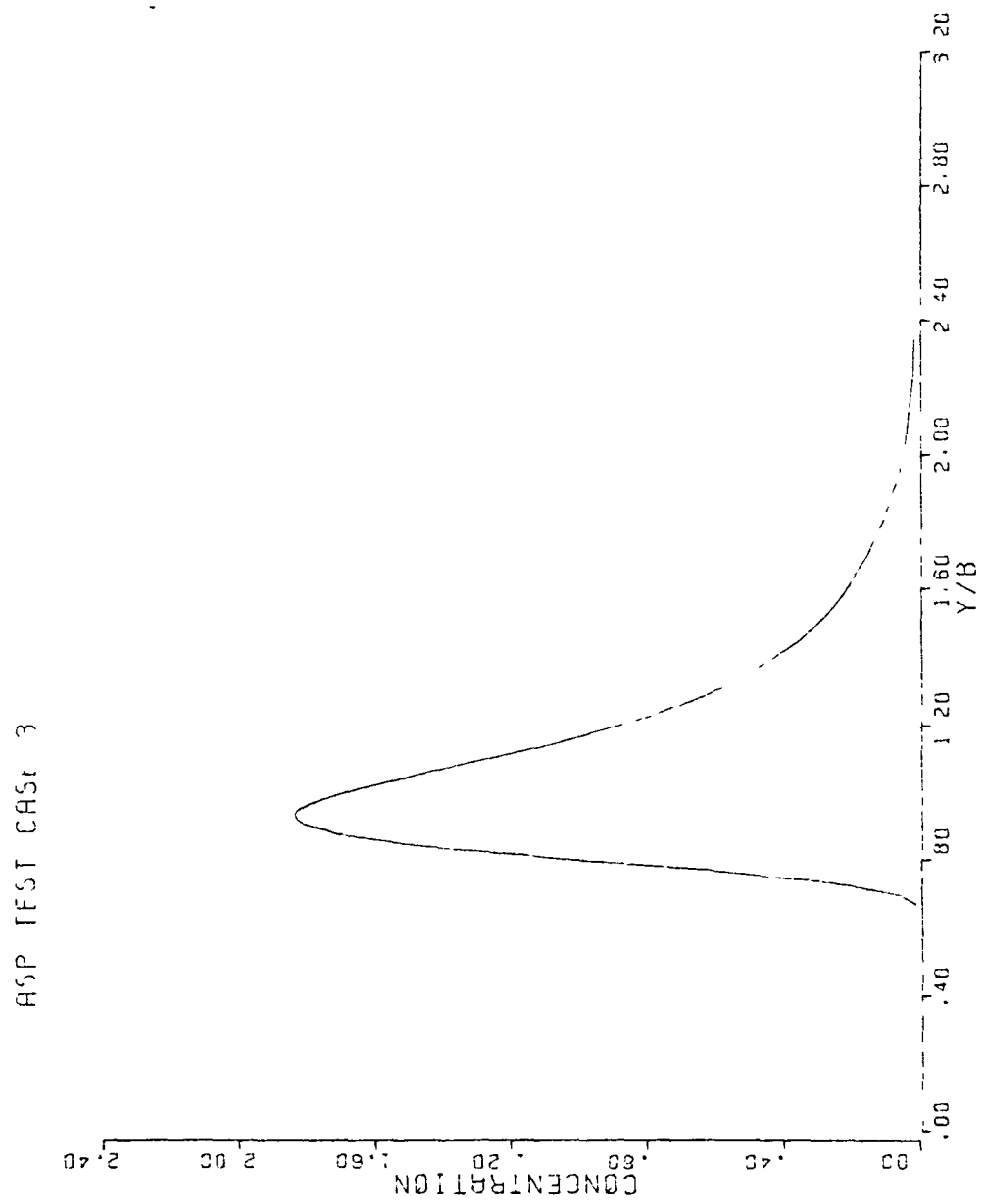
YG	DIA	DIAG
0.566534E+00	0.600000E+03	0.598786E+03
0.786095E+00	0.300000E+03	0.297565E+03
0.892304E+00	0.250000E+03	0.247031E+03
0.108410E+01	0.200000E+03	0.196103E+03
0.155559E+01	0.150000E+03	0.143102E+03
0.204485E+01	0.131864E+03	0.119342E+03
0.235994E+01	0.127329E+03	0.109949E+03
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01

FINAL DISTRIBUTION

YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION
0.64	0.124109E-03	0.65	0.445961E-03	0.66	0.134425E-02	0.67	0.349339E-02	0.68	0.800428E-02
0.69	0.164709E-01	0.70	0.309088E-01	0.71	0.535747E-01	0.72	0.866979E-01	0.73	0.132177E+00
0.74	0.191308E+00	0.75	0.264595E+00	0.76	0.351662E+00	0.77	0.451289E+00	0.78	0.561524E+00
0.79	0.679842E+00	0.80	0.803113E+00	0.81	0.928154E+00	0.82	0.105193E+01	0.83	0.117164E+01
0.84	0.128490E+01	0.85	0.138974E+01	0.86	0.148466E+01	0.87	0.156864E+01	0.88	0.164107E+01
0.89	0.170174E+01	0.90	0.175078E+01	0.91	0.178863E+01	0.92	0.181580E+01	0.93	0.183294E+01
0.94	0.184078E+01	0.95	0.184014E+01	0.96	0.183185E+01	0.97	0.181677E+01	0.98	0.179573E+01
0.99	0.176951E+01	1.00	0.173887E+01	1.01	0.170452E+01	1.02	0.166711E+01	1.03	0.162724E+01
1.04	0.158543E+01	1.05	0.154217E+01	1.06	0.149790E+01	1.07	0.145297E+01	1.08	0.140773E+01
1.09	0.136244E+01	1.10	0.131730E+01	1.11	0.127254E+01	1.12	0.122836E+01	1.13	0.118492E+01
1.14	0.114237E+01	1.15	0.110081E+01	1.16	0.106032E+01	1.17	0.102097E+01	1.18	0.982809E+00
1.19	0.945863E+00	1.20	0.910151E+00	1.21	0.875679E+00	1.22	0.842445E+00	1.23	0.810440E+00
1.24	0.779645E+00	1.25	0.750041E+00	1.26	0.721601E+00	1.27	0.694295E+00	1.28	0.668093E+00
1.29	0.642961E+00	1.30	0.618865E+00	1.31	0.595770E+00	1.32	0.573638E+00	1.33	0.552436E+00
1.34	0.532126E+00	1.35	0.512674E+00	1.36	0.494045E+00	1.37	0.476205E+00	1.38	0.459121E+00
1.39	0.442760E+00	1.40	0.427091E+00	1.41	0.412084E+00	1.42	0.397710E+00	1.43	0.383941E+00
1.44	0.370749E+00	1.45	0.358108E+00	1.46	0.345994E+00	1.47	0.334383E+00	1.48	0.323252E+00
1.49	0.312579E+00	1.50	0.302342E+00	1.51	0.292523E+00	1.52	0.283103E+00	1.53	0.274062E+00
1.54	0.265384E+00	1.55	0.257052E+00	1.56	0.249039E+00	1.57	0.241244E+00	1.58	0.233645E+00
1.59	0.226239E+00	1.60	0.219023E+00	1.61	0.211994E+00	1.62	0.205151E+00	1.63	0.198490E+00
1.64	0.192008E+00	1.65	0.185704E+00	1.66	0.179573E+00	1.67	0.173614E+00	1.68	0.167824E+00
1.69	0.162200E+00	1.70	0.156739E+00	1.71	0.151439E+00	1.72	0.146296E+00	1.73	0.141308E+00
1.74	0.136471E+00	1.75	0.1317A3E+00	1.76	0.127240E+00	1.77	0.122840E+00	1.78	0.118579E+00
1.79	0.114455E+00	1.80	0.110463E+00	1.81	0.106601E+00	1.82	0.102866E+00	1.83	0.992536E-01
1.84	0.957618E-01	1.85	0.923869E-01	1.86	0.891259E-01	1.87	0.859754E-01	1.88	0.829325E-01
1.89	0.799939E-01	1.90	0.771566E-01	1.91	0.744176E-01	1.92	0.717737E-01	1.93	0.692221E-01
1.94	0.667599E-01	1.95	0.643842E-01	1.96	0.620922E-01	1.97	0.598811E-01	1.98	0.577482E-01
1.99	0.556909E-01	2.00	0.537067E-01	2.01	0.517930E-01	2.02	0.499474E-01	2.03	0.481675E-01
2.04	0.464509E-01	2.05	0.447997E-01	2.06	0.432341E-01	2.07	0.417527E-01	2.08	0.403504E-01
2.09	0.390227E-01	2.10	0.377650E-01	2.11	0.365733E-01	2.12	0.354437E-01	2.13	0.343724E-01
2.14	0.333562E-01	2.15	0.323918E-01	2.16	0.314761E-01	2.17	0.306064E-01	2.18	0.297799E-01
2.19	0.289942E-01	2.20	0.282470E-01	2.21	0.275361E-01	2.22	0.268593E-01	2.23	0.262148E-01
2.24	0.256007E-01	2.25	0.250153E-01	2.26	0.244571E-01	2.27	0.239245E-01	2.28	0.234160E-01
2.29	0.229304E-01	2.30	0.224664E-01	2.31	0.220229E-01	2.32	0.215986E-01	2.33	0.211926E-01
2.34	0.208038E-01	2.35	0.204314E-01						

TOTAL DRIFT= 0.212474E+02

TOTAL= 0.860481E+02
BAKGND: STOP


ASP TEST CASE 3
CONCENTRATION
Y/B
.00
.40
.80
1.20
1.60
2.00
2.40
2.80
3.20
.00
.40
.80
1.20
1.60
2.00
2.40

OSU / AARL

AERIAL SPRAY PROGRAM

LAST UPDATE 2/1/81

ASP TEST CASE 4

PROGRAM CONTROL

N2D= 1	N3D= 0	NEVAP= 0	NPROP2= 0	NCW= 0
NTUN= 1	NDIST= 1	NPRINT= 0	NPLOT= 1	EPS= 0.100000E-04

PARAMETER VALUES

A= 6.0000	CL= 0.6000	B= 6.0960	U= 53.0350	G= 9.8066
ZY0= 0.8000	ZZ0= 0.5000	DA= 0.122500E+01	VIS= 0.179320E-04	VCW= 0.0000
D= 36.5760	DD= 1000.0000			

DISTRIBUTION INPUTS

NCOL= 1	NROW= 6	NDIAMN= 1	NSTDEV= 1	NQ= 1
NZNOZ= 1	DD=1000.00000	X= 0.00000	UD= 0.00000	VD= 0.00000
WD= 0.00000	SWIDTH= 4.00000	DERR= 1.00000	DWIDTH= 5.00000	

NOZZLE NO.	YNOZ	ZNOZ	DIAMN	STDEV	Q	DRIFT
1	0.4000	0.4000	200.0000	50.0000	1.0000	5.5777

SINGLE DROPLET LATERAL DISPLACEMENT

NOZZLE: 1

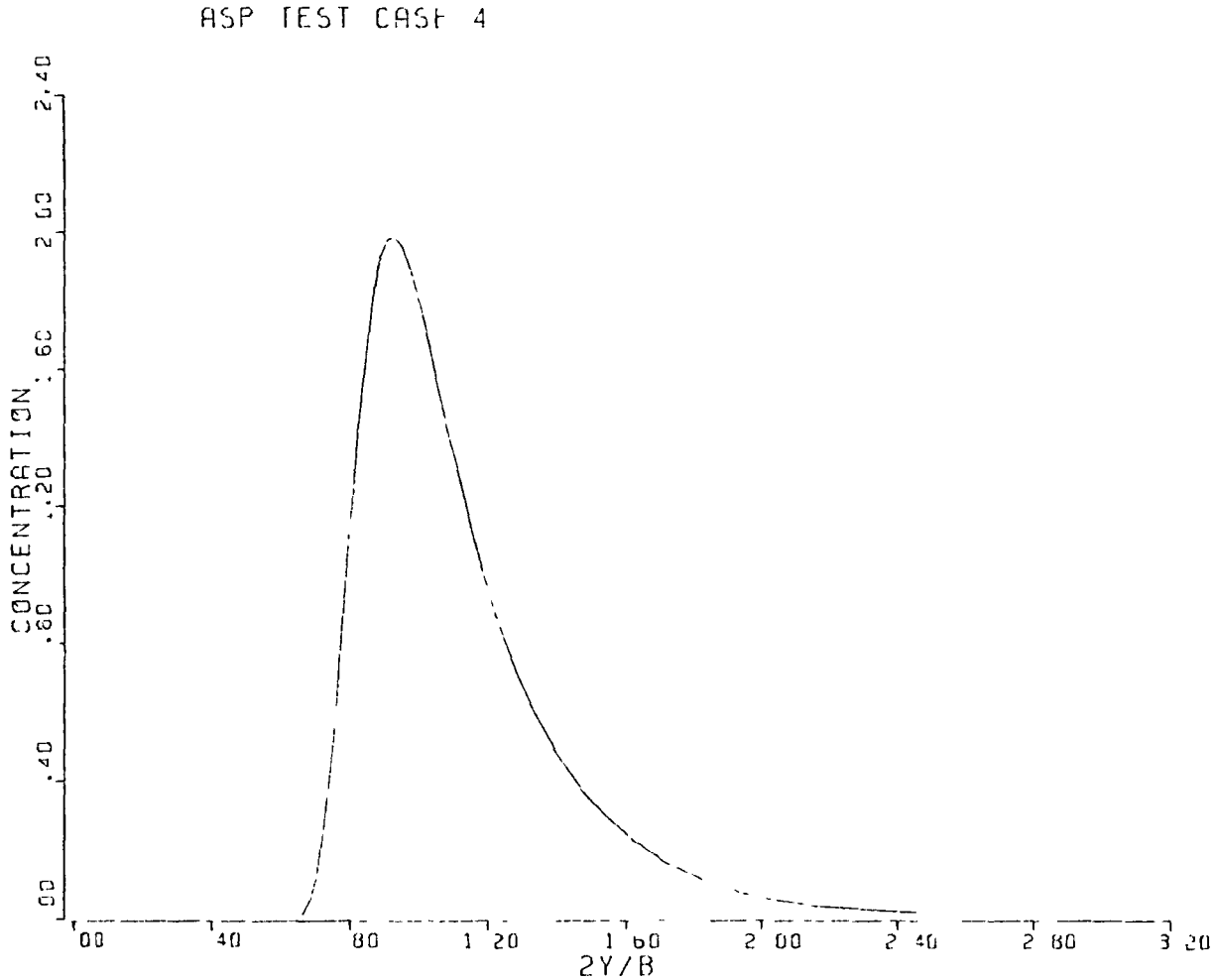
YG	DIA
0.567303E+00	0.600000E+03
0.785011E+00	0.300000E+03
0.888992E+00	0.250000E+03
0.107310E+01	0.200000E+03
0.150001E+01	0.150000E+03
0.191081E+01	0.130292E+03
0.248190E+01	0.120437E+03
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01

FINAL DISTRIBUTION

YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION
0.64	0.117847E-03	0.65	0.431420E-03	0.66	0.132101E-02	0.67	0.347890E-02	0.68	0.806143E-02
0.69	0.167483E-01	0.70	0.316871E-01	0.71	0.553080E-01	0.72	0.900375E-01	0.73	0.137970E+00
0.74	0.200565E+00	0.75	0.278435E+00	0.76	0.371242E+00	0.77	0.477720E+00	0.78	0.595802E+00
0.79	0.722783E+00	0.80	0.855396E+00	0.81	0.990285E+00	0.82	0.112419E+01	0.83	0.125410E+01
0.84	0.137738E+01	0.85	0.149188E+01	0.86	0.159591E+01	0.87	0.168829E+01	0.88	0.176829E+01
0.89	0.183559E+01	0.90	0.189011E+01	0.91	0.193209E+01	0.92	0.196208E+01	0.93	0.198083E+01
0.94	0.198918E+01	0.95	0.198809E+01	0.96	0.197851E+01	0.97	0.196144E+01	0.98	0.193781E+01
0.99	0.190854E+01	1.00	0.187451E+01	1.01	0.183650E+01	1.02	0.179526E+01	1.03	0.175145E+01
1.04	0.170567E+01	1.05	0.165845E+01	1.06	0.161025E+01	1.07	0.156150E+01	1.08	0.151260E+01
1.09	0.146403E+01	1.10	0.141601E+01	1.11	0.136872E+01	1.12	0.132230E+01	1.13	0.127688E+01
1.14	0.123253E+01	1.15	0.118933E+01	1.16	0.114733E+01	1.17	0.110657E+01	1.18	0.106707E+01
1.19	0.102884E+01	1.20	0.991886E+00	1.21	0.956193E+00	1.22	0.921753E+00	1.23	0.888547E+00
1.24	0.856552E+00	1.25	0.825743E+00	1.26	0.796091E+00	1.27	0.767564E+00	1.28	0.740131E+00
1.29	0.713757E+00	1.30	0.688409E+00	1.31	0.664052E+00	1.32	0.640652E+00	1.33	0.618174E+00
1.34	0.596584E+00	1.35	0.575848E+00	1.36	0.555935E+00	1.37	0.536811E+00	1.38	0.518445E+00
1.39	0.500807E+00	1.40	0.483868E+00	1.41	0.467598E+00	1.42	0.451970E+00	1.43	0.436958E+00
1.44	0.422535E+00	1.45	0.408677E+00	1.46	0.395361E+00	1.47	0.382563E+00	1.48	0.370261E+00
1.49	0.358435E+00	1.50	0.347063E+00	1.51	0.336030E+00	1.52	0.325237E+00	1.53	0.314697E+00
1.54	0.304418E+00	1.55	0.294405E+00	1.56	0.284664E+00	1.57	0.275197E+00	1.58	0.266004E+00
1.59	0.257084F+00	1.60	0.248437E+00	1.61	0.240058E+00	1.62	0.231946E+00	1.63	0.224095E+00
1.64	0.216501E+00	1.65	0.209158E+00	1.66	0.202061E+00	1.67	0.195204E+00	1.68	0.188580E+00
1.69	0.182184E+00	1.70	0.176009E+00	1.71	0.170048E+00	1.72	0.164295E+00	1.73	0.158743E+00
1.74	0.153386E+00	1.75	0.148218E+00	1.76	0.143231E+00	1.77	0.138420E+00	1.78	0.133779E+00
1.79	0.129302E+00	1.80	0.124982E+00	1.81	0.120815E+00	1.82	0.116794E+00	1.83	0.112915E+00
1.84	0.109171E+00	1.85	0.105559E+00	1.86	0.102073E+00	1.87	0.987078E-01	1.88	0.954596E-01
1.89	0.923239E-01	1.90	0.892963E-01	1.91	0.863727E-01	1.92	0.835671E-01	1.93	0.808973E-01
1.94	0.783554F-01	1.95	0.759341E-01	1.96	0.736265E-01	1.97	0.714261E-01	1.98	0.693269E-01
1.99	0.673232E-01	2.00	0.654097E-01	2.01	0.635815E-01	2.02	0.618341E-01	2.03	0.601629E-01
2.04	0.585640E-01	2.05	0.570334E-01	2.06	0.555678E-01	2.07	0.541635E-01	2.08	0.528176E-01
2.09	0.515269E-01	2.10	0.502887E-01	2.11	0.491003E-01	2.12	0.479593E-01	2.13	0.468633E-01
2.14	0.458100E-01	2.15	0.447975E-01	2.16	0.438237E-01	2.17	0.428867E-01	2.18	0.419848E-01
2.19	0.411164E-01	2.20	0.402798E-01	2.21	0.394737E-01	2.22	0.386965E-01	2.23	0.379469E-01
2.24	0.372237E-01	2.25	0.365258E-01	2.26	0.358519E-01	2.27	0.352009E-01	2.28	0.345720E-01
2.29	0.339640E-01	2.30	0.333761E-01	2.31	0.328075E-01	2.32	0.322572E-01	2.33	0.317246E-01
2.34	0.312088E-01	2.35	0.307091E-01	2.36	0.302249E-01	2.37	0.297556E-01	2.38	0.293004E-01
2.39	0.288590E-01	2.40	0.284305E-01	2.41	0.280147E-01	2.42	0.276109E-01	2.43	0.272187E-01
2.44	0.268375E-01	2.45	0.264671E-01	2.46	0.261069E-01	2.47	0.257566E-01	2.48	0.254158E-01

TOTAL DRIFT= 0.557766E+01

TOTAL= 0.944302E+02
BAKGND: STOP


ASP TEST CASE 4
CONCENTRATION
.00
.40
.80
1.20
1.60
2.00
2.40
.00
.40
.80
1.20
1.60
2.00
2.40
2.80
3.20
2Y/B

OSU / AARL

AERIAL SPRAY PROGRAM

LAST UPDATE 2/1/81

ASP TEST CASE 5

PROGRAM CONTROL

N2D= 0	N3D= 1	NEVAP= 1	NPROP2= 1	NCW= 1
NTUN= 0	NDIST= 1	NPRINT= 0	NPLOT= 1	EPS= 0.100000E-04

PARAMETER VALUES

A= 6.0000	CL= 0.6000	B= 6.0960	U= 53.0350	G= 9.8066
ZY0= 0.8000	ZZ0= 0.5000	DA= 0.118901E+01	VIS= 0.181330E-04	VCW= 1.0000
D= 0.0000	DD= 1000.0000			

EVAPORATION INPUTS

PA= 101352.10	TDR= 23.888900	TWR= 18.333300

PROP2 INPUTS

ZPROP2= 0.5000	PK1= 1.7930	PK2= 17.9300	PK3= 0.0000	PK4= 6.0290
RP= 0.2000				

DISTRIBUTION INPUTS

NCOL= 3	NROW= 6	NDIAMN= 1	NSTDEV= 1	NQ= 1
NZNOZ= 1	DD=1000.00000	X= 0.00000	UD= 0.00000	VD= 0.00000
WD= 0.00000	SWIDTH= 4.00000	DFRR= 1.00000	DWIDTH= 5.00000	

NOZZLE NO.	YNOZ	ZNOZ	DIAMN	STDEV	Q	DRIFT
1	-0.3000	0.4000	200.0000	50.0000	1.0000	7.1442
2	0.0000	0.4000	200.0000	50.0000	1.0000	13.0321
3	0.3000	0.4000	200.0000	50.0000	1.0000	9.2220

SINGLE DROPLET LATERAL DISPLACEMENT

NOZZLE:	1			2			3	
YG	DIA	DIAG	YG	DIA	DIAG	YG	DIA	DIAG
-0.320151E+00	0.600000E+03	0.598080E+03	-0.876441E-01	0.600000E+03	0.597780E+03	0.544745E+00	0.600000E+03	0.598063E+03
-0.407045E+00	0.300000E+03	0.297088E+03	-0.515855E-01	0.300000E+03	0.296151E+03	0.708199E+00	0.300000E+03	0.297044E+03
-0.459665E+00	0.250000E+03	0.246594E+03	-0.539186E-01	0.275000E+03	0.270796E+03	0.781975E+00	0.250000E+03	0.246526E+03
-0.557848E+00	0.200000E+03	0.195780E+03	-0.593184E-01	0.250000E+03	0.245340E+03	0.896006E+00	0.200000E+03	0.195665E+03
-0.783947E+00	0.150000E+03	0.144136E+03	-0.842100E-01	0.200000E+03	0.193927E+03	0.109198E+01	0.150000E+03	0.144039E+03
-0.147024E+01	0.100000E+03	0.740140E+02	-0.139088E+00	0.150000E+03	0.140996E+03	0.152290E+01	0.100000E+03	0.900272E+02
-0.151925E+01	0.984375E+02	0.632314E+02	-0.172918E+00	0.125000E+03	0.112875E+03	0.209856E+01	0.770271E+02	0.613805E+02
0.000000E+01	0.000000E+01	0.000000E+01	0.321932E+00	0.100000E+03	0.710852E+02	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.325157E+00	0.725000E+02	0.451472E+02	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.704499E-01	0.690625E+02	0.157827E+02	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01
0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01	0.000000E+01

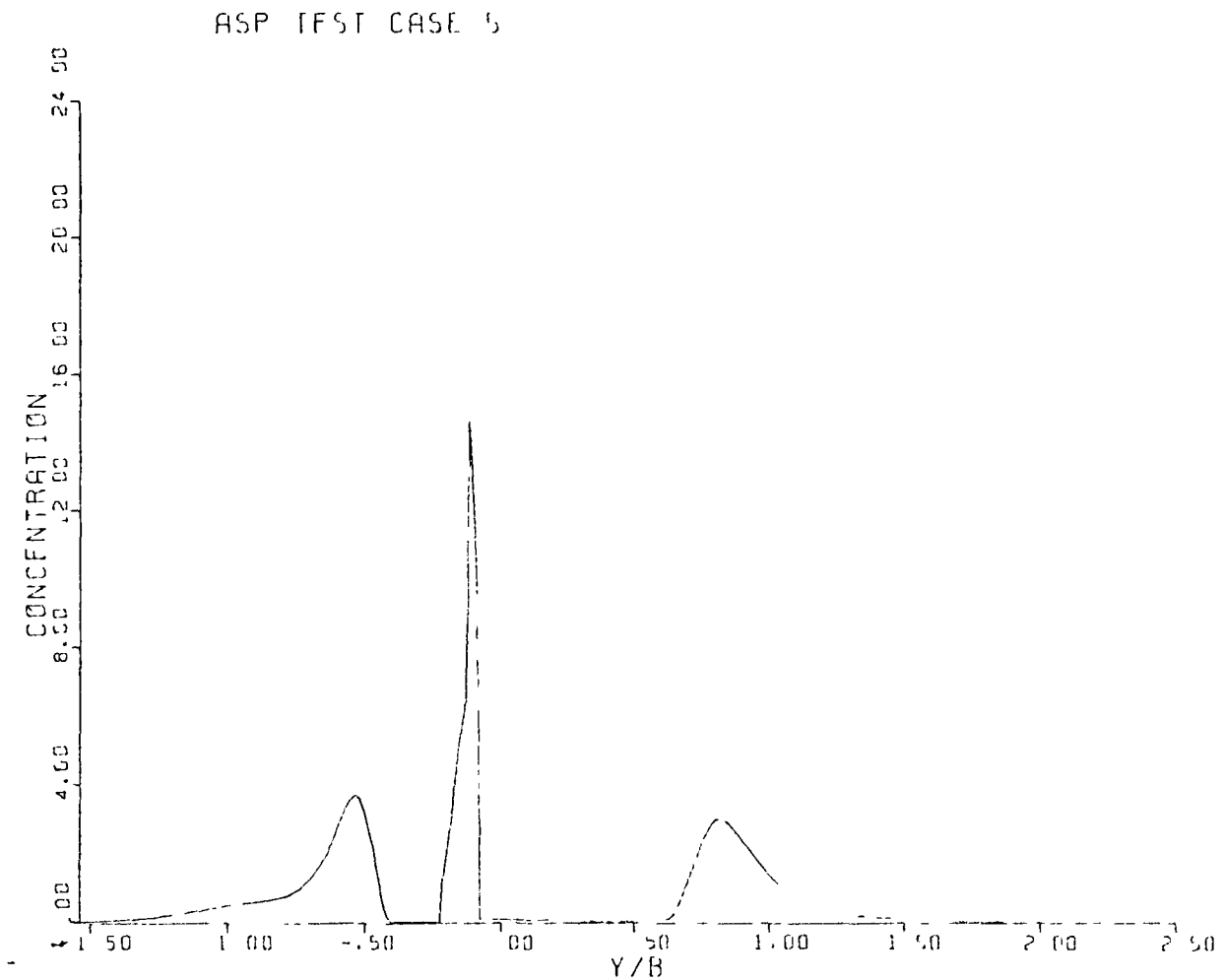
FINAL DISTRIBUTION

YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION	YG	CONCENTRATION
-1.51	0.919440E-02	-1.50	0.103502E-01	-1.49	0.116264E-01	-1.48	0.130289E-01	-1.47	0.145629E-01
-1.46	0.162340E-01	-1.45	0.180510E-01	-1.44	0.200232E-01	-1.43	0.221601E-01	-1.42	0.244715E-01
-1.41	0.269678E-01	-1.40	0.296594E-01	-1.39	0.325572E-01	-1.38	0.356725E-01	-1.37	0.390167E-01
-1.36	0.426016E-01	-1.35	0.464390E-01	-1.34	0.505412E-01	-1.33	0.549204E-01	-1.32	0.595890E-01
-1.31	0.645596E-01	-1.30	0.698445E-01	-1.29	0.754561E-01	-1.28	0.814066E-01	-1.27	0.877078E-01
-1.26	0.943714E-01	-1.25	0.101408E+00	-1.24	0.108829E+00	-1.23	0.116644E+00	-1.22	0.124861E+00
-1.21	0.133489E+00	-1.20	0.142533E+00	-1.19	0.152000E+00	-1.18	0.161892E+00	-1.17	0.172212E+00
-1.16	0.182959E+00	-1.15	0.194131E+00	-1.14	0.205723E+00	-1.13	0.217726E+00	-1.12	0.230131E+00
-1.11	0.242923E+00	-1.10	0.256085E+00	-1.09	0.269595E+00	-1.08	0.283428E+00	-1.07	0.297556E+00
-1.06	0.311945E+00	-1.05	0.326556E+00	-1.04	0.341349E+00	-1.03	0.356277E+00	-1.02	0.371289E+00
-1.01	0.386331E+00	-1.00	0.401346E+00	-0.99	0.416273E+00	-0.98	0.431049E+00	-0.97	0.445610E+00
-0.96	0.459892E+00	-0.95	0.473831E+00	-0.94	0.487368E+00	-0.93	0.500447E+00	-0.92	0.513020E+00
-0.91	0.525048E+00	-0.90	0.536505E+00	-0.89	0.547382E+00	-0.88	0.557687E+00	-0.87	0.567455E+00
-0.86	0.576747E+00	-0.85	0.585659E+00	-0.84	0.594326E+00	-0.83	0.602928E+00	-0.82	0.611698E+00
-0.81	0.620931E+00	-0.80	0.630991E+00	-0.79	0.642328E+00	-0.78	0.655514E+00	-0.77	0.671325E+00
-0.76	0.690124E+00	-0.75	0.712217E+00	-0.74	0.737946E+00	-0.73	0.767698E+00	-0.72	0.801901E+00
-0.71	0.841038E+00	-0.70	0.885644E+00	-0.69	0.936312E+00	-0.68	0.993698E+00	-0.67	0.105852E+01
-0.66	0.113158E+01	-0.65	0.121374E+01	-0.64	0.130592E+01	-0.63	0.140916E+01	-0.62	0.152453E+01
-0.61	0.165320E+01	-0.60	0.179643E+01	-0.59	0.195549E+01	-0.58	0.213168E+01	-0.57	0.232615E+01
-0.56	0.253965E+01	-0.55	0.276672E+01	-0.54	0.299187E+01	-0.53	0.320669E+01	-0.52	0.340104E+01
-0.51	0.356281E+01	-0.50	0.367833E+01	-0.49	0.373321E+01	-0.48	0.371375E+01	-0.47	0.360894E+01
-0.46	0.341294E+01	-0.45	0.313619E+01	-0.44	0.279241E+01	-0.43	0.238913E+01	-0.42	0.194197E+01
-0.41	0.147452E+01	-0.40	0.100968E+01	-0.39	0.581835E+00	-0.38	0.260214E+00	-0.37	0.796776E-01
-0.36	0.136499E-01	-0.35	0.938853E-03	-0.17	0.168032E+01	-0.16	0.221909E+01	-0.15	0.265141E+01
-0.14	0.302479E+01	-0.13	0.430308E+01	-0.12	0.496400E+01	-0.11	0.561741E+01	-0.10	0.618396E+01
-0.09	0.657872E+01	-0.08	0.146893E+02	-0.07	0.128646E+02	-0.06	0.969981E+01	-0.05	0.625907E-01
-0.04	0.601423E-01	-0.03	0.577604E-01	-0.02	0.554479E-01	-0.01	0.532070E-01	0.00	0.510397E-01
0.01	0.489476E-01	0.02	0.469318E-01	0.03	0.449931E-01	0.04	0.431322E-01	0.05	0.413491E-01
0.06	0.396439E-01	0.07	0.380163E-01	0.08	0.365174E-01	0.09	0.350553E-01	0.10	0.336704E-01
0.11	0.323619E-01	0.12	0.311288E-01	0.13	0.299698E-01	0.14	0.288839E-01	0.15	0.278698E-01
0.16	0.269261E-01	0.17	0.260517E-01	0.18	0.252451E-01	0.19	0.245051E-01	0.20	0.238307E-01
0.21	0.232205E-01	0.22	0.226735E-01	0.23	0.221889E-01	0.24	0.217659E-01	0.25	0.214037E-01
0.26	0.211019E-01	0.27	0.208601E-01	0.28	0.206784E-01	0.29	0.205569E-01	0.30	0.204959E-01
0.31	0.204961E-01	0.32	0.205586E-01	0.61	0.398603E-03	0.62	0.188731E-02	0.63	0.691297E-02
0.64	0.204101E-01	0.65	0.502728E-01	0.66	0.106330E+00	0.67	0.197834E+00	0.68	0.330412E+00
0.69	0.503837E+00	0.70	0.711515E+00	0.71	0.941824E+00	0.72	0.118517E+01	0.73	0.143373E+01
0.74	0.167951E+01	0.75	0.191594E+01	0.76	0.213787E+01	0.77	0.234145E+01	0.78	0.252389E+01
0.79	0.268062E+01	0.80	0.280446E+01	0.81	0.289454E+01	0.82	0.295156E+01	0.83	0.297733E+01
0.84	0.297448E+01	0.85	0.294617E+01	0.86	0.289584E+01	0.87	0.282701E+01	0.88	0.274313E+01
0.89	0.264744E+01	0.90	0.254306E+01	0.91	0.243368E+01	0.92	0.232165E+01	0.93	0.220864E+01
0.94	0.209605E+01	0.95	0.198500E+01	0.96	0.187638E+01	0.97	0.177087E+01	0.98	0.166897E+01
0.99	0.157106E+01	1.00	0.147738E+01	1.01	0.138806E+01	1.02	0.130318E+01	1.03	0.122273E+01
1.04	0.114665E+01	1.05	0.107486E+01	1.06	0.100723E+01	1.07	0.943617E+00	1.08	0.883859E+00
1.09	0.827786E+00	1.10	0.775062E+00	1.11	0.725256E+00	1.12	0.678293E+00	1.13	0.634094E+00
1.14	0.592563E+00	1.15	0.553596E+00	1.16	0.517082E+00	1.17	0.482905E+00	1.18	0.450947E+00
1.19	0.421089E+00	1.20	0.393215E+00	1.21	0.367209E+00	1.22	0.342959E+00	1.23	0.320356E+00
1.24	0.299299E+00	1.25	0.279683E+00	1.26	0.261418E+00	1.27	0.244412E+00	1.28	0.228580E+00
1.29	0.213842E+00	1.30	0.200122E+00	1.31	0.187350E+00	1.32	0.175459E+00	1.33	0.164388E+00
1.34	0.154078E+00	1.35	0.144474E+00	1.36	0.135528E+00	1.37	0.127192E+00	1.38	0.119422E+00
1.39	0.112178E+00	1.40	0.105422E+00	1.41	0.991196E-01	1.42	0.932381E-01	1.43	0.877476E-01
1.44	0.826202E-01	1.45	0.778301E-01	1.46	0.733534E-01	1.47	0.691679E-01	1.48	0.652532E-01
1.49	0.615902E-01	1.50	0.581613E-01	1.51	0.549501E-01	1.52	0.519417E-01	1.53	0.491255E-01
1.54	0.464975E-01	1.55	0.440436E-01	1.56	0.417504E-01	1.57	0.396055E-01	1.58	0.375977E-01
1.59	0.357167E-01	1.60	0.339532E-01	1.61	0.322984E-01	1.62	0.307446E-01	1.63	0.292843E-01
1.64	0.279110E-01	1.65	0.266185E-01	1.66	0.254011E-01	1.67	0.242538E-01	1.68	0.231716E-01

1.73	0.[illegible]E-01	1.74	0.178233E-01	1.75	0.170913E-01	1.76	0.163973E-01	1.77	0.157389E-01
1.78	0.151139E-01	1.79	0.145204E-01	1.80	0.139563E-01	1.81	0.134200E-01	1.82	0.129097E-01
1.83	0.124241E-01	1.84	0.119615E-01	1.85	0.115208E-01	1.86	0.111006E-01	1.87	0.106998E-01
1.88	0.103174E-01	1.89	0.995225E-02	1.90	0.960347E-02	1.91	0.927016E-02	1.92	0.895150E-02
1.93	0.864670E-02	1.94	0.835502E-02	1.95	0.807580E-02	1.96	0.780837E-02	1.97	0.755215E-02
1.98	0.730654E-02	1.99	0.707104E-02	2.00	0.684512E-02	2.01	0.662831E-02	2.02	0.642017E-02
2.03	0.622028E-02	2.04	0.602825E-02	2.05	0.584368E-02	2.06	0.566624E-02	2.07	0.549559E-02
2.08	0.533141E-02	2.09	0.517340E-02						

TOTAL DRIFT= 0.979943E+01

TOTAL= 0.873970E+02
BAKGND: STOP


ASP TEST CASE 5
CONCENTRATION
24.00
20.00
16.00
12.00
8.00
4.00
.00
-1.50
-1.00
-.50
.00
.50
1.00
1.50
2.00
2.50
Y/B

APPENDIX B

FORTRAN COMPUTER PROGRAM LISTING

```
C                                                                       10
C       ASP  -   AERIAL SPRAY PROGRAM                                   20
C                                                                       30
C       ASP WAS BEEN DESIGNED TO PREDICT THE GROUND DEPOSITION          40
C       AND PERCENT OF MATERIAL LOST DUE TO DRIFT FROM AN               50
C       AGRICULTURAL AIRCRAFT.  THE PROGRAM IS WRITTEN TO INPUT         60
C       DATA IN SI UNITS AND INCLUDES THE FOLLOWING OPTIONS:            70
C           1) 2D OR 3D WAKE MODEL AND DROPLET DYNAMICS                 80
C           2) A DROPLET EVAPORATION MODEL                              90
C           3) A PROPELLER SLIPSTREAM MODEL                            100
C           4) A CROSSWIND MODEL                                       110
C           5) A TUNNEL WALL MODEL                                     120
C           6) THE ABILITY FOR THE USER TO SUPPLY HIS OWN              130
C              FLOWFIELD MODEL.                                        140
C                                                                      150
C       DOCUMENTATION AVAILABLE IN THE FORM OF A NASA CONTRACTORS      160
C       REPORT                                                         170
C                                                                      180
C       CODE WRITTEN AT THE AERONAUTICAL AND ASTRONAUTICAL ENGINEERING 190
C       RESEARCH LABORATORY,  THE OHIO STATE UNIVERSITY,  COLUMBUS,    200
C       OHIO  1981     AUTHOR  MICHAEL B. BRAGG                        210
C                                                                      220
C       LAST UPDATE 2/1/81                                             230
C                                                                      240
C                                                                      250
CDC   PROGRAM MAIN(INPUT,OUTPUT,TAPE8,TAPE5=INPUT,TAPE6=OUTPUT)       260
      DIMENSION YMOZ(100),SIZE(15),DIST(1001),DRIFT(100),NRUN(100)     270
      DIMENSION DIAMN(100),STDEV(100),Q(100),ZNOZ(100),DIAG(15,100)    280
      DIMENSION IRUN(50),TRAJ(15,100),SIZ(15,100)                      290
     &          ,SLP(15),XLIST(5),DLIST(5)                             300
      DIMENSION YY(13,13),SAVE(13,13),CSAVE(13,3),YMAX(13),MET(100)    310
      DIMENSION ERROR(13),DY(13),YY1(13),PW(13,13),IP(13),TITLE(13)    320
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                330
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT    340
      COMMON /AREA3/ PSWB,PAE,PV,SCN,DV                                350
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                         360
      COMMON /AREA6/ JJ,IRUN,ICOUNT                                    370
      COMMON /AREA7/ NVAR                                              380
      COMMON /AREA10/ TRAJ,DIAG,SIZ                                    390
C                                                                      400
C       INPUT THE NECESSARY PARAMETERS ACCORDING TO THE OPTIONS        410
C       SELECTED AND OUTPUT HEADER AND TITLE                           420
C                                                                      430
  800 CONTINUE                                                         440
      REWIND 8                                                         450
      READ(5,3,END=700) (TITLE(K),K=1,13)                              460
    3 FORMAT(13A6)                                                     470
      WRITE(6,5) (TITLE(K),K=1,13)                                     480
    5 FORMAT("1",T50,"OSU / AARL"/"0",T50,                             490
     &       "AERIAL SPRAY PROGRAM"/"0",T50,                           500
     &       "LAST UPDATE 2/1/81"/////"0",13A6//)                      510
      DO 1 K=1,100                                                     520
      DRIFT(K)=0.                                                      530
      NRUN(K)=0                                                        540
      DO 1 J=1,15                                                      550
```

```
      SIZ(J,K)=0.                                                       560
      DIAG(J,K)=0.                                                      570
    1 TRAJ(J,K)=0.                                                      580
      DO 2 K=1,1001                                                     590
    2 DIST(K)=0.                                                        600
      ICOUNT=1                                                          610
      JJ=0                                                              620
      READ(5,10)NDROPS                                                  630
   10 FORMAT(I5)                                                        640
      DO 210 I=1,NDROPS                                                 650
      READ(5,20) N2D,N3D,NEVAP,NPROP2,NCW,NTUN,NDIST,                   660
     &           NPRINT,NPLOT,EPS                                       670
   20 FORMAT(9I2,2X,E15.6)                                              680
      IF(NEVAP.EQ.1) READ(5,30) PA,TDB,TWB                              690
   30 FORMAT(3F10.6)                                                    700
      IF(NPROP2.EQ.1) READ(5,50) ZPROP2,PK1,PK2,PK3,PK4,RP              710
   50 FORMAT(6F10.4)                                                    720
      READ(5,60) A,CL,B,U,G,ZY0,ZZ0                                     730
   60 FORMAT(7F10.4)                                                    740
      READ(5,70) DA,VIS,VCW,D                                           750
   70 FORMAT(2E20.6,2F10.4)                                             760
      IF(NDIST.EQ.1) GO TO 90                                           770
      READ(5,90) DIA,DD,X,Y,Z,UD,VD,WD                                  780
   80 FORMAT(8F10.5)                                                    790
      GO TO 120                                                         800
   90 CONTINUE                                                          810
      READ(5,95) NCOL,NROW,NDIAMN,NSTDEV,NQ,NZNOZ                       820
   95 FORMAT(6I5)                                                       830
      READ(5,100)DD,X0,UD0,VD0,WD0,SWIDTH,DERR,DWIDTH                   840
  100 FORMAT(8F10.5)                                                    850
      READ(5,110) (YNOZ(K),K=1,NCOL)                                    860
  110 FORMAT(8F10.5)                                                    870
      READ(5,110) (SIZE(K),K=1,NROW)                                    880
      IF(NDIAMN.EQ.1) READ(5,110) (DIAMN(K),K=1,NCOL)                   890
      IF(NDIAMN.EQ.0) READ(5,110) DIAMN1                                900
      IF(NSTDEV.EQ.1) READ(5,110) (STDEV(K),K=1,NCOL)                   910
      IF(NSTDEV.EQ.0) READ(5,110) STDEV1                                920
      IF(NQ.EQ.1) READ(5,110) (Q(K),K=1,NCOL)                           930
      IF(NQ.EQ.0) READ(5,110) Q1                                        940
      IF(NZNOZ.EQ.1) READ(5,110) (ZNOZ(K),K=1,NCOL)                     950
      IF(NZNOZ.EQ.0) READ(5,110) ZNOZ1                                  960
      DO 115 K=1,NCOL                                                   970
      IF(NDIAMN.EQ.0) DIAMN(K)=DIAMN1                                   980
      IF(NQ.EQ.0) Q(K)=Q1                                               990
      IF(NSTDEV.EQ.0) STDEV(K)=STDEV1                                  1000
      IF(NZNOZ.EQ.0) ZNOZ(K)=ZNOZ1                                     1010
  115 CONTINUE                                                         1020
  120 CONTINUE                                                         1030
      C=3.141592653589793                                              1040
C                                                                      1050
C        CALCULATE EVAPORATION PARAMETERS                              1060
C                                                                      1070
      IF(NEVAP.EQ.0) GO TO 130                                         1080
      TDBK=TDB+273.15                                                  1090
      TDBR=TDB*(9./5.)+32.+459.67                                      1100
```

```
      TWBR=TWB*(9./5.)+32.+459.67                                       1110
      PAE=PA*1.4504E-4                                                  1120
      PS=EXP(54.6329-12301.688/TDBR-5.16923*ALOG(TDBR))                 1130
      PSWB=EXP(54.6329-12301.688/TWBR-5.16923*ALOG(TWBR))               1140
      PV=PSWB-((.2405*(PAE-PSWB))/(.62194*(1075.8965-.56983*            1150
     &    (TWBR-491.69))))*(TDBR-TWBR)                                  1160
      RH=PV/PS                                                          1170
      DA=((PAE*144.)/(G*3.280839*53.34*TDBR))*515.4                     1180
      DV=(5.2AE-6*TDBK**1.88)*1.E-4                                     1190
      VIS=1.795E-5*(TDBK/293.16)**1.5*((293.16+110.)/(TDBK+110.))       1200
      SCN=(DV*DA)/VIS                                                   1210
  130 CONTINUE                                                          1220
C                                                                       1230
C        DETERMINE NVAR, THE NUMBER OF SIMULTANEOUS FIRST ORDER         1240
C        DIFFERENTIAL EQUATIONS TO BE SOLVED                            1250
C                                                                       1260
      NVAR=4                                                            1270
      IF(N3D.NE.0) NVAR=6                                               1280
      IF(NEVAP.EQ.1) NVAR=NVAR+1                                        1290
      IF(N2D.EQ.2.OR.N3D.EQ.2) GO TO 138                                1300
      IF(NTUN.EQ.1) GO TO 136                                           1310
      IF(NCW.EQ.1.AND.NPROP2.EQ.1) GO TO 132                            1320
      IF(NCW.EQ.1) GO TO 134                                            1330
      IF(NPROP2.EQ.1) NVAR=NVAR+1                                       1340
      GO TO 138                                                         1350
  132 NVAR=NVAR+6                                                       1360
      GO TO 138                                                         1370
  134 NVAR=NVAR+4                                                       1380
      GO TO 138                                                         1390
  136 NVAR=NVAR+2                                                       1400
      IF(NPROP2.EQ.1) NVAR=NVAR+1                                       1410
      GO TO 138                                                         1420
  138 CONTINUE                                                          1430
C                                                                       1440
C        OUTPUT THE CONSTANTS THAT WERE INPUT                           1450
C                                                                       1460
      WRITE(6,150) N2D,N3D,NEVAP,NPROP2,NCW,NTUN,NDIST,NPRINT,          1470
     &             NPLOT,EPS                                            1480
  150 FORMAT("0","PROGRAM CONTROL",//" ",T5,"N2D=",I2,T25,"N3D=",I2,    1490
     &       T45,"NEVAP=",I2,T65,"NPROP2=",I2,T85,"NCW=",I2/" "         1500
     &      ,T5,"NTUN=",I2,T25,"NDIST=",I2,T45,"NPRINT=",I2,T65,        1510
     &       "NPLOT=",I2,T85,"EPS=",E13.6/)                            1520
      WRITE(6,160) A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                   1530
  160 FORMAT("0","PARAMETER VALUES"//" ",T5,"A=",F10.4,T25,"CL=",       1540
     &       F10.4,T45,"B=",F10.4,T65,"U=",F10.4,T85,"G=",F10.4/" ",    1550
     &       T5,"ZY0=",F10.4,T25,"ZZ0=",F10.4,T45,"DA=",E13.6,T65,      1560
     &       "VIS=",E13.6,T85,"VCW=",F10.4/" ",T5,"D=",F10.4,           1570
     &       T25,"DD=",F10.4/)                                          1580
      IF(NEVAP.EQ.1) WRITE(6,170) PA,TDB,TWB                            1590
  170 FORMAT("0","EVAPORATION INPUTS"//" ",T5,"PA=",F10.2,T25,          1600
     &       "TDB=",F10.6,T45,"TWB=",F10.6/)                           1610
      IF(NPROP2.EQ.1) WRITE(6,190) ZPROP2,PK1,PK2,PK3,PK4,RP            1620
  190 FORMAT("0","PROP2 INPUTS"//" ",T5,"ZPROP2=",F10.4,T25,            1630
     &       "PK1=",F10.4,T45,"PK2=",F10.4,T65,"PK3=",F10.4             1640
     &       ,T85,"PK4=",F10.4/" ",T5,"RP=",F10.4/)                    1650
```

```
C         CHANGE FROM RECTANGULAR TO ELLIPTICAL LOAD DISTRIBUTION          1660
C         BY ADJUSTING CL                                                  1670
      CL=(4./C)*CL                                                         1680
      IF(NDIST.EQ.1) GO TO 220                                             1690
      WRITE(6,195) X,Y,Z,UD,VD,WD,DIA                                      1700
  195 FORMAT("0","INITIAL VALUES"//" ",T5,"X=",F10.6,T25,                  1710
     &        "Y=",F10.6,T45,"Z=",F10.6,T65,"UD=",F10.6,T85,               1720
     &        "VD=",F10.6/" ",T5,"WD=",F10.6,T25,"DIA=",                   1730
     &        F10.4/)                                                      1740
C                                                                          1750
C         CALL SUB2D OR SUB3D TO CALCULATE THE DROPLET TRAJECTORY          1760
C                                                                          1770
      IF(N2D.NE.0) CALL SUB2D(NVAR,Y,Z,VD,WD,T,DIA,YY,SAVE                 1780
     &              ,CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                        1790
      IF(N3D.NE.0) CALL SUB3D(NVAR,X,Y,Z,UD,VD,WD,T,DIA,YY,SAVE            1800
     &              ,CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                        1810
      ICOUNT=ICOUNT+1                                                      1820
      WRITE(6,200) X,Y,Z,UD,VD,WD,DIA,T                                    1830
  200 FORMAT("0","FINAL VALUES"//" ",T5,"X=",F10.6,T25,"Y=",               1840
     &        F10.6,T45,"Z=",F10.6,T65,"UD=",F10.6,T85,"VD=",              1850
     &        F10.6/" ",T5,"WD=",F10.6,T25,"DIA=",F10.4,T45,               1860
     &        "T=",F10.6/)                                                 1870
  210 CONTINUE                                                             1880
      GO TO 320                                                            1890
  220 CONTINUE                                                             1900
C                                                                          1910
C         THIS PART OF THE MAIN PROGRAM CONTROLS THE NDIST=1 CASE          1920
C                                                                          1930
      WRITE(6,225) NCOL,NROW,NDIAMN,NSTDEV,NQ,NZNOZ,DD,                    1940
     &              X0,UD0,VD0,WD0,SWIDTH,DERR,DWIDTH                      1950
  225 FORMAT("0","DISTRIBUTION INPUTS"//" ",T5,"NCOL=",I2,                 1960
     &        T25,"NROW=",I2,T45,"NDIAMN=",I2,T65,"NSTDEV=",I2,            1970
     &        T85,"NQ=",I2/" ",T5,"NZNOZ=",I2,T25,"DD=",F10.5,             1980
     &        T45,"X=",F10.5,T65,"UD=",F10.5,T85,"VD=",F10.5/              1990
     &        " ",T5,"WD=",F10.5,T25,"SWIDTH=",F10.5,T45,"DERR=",          2000
     &        F10.5,T65,"DWIDTH=",F10.5)                                   2010
C                                                                          2020
C         PERFORM ALL THE TRAJECTORIES REQUIRED TO CALCULATE THE           2030
C         REQUIRED DISTRIBUTION                                            2040
C                                                                          2050
      DO 250 I=1,NCOL                                                      2060
      DO 240 J=1,NROW                                                      2070
      DIA=SIZE(J)                                                          2080
      DIA1=DIA                                                             2090
      K=K-1                                                                2100
      T=0.                                                                 2110
      X=X0                                                                 2120
      UD=UD0                                                               2130
      VD=VD0                                                               2140
      WD=WD0                                                               2150
      Z=ZNOZ(I)                                                            2160
      Y=YNOZ(I)                                                            2170
      IF(N2D.NE.0) CALL SUB2D(NVAR,Y,Z,VD,WD,T,DIA,YY,SAVE,                2180
     &              CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                         2190
      IF(N3D.NE.0) CALL SUB3D(NVAR,X,Y,Z,UD,VD,WD,T,DIA,YY,SAVE,           2200
```

```
     &               CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                          2210
      TRAJ(J,I)=Y                                                            2220
      DIAG(J,I)=DIA                                                          2230
      SIZ(J,I)=SIZE(J)                                                       2240
      IF(Z.NE.0.) GO TO 241                                                  2250
      NRUN(I)=NRUN(I)+1                                                      2260
      IF(Z.EQ.0.AND.ABS(Y).GT.DWIDTH) GO TO 241                              2270
  240 CONTINUE                                                               2280
C                                                                            2290
C        THIS SECTION UP TO STMT NO 250 CONTROLS THE CALCULATION             2300
C        OF ADDITIONAL TRAJECTORIES IN ORDER TO ESTIMATE THE DRIFT           2310
C        AND INSERTS PARTICLES IN REGIONS OF A LARGE GRADIENT                2320
C        DDIA/DYG                                                            2330
C                                                                            2340
      KMISS=0                                                                2350
      SIZMIS=0.                                                              2360
  241 CONTINUE                                                               2370
      J=NRUN(I)+1                                                            2380
      MET(I)=0                                                               2390
      IF(J.EQ.1) DRIFT(I)=SIZ(J,I)                                           2400
      IF(J.EQ.1) GO TO 250                                                   2410
      DSIZ1=ABS(DIAMN(I)-SIZ(J-1,I))                                         2420
      K250=0                                                                 2430
      GO TO 243                                                              2440
  234 CONTINUE                                                               2450
      IF(Z.EQ.0.AND.ABS(Y).GT.DWIDTH) GO TO 250                              2460
      IF((DSIZ1/STDEV(I)).LT.4.) GO TO 242                                   2470
      DRIFT(I)=0.                                                            2480
      GO TO 250                                                              2490
  242 CONTINUE                                                               2500
C                                                                            2510
C        DEFINE ACCEPTABLE ERROR IN TERMS OF STDEV                           2520
C                                                                            2530
      ERR=.5*STDEV(I)                                                        2540
      IF(DSIZ1.LT.(2.*STDEV(I))) ERR=.30*STDEV(I)                            2550
      IF(DSIZ1.LT.STDEV(I)) ERR=.20*STDEV(I)                                 2560
      ERR=ERR*DERR                                                           2570
  246 CONTINUE                                                               2580
      IF(Z.NE.0.) KMISS=1                                                    2590
      IF(Z.NE.0.) SIZMIS=SIZ(J,I)                                            2600
      IF(J.GE.3) GO TO 239                                                   2610
      IF(J.EQ.2) SIZ(J,I)=SIZ(J-1,I)-(SIZ(J-1,I)-SIZMIS)/2.                  2620
      GO TO 245                                                              2630
  239 CONTINUE                                                               2640
C                                                                            2650
C        DETERMINE PARTICLE SIZE FOR DRIFT ESTIMATE                          2660
C        AND CALCULATE TRAJECTORIES                                          2670
C                                                                            2680
      YGM1=TRAJ(J-2,I)                                                       2690
      YG=TRAJ(J-1,I)                                                         2700
      Y1=ABS(1./(YG-YNOZ(I)))                                                2710
      Y2=ABS(1./(YGM1-YNOZ(I)))                                              2720
      SLOPE=(SIZ(J-2,I)-SIZ(J-1,I))/(Y2-Y1)                                  2730
      SIZ(J,I)=SIZ(J-1,I)-SLOPE*Y1/2                                         2740
      IF((SLOPE*Y1/2.).LT.ERR) SIZ(J,I)=SIZ(J-1,I)-ERR                       2750
```

```
      IF(SIZ(J,I).GT.SIZMIS) GO TO 245                                  2760
      SIZ(J,I)=SIZMIS+(SIZ(J-1,I)-SIZMIS)/2.                            2770
  245 CONTINUE                                                          2780
      DIA=SIZ(J,I)                                                      2790
      DIA1=DIA                                                          2800
      T=0.                                                              2810
      X=XU                                                              2820
      UD=UD0                                                            2830
      VD=VD0                                                            2840
      WD=WD0                                                            2850
      Z=ZNOZ(I)                                                         2860
      Y=YNOZ(I)                                                         2870
      IF(N2D.NE.0) CALL SUB2D(NVAR,Y,Z,VD,WD,T,DIA,YY,SAVE,             2880
     &                 CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                   2890
      IF(N3D.NE.0) CALL SUB3D(NVAR,X,Y,Z,UD,VD,WD,T,DIA,YY,SAVE,        2900
     &                 CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                   2910
C                                                                       2920
C        STORE TRAJECTORY INFORMATION, IF ERROR.LT.ERR GO TO 250        2930
C        OTHERWISE ITERATE                                              2940
C                                                                       2950
      TRAJ(J,I)=Y                                                       2960
      DIAG(J,I)=DIA                                                     2970
      IF(MET(I).EQ.1) GO TO 228                                         2980
      IF(Z.NE.0.) GO TO 246                                             2990
      NRUN(I)=NRUN(I)+1                                                 3000
      IF(ABS(Y).LT.DWIDTH) GO TO 330                                    3010
      GO TO 250                                                         3020
  330 CONTINUE                                                          3030
      IF((SIZ(J,I)-SIZMIS).GT.ERR) GO TO 244                            3040
      DRIFT(I)=SIZ(J,I)                                                 3050
      K250=1                                                            3060
      GO TO 243                                                         3070
  244 CONTINUE                                                          3080
      J=J+1                                                             3090
      IF(J.LE.15) GO TO 246                                             3100
      WRITE(6,247)                                                      3110
  247 FORMAT(" ","*** MAX NUMBER OF RUNS EXCEEDED BEFORE DRIFT",        3120
     &       " CALCULATION COMPLETED")                                  3130
      DRIFT(I)=SIZ(J,I)                                                 3140
      GO TO 250                                                         3150
  243 CONTINUE                                                          3160
C                                                                       3170
C        THIS SECTION HANDLLES THE CASE WHERE DYG/DDIA CHANGES          3180
C        SIGN BETWEEN POINTS                                            3190
C                                                                       3200
      IF(J.EQ.2) GO TO 227                                              3210
      J2=J-2                                                            3220
      DO 410 K=1,J2                                                     3230
      SLP(K)=(TRAJ(K+1,I)-TRAJ(K,I))/(SIZ(K+1,I)-SIZ(K,I))              3240
  410 CONTINUE                                                          3250
      DO 221 K=2,J2                                                     3260
      IF(SLP(K).GT.0.AND.SLP(K-1).LT.0.) GO TO 222                      3270
      IF(SLP(K).LT.0.AND.SLP(K-1).GT.0.) GO TO 222                      3280
  221 CONTINUE                                                          3290
      IF(K250.EQ.1) GO TO 250                                           3300
```

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      GO TO 234                                                          3310
  222 CONTINUE                                                           3320
C                                                                        3330
C        INSERT PARTICLES WHERE DYG/DDIA CHANGES SIGN                    3340
C                                                                        3350
      MET(I)=1                                                           3360
      IF(K250.EQ.1) GO TO 250                                            3370
      IADD=0                                                             3380
      DO 223 K2=2,J2                                                     3390
      K=K2                                                               3400
      IF(SLP(K).LT.0.AND.SLP(K-1).LT.0.) GO TO 223                       3410
      IF(SLP(K).GT.0.AND.SLP(K-1).GT.0.) GO TO 223                       3420
      IF(IADD.NE.0) K=K2+IADD                                            3430
      DELTA=ABS(SIZ(K,I)-DIAMN(I))/STDEV(I)                              3440
      ER=1.0*STDEV(I)                                                    3450
      IF(DELTA.LT.2.) ER=.75*STDEV(I)                                    3460
      IF(DELTA.LT.1.) ER=.50*STDEV(I)                                    3470
      ER=ER*DERR                                                         3480
      IDELTA=ABS(SIZ(K+1,I)-SIZ(K,I))/ER                                 3490
      IADD=IADD+IDELTA                                                   3500
      DELTA=(SIZ(K+1,I)-SIZ(K,I))/(IDELTA+1)                             3510
      K1=K+1                                                             3520
      J1=J-1                                                             3530
      DO 224 K5=K1,J1                                                    3540
      KK=K1-K5+J1                                                        3550
      TRAJ(KK+IDELTA,I)=TRAJ(KK,I)                                       3560
      DIAG(KK+IDELTA,I)=DIAG(KK,I)                                       3570
      SIZ(KK+IDELTA,I)=SIZ(KK,I)                                         3580
  224 CONTINUE                                                           3590
      DO 226 KK=1,IDELTA                                                 3600
      SIZ(K+KK,I)=SIZ(K,I)+KK*DELTA                                      3610
      DIA=SIZ(K+KK,I)                                                    3620
      T=0.                                                               3630
      X=X0                                                               3640
      UD=UD0                                                             3650
      VD=VD0                                                             3660
      WD=WD0                                                             3670
      Z=ZNOZ(I)                                                          3680
      Y=YNOZ(I)                                                          3690
      IF(N2D.NE.0) CALL SUB2D(NVAR,Y,Z,VD,WD,T,DIA,YY,SAVE,              3700
     &                 CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                  3710
      IF(N3D.NE.0) CALL SUB3D(NVAR,X,Y,Z,UD,VD,WD,T,DIA,YY,SAVE,         3720
     &                 CSAVE,YMAX,ERROR,DY,YY1,PW,IP)                  3730
      TRAJ(KK+K,I)=Y                                                     3740
      DIAG(KK+K,I)=DIA                                                   3750
      NRUN(I)=NRUN(I)+1                                                  3760
      J=J+1                                                              3770
  226 CONTINUE                                                           3780
      NRR=NRUN(I)                                                        3790
  223 CONTINUE                                                           3800
  227 CONTINUE                                                           3810
C                                                                        3820
C        DETERMINE PARTICLE SIZE FOR DRIFT ESTIMATE AND                  3830
C        CALCULATE THE TRAJECTORY                                        3840
C                                                                        3850
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      DSIZ1=ABS(DIAMN(I)-SIZ(J-1,I))                                    3860
      IF((DSIZ1/STDEV(I)).LT.4) GO TO 237                               3870
      DRIFT(I)=0.                                                       3880
      GO TO 250                                                         3890
  237 CONTINUE                                                          3900
      ERR=.5*STDEV(I)                                                   3910
      IF(DSIZ1.LT.(2.*STDEV(I))) ERR=.30*STDEV(I)                       3920
      IF(DSIZ1.LT.STDEV(I)) ERR=.20*STDEV(I)                            3930
      ERR=ERR*ERR                                                       3940
  236 CONTINUE                                                          3950
      IF(KMISS.EQ.0) SIZ(J,I)=SIZ(J-1,I)-1.1*ERR                        3960
      IF(KMISS.EQ.1) SIZ(J,I)=SIZ(J-1,I)-(SIZ(J-1,I)-SIZMIS)/2.         3970
      GO TO 245                                                         3980
  228 CONTINUE                                                          3990
C                                                                       4000
C        IF PARTICLE WITHIN ERR GO TO 250 OTHERWISE ITERATE             4010
C                                                                       4020
      IF(Z.EQ.0.) GO TO 229                                             4030
      KMISS=1                                                           4040
      SIZMIS=SIZ(J,I)                                                   4050
      GO TO 227                                                         4060
  229 CONTINUE                                                          4070
      NRUN(I)=NRUN(I)+1                                                 4080
      IF(ABS(Y).LT.DWIDTH) GO TO 340                                    4090
      DRIFT(I)=SIZ(J-1,I)-ABS((SIZ(J,I)-SIZ(J-1,I))/(Y-TRAJ(J-1,I)))*   4100
     &         (DWIDTH-ABS(TRAJ(J-1,I)))                                4110
      GO TO 250                                                         4120
  340 CONTINUE                                                          4130
      IF(ABS(SIZ(J,I)-SIZ(J-1,I)).GT.ERR) GO TO 233                     4140
      DRIFT(I)=SIZ(J,I)                                                 4150
      GO TO 250                                                         4160
  233 CONTINUE                                                          4170
      J=J+1                                                             4180
      IF(J.LE.15) GO TO 236                                             4190
      WRITE(6,247)                                                      4200
  250 CONTINUE                                                          4210
C                                                                       4220
C        COMBINE TRAJECTORY INFORMATION TO BUILD-UP THE DISTRIBUTION     4230
C        AND ESTIMATE THE DRIFT OUTPUT RESULTS                          4240
C                                                                       4250
      CALL SWATH(NCOL,NROW,Q,DIAMN,STDEV,YNOZ,DWIDTH,NRUN,MET,          4260
     &           SWIDTH,DIST,DRIFT)                                     4270
      WRITE(6,252)                                                      4280
  252 FORMAT("0","NOZZLE NO.",8X,"YNOZ",11X,"ZNOZ",8X,                  4290
     &       "DIAMN",10X,"STDEV",13X,"Q",12X,"DRIFT"/)                  4300
      DO 255 K=1,NCOL                                                   4310
      WRITE(6,253) K,YNOZ(K),ZNOZ(K),DIAMN(K),STDEV(K),Q(K),DRIFT(K)    4320
  253 FORMAT(" ",4X,I3,6F15.4)                                          4330
  255 CONTINUE                                                          4340
      WRITE(6,256)                                                      4350
  256 FORMAT("1"//" SINGLE DROPLET LATERAL DISPLACEMENT"//)             4360
C                                                                       4370
C        OUTPUT TRAJECTORY INFORMATION TO PRINTER                       4380
C                                                                       4390
      NP=NCOL/3                                                         4400
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      NLEFT=NCOL-NP*3                                                   4410
      KP=-2                                                             4420
      IF(NP.EQ.0) GO TO 425                                             4430
      DO 405 K1=1,NP                                                    4440
      KK=IFIX(K1/2.)*2                                                  4450
      IF(K1.EQ.KK) WRITE(6,415)                                         4460
  415 FORMAT("1"," ")                                                   4470
      KP=K1*3-2                                                         4480
      KP1=KP+1                                                          4490
      KP2=KP+2                                                          4500
      IF(NEVAP.EQ.1) GO TO 450                                          4510
      WRITE(6,420) KP,KP1,KP2                                           4520
  420 FORMAT("0","NOZZLE:",T13,I3,T55,I3,T97,I3/" ",T7,"YG",T21,"DIA",  4530
     &       T49,"YG",T63,"DIA",T91,"YG",T105,"DIA")                    4540
      DO 430 K2=1,15                                                    4550
      WRITE(6,440) TRAJ(K2,KP),SIZ(K2,KP),TRAJ(K2,KP+1),SIZ(K2,KP+1),   4560
     &             TRAJ(K2,KP+2),SIZ(K2,KP+2)                           4570
  440 FORMAT(" ",2F14.6,14X,2E14.6,14X,2E14.6)                          4580
  430 CONTINUE                                                          4590
      GO TO 405                                                         4600
  450 CONTINUE                                                          4610
      WRITE(6,460) KP,KP1,KP2                                           4620
  460 FORMAT("0","NOZZLE:",T20,I3,T62,I3,T104,I3/" ",T7,"YG",T21,"DIA", 4630
     &       T35,"DIAG",T49,"YG",T63,"DIA",T77,"DIAG",T91,"YG",T105,    4640
     &       "DIA",T119,"DIAG")                                         4650
      DO 470 K2=1,15                                                    4660
      WRITE(6,480) TRAJ(K2,KP),SIZ(K2,KP),DIAG(K2,KP),TRAJ(K2,KP+1),    4670
     &             SIZ(K2,KP+1),DIAG(K2,KP+1),TRAJ(K2,KP+2),SIZ(K2,KP+2) 4680
     &             ,DIAG(K2,KP+2)                                       4690
  480 FORMAT(" ",9E14.6)                                                4700
  470 CONTINUE                                                          4710
  405 CONTINUE                                                          4720
  425 CONTINUE                                                          4730
      IF(NLEFT.EQ.0) GO TO 600                                          4740
      KK=IFIX(K1/2.)*2                                                  4750
      KP3=KP+3                                                          4760
      KP4=KP+4                                                          4770
      IF(K1.NE.KK) WRITE(6,415)                                         4780
      IF(NLEFT.EQ.1) GO TO 550                                          4790
      IF(NEVAP.EQ.1) GO TO 510                                          4800
      WRITE(6,490) KP3,KP4                                              4810
  490 FORMAT("0","NOZZLE:",T13,I3,T55,I3/" ",T7,"YG",T21,"DIA",T49,"YG", 4820
     &       T63,"DIA")                                                 4830
      DO 500 K2=1,15                                                    4840
      WRITE(6,440) TRAJ(K2,KP+3),SIZ(K2,KP+3),TRAJ(K2,KP+4),SIZ(K2,KP+4) 4850
  500 CONTINUE                                                          4860
      GO TO 600                                                         4870
  510 CONTINUE                                                          4880
      WRITE(6,520) KP3,KP4                                              4890
  520 FORMAT("0","NOZZLE:",T20,I3,T62,I3/" ",T7,"YG",T21,"DIA",T35,     4900
     &       "DIAG",T49,"YG",T63,"DIA",T77,"DIAG")                      4910
      DO 530 K2=1,15                                                    4920
      WRITE(6,480) TRAJ(K2,KP+3),SIZ(K2,KP+3),DIAG(K2,KP+3),            4930
     &             TRAJ(K2,KP+4),SIZ(K2,KP+4),DIAG(K2,KP+4)             4940
  530 CONTINUE                                                          4950
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      GO TO 600                                                          4960
  550 CONTINUE                                                           4970
      IF(NEVAP.EQ.1) GO TO 580                                           4980
      WRITE(6,560) KP3                                                   4990
  560 FORMAT("0","NOZZLE:",T13,I3/" ",T7,"YG",T21,"DIA")                 5000
      WRITE(6,570) (TRAJ(K2,KP+3),SIZ(K2,KP+3),K2=1,15)                  5010
  570 FORMAT(" ",2E14.6)                                                 5020
      GO TO 600                                                          5030
  580 CONTINUE                                                           5040
      WRITE(6,585) KP3                                                   5050
  585 FORMAT("0","NOZZLE:",T20,I3/" ",T7,"YG",T21,"DIA",T35,"DIAG")      5060
      WRITE(6,590) (TRAJ(K2,KP+3),SIZ(K2,KP+3),DIAG(K2,KP+3),K2=1,15)    5070
  590 FORMAT(" ",3E14.6)                                                 5080
  600 CONTINUE                                                           5090
      WRITE(6,260)                                                       5100
  260 FORMAT("1","FINAL DISTRIBUTION"//"0",5(3X," YG",6X,                5110
     &       "CONCENTRATION")//)                                         5120
C                                                                        5130
C        WRITE TO FILE 8 AND OUTPUT TO 6 THE FINAL DISTRIBUTION          5140
C                                                                        5150
      KJ=0                                                               5160
      TOT=0.                                                             5170
      START=-SWIDTH                                                      5180
      NPTS=SWIDTH*200+1                                                  5190
      JJ=NPTS                                                            5200
      DO 310 J=1,NPTS                                                    5210
      XPL=START+(J-1)*.01                                                5220
      WRITE(8,302) XPL,DIST(J)                                           5230
  302 FORMAT(2E13.6)                                                     5240
      TOT=TOT+DIST(J)                                                    5250
      IF(DIST(J).LT.1.E-4) GO TO 310                                     5260
      IF(KJ.EQ.5) KJ=0                                                   5270
      KJ=KJ+1                                                            5280
      XLIST(KJ)=XPL                                                      5290
      DLIST(KJ)=DIST(J)                                                  5300
      IF(KJ.EQ.5) WRITE(6,300) (XLIST(K),DLIST(K),K=1,5)                 5310
  300 FORMAT(" ",5(3X,F6.2,3X,E13.6))                                    5320
  310 CONTINUE                                                           5330
      IF(KJ.NE.5) WRITE(6,300) (XLIST(K),DLIST(K),K=1,KJ)                5340
C                                                                        5350
C        DETERMINE TOTAL DRIFT                                           5360
C                                                                        5370
      QF=0.                                                              5380
      DRIFTF=0.                                                          5390
      DO 261 K=1,NCOL                                                    5400
      DRIFTF=DRIFTF+DRIFT(K)*Q(K)                                        5410
      QF=QF+Q(K)                                                         5420
  261 CONTINUE                                                           5430
      DRIFTF=DRIFTF/QF                                                   5440
      WRITE(6,265) DRIFTF                                                5450
      TOT=TOT/QF                                                         5460
  265 FORMAT("0","TOTAL DRIFT=",E13.6)                                   5470
      WRITE(6,266) TOT                                                   5480
  266 FORMAT("0","TOTAL=",E14.6)                                         5490
  320 CONTINUE                                                           5500
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      IF(NPLOT.EQ.1) CALL PLOT1(TITLE)                                  5510
      GO TO 800                                                         5520
  700 CONTINUE                                                          5530
      STOP                                                              5540
      END                                                               5550
C                                                                       5560
C        SUBROUTINE SUB2D: CALLED BY THE MAIN PROGRAM, SUB2D CONTROLS   5570
C        THE TRAJECTORY CALCULATION FOR ALL 2D CASES. GIVEN THE         5580
C        INITIAL VALUES AND USER SELECTED OPTIONS, SUB2D CALCULATES     5590
C        THE TRAJECTORY AND RETURNS THE FINAL VALUES OF THE VARIABLES   5600
C                                                                       5610
      SUBROUTINE SUB2D(NVAR,Y,Z,VD,WD,T,DIA,YY,SAVE,CSAVE,              5620
     &                 YMAX,ERROR,DY,YY1,PW,IP)                         5630
      DIMENSION YY(13,NVAR),SAVE(13,NVAR),CSAVE(NVAR,3),YMAX(NVAR)      5640
      DIMENSION ERROR(NVAR),DY(NVAR),YY1(NVAR)                          5650
      DIMENSION PW(NVAR,NVAR),IP(NVAR),IRUN(50)                         5660
      COMMON /AREA1/ A,CL,B,U'G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 5670
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT     5680
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                          5690
      COMMON /AREA6/ JJ,IRUN,ICOUNT                                     5700
      COMMON /AREA8/ DIA1                                               5710
C                                                                       5720
C        INITIALIZE THE DEPENDENT VARIABLES AND STORE IN ARRAY          5730
C        YY(1,NVAR)                                                     5740
C                                                                       5750
      DIA=DIA*1.E-6                                                     5760
      DIA1=DIA                                                          5770
      C=3.141592653589793                                               5780
      T=0.E0                                                            5790
      YY(1,1)=Y                                                         5800
      YY(1,2)=VD                                                        5810
      YY(1,3)=Z                                                         5820
      YY(1,4)=WD                                                        5830
      IF(NEVAP.EQ.1) YY(1,NVAR)=DIA                                     5840
      IF(N2D.EQ.2) GO TO 4                                              5850
      IF(NVAR.GE.10) GO TO 1                                            5860
      IF(NVAR.GE.8.AND.NPROP2*EQ.0) GO TO 2                             5870
      IF(NTUN.EQ.1.AND.NPROP2.EQ.1) YY(1,7)=ZPROP2                      5880
      IF(NTUN.EQ.1) GO TO 3                                             5890
      IF(NPROP2.EQ.1) YY(1,5)=ZPROP2                                    5900
      GO TO 4                                                           5910
    1 YY(1,10)=ZPROP2                                                   5920
      YY(1,9)=0.                                                        5930
    2 YY(1,8)=ZZ0                                                       5940
      YY(1,7)=-ZY0                                                      5950
    3 YY(1,6)=ZZ0                                                       5960
      YY(1,5)=ZY0                                                       5970
    4 CONTINUE                                                          5980
      IF(VD.EQ.0.AND.WD.EQ.0.) CALL INCON(YY,DIA,NVAR)                  5990
      IF(YY(1,4).EQ.0.E0.AND.YY(1,2).EQ.0.E0)GO TO 20                   6000
C                                                                       6010
C        INITIALIZE VALUES FOR DIFSUB                                   6020
C                                                                       6030
      H=1.E-4                                                           6040
      MF=2                                                              6050
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      DO 5 I=1,NVAR                                                    6060
      YMAX(I)=1.E0                                                     6070
    5 CONTINUE                                                         6080
      MAXDER=6                                                         6090
      HMIN=1.E-16                                                      6100
      HMAX=1.E0                                                        6110
      JSTART=0                                                         6120
      LOOP=0                                                           6130
      YPROP=0.                                                         6140
C                                                                      6150
C        PERFORM THE STEP INTEGRATION  BY SUCCESSIVE CALLS OF DIFSUB   6160
C                                                                      6170
C        DIFSUB IS A FORTUOI SUBROUTINE TO SOLVE A SYSTEM OF N SIMULTANE 6180
C        DIFFERENTIAL EQUATIONS                                        6190
C                                                                      6200
      DO 14 K=1,1000                                                   6210
      DO 9 I=1,NVAR                                                    6220
      YY1(I)=YY(1,I)                                                   6230
    9 CONTINUE                                                         6240
      T1=T                                                             6250
C                                                                      6260
      CALL DIFSBM(NVAR,T,YY,SAVE,CSAVE,H,HMIN,HMAX,EPS,MF,YMAX,ERROR,  6270
     &            KFLAG,JSTART,MAXDER,PW,IP)                           6280
C                                                                      6290
C        MONITOR VARIABLES AFTER EACH TIME-STEP TO CONTROL OUTPUT      6300
C        AND STORAGE OF TRAJECTORY AND TERMINATE TRAJECTORY IF         6310
C        PARTICLE BECOMES ENTRAINED IN THE VORTEX OR HITS THE GROUND   6320
C                                                                      6330
      DIAPL=YY(1,NVAR)/1.E-6                                           6340
      IF(NEVAP.EQ.1) YY(1,NVAR)=YY(1,NVAR)/1.E-6                       6350
      IF(NPRINT.EQ.1.AND.NDIST.EQ.0) WRITE (6,11) K,T,(YY(1,I),I=1,NVAR) 6360
   11 FORMAT(" ",I4,4X,12F10.6)                                        6370
      IF(NEVAP.EQ.1) YY(1,NVAR)=YY(1,NVAR)*1.E-6                       6380
      L=K+JJ                                                           6390
      IF(YY(1,3).LT.0.E0)GO TO 16                                      6400
      IF(NDIST.EQ.1) GO TO 10                                          6410
      WRITE(8,22) T,YY(1,1),YY(1,3)                                    6420
   22 FORMAT(3E13.6)                                                   6430
   10 CONTINUE                                                         6440
      IF(NEVAP.EQ.1.AND.DIAPL.LT.15) GO TO 20                          6450
      IF(NPROP2.NE.1) GO TO 25                                         6460
      IF(NCW.EQ.1) YPROP=YY(1,10)                                      6470
      IF(YY1(1).LE.YPROP.AND.YY(1,1).GT.YPROP) LOOP=LOOP+1             6480
      IF(LOOP.LT.2) GO TO 25                                           6490
      IF(NPRINT.EQ.1.AND.NDIST.EQ.0) WRITE(6,30)                       6500
   30 FORMAT("*** TRAJECTORY TERMINATED, PROPELLER SLIPSTREAM ",       6510
     &       "ENTRAINMENT ***")                                        6520
      GO TO 20                                                         6530
   25 CONTINUE                                                         6540
      IF(YY(1,3).GT.YY1(3))GO TO 12                                    6550
      GO TO 14                                                         6560
   12 IF(ABS(YY(1,1)).GT.1.E0)GO TO 13                                 6570
      GO TO 14                                                         6580
   13 IF(YY(1,3).GT.ZZ0.AND.ABS(YY(1,1)).LT.ABS(YY1(1))) GO TO 18      6590
   14 CONTINUE                                                         6600
```

```
      K=K-1                                                              6610
      WRITE (6,15)                                                       6620
   15 FORMAT("0","**** DO LOOP PARAMETER EXCEEDED IN SUB2D ****")        6630
      GO TO 20                                                           6640
   16 CONTINUE                                                           6650
      IF(NDIST.EQ.0.AND.NPRINT.EQ.1) WRITE (6,17)                        6660
   17 FORMAT("0","**** TRAJECTORY COMPLETED, Z LESS THAN ZERO ****")     6670
      CALL YZFIN(YY,YY1,NVAR,T,T1,L)                                     6680
      GO TO 20                                                           6690
   18 CONTINUE                                                           6700
      IF(NDIST.EQ.0.AND.NPRINT.EQ.1) WRITE (6,19)                        6710
   19 FORMAT("0","**** TRAJECTORY TERMINATED, VORTEX ENTRAINMENT ****")  6720
   20 CONTINUE                                                           6730
      JJ=JJ+K                                                            6740
      IRUN(ICOUNT)=K                                                     6750
      Y=YY(1,1)                                                          6760
      VD=YY(1,2)                                                         6770
      Z=YY(1,3)                                                          6780
      WD=YY(1,4)                                                         6790
      IF(NEVAP.EQ.1) DIA=YY(1,NVAR)/1.E-6                                6800
      IF(NEVAP.EQ.0) DIA=DIA1/1.E-6                                      6810
      RETURN                                                             6820
      END                                                                6830
C                                                                        6840
C        SUBROUTINE SUB3D: CALLED BY THE MAIN PROGRAM, SUB3D CONTROLS    6850
C        THE TRAJECTORY CALCULATION FOR ALL 3D CASES. GIVEN THE          6860
C        INITIAL VALUES AND USER SELECTED OPTIONS, SUB3D CALCULATES      6870
C        THE TRAJECTORY AND RETURNS THE FINAL VALUES OF THE VARIABLES    6880
C                                                                        6890
      SUBROUTINE SUB3D(NVAR,X,Y,Z,UD,VD,WD,T,DIA,YY,SAVE,CSAVE,         6900
     &                 YMAX,ERROR,DY,YY1,PW,IP)                        6910
      DIMENSION YY(13,NVAR),SAVE(13,NVAR),CSAVE(NVAR,3),YMAX(NVAR)       6920
      DIMENSION ERROR(NVAR),DY(NVAR),YY1(NVAR)                           6930
      DIMENSION PW(NVAR,NVAR),IP(NVAR),IRUN(50)                          6940
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                  6950
      COMMON /AREA2/ N2D,N3D,NEVAP,FPS,NPROP2,NCW,NTUN,NDIST,NPRINT      6960
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                           6970
      COMMON /AREA6/ JJ,IRUN,ICOUNT                                      6980
      COMMON /AREA8/ DIA1                                                6990
C                                                                        7000
C        INITIALIZE THE DEPENDENT VARIABLES AND STORE IN ARRAY           7010
C        YY(1,NVAR)                                                      7020
C                                                                        7030
      DIA=DIA*1.E-6                                                      7040
      DIA1=DIA                                                           7050
      C=3.141592653589793                                                7060
      T=0.E0                                                             7070
      YY(1,1)=Y                                                          7080
      YY(1,2)=VD                                                         7090
      YY(1,3)=Z                                                          7100
      YY(1,4)=WD                                                         7110
      YY(1,5)=X                                                          7120
      YY(1,6)=UD                                                         7130
      IF(NEVAP.EQ.1) YY(1,NVAR)=DIA                                      7140
      IF(N3D.EQ.2) GO TO 4                                               7150
```

```
      IF(NVAR.GE.12) GO TO 1                                              7160
      IF(NVAR.GE.10) GO TO 2                                              7170
      IF(NPROP2.EQ.1) YY(1,7)=ZPROP2                                      7180
      GO TO 4                                                             7190
    1 YY(1,12)=ZPROP2                                                     7200
      YY(1,11)=0.                                                         7210
    2 YY(1,10)=ZZ0                                                        7220
      YY(1,9)=-ZY0                                                        7230
    3 YY(1,8)=ZZ0                                                         7240
      YY(1,7)=ZY0                                                         7250
    4 CONTINUE                                                            7260
C                                                                         7270
C        INITIALIZE VALUES FOR DIFSUB                                     7280
C                                                                         7290
      H=1.E-4                                                             7300
      MF=2                                                                7310
      DO 5 I=1,NVAR                                                       7320
      YMAX(I)=1.E0                                                        7330
    5 CONTINUE                                                            7340
      MAXDER=6                                                            7350
      HMIN=1.E-16                                                         7360
      HMAX=1.E0                                                           7370
      JSTART=0                                                            7380
      LOOP=0                                                              7390
      YPROP=0.                                                            7400
C                                                                         7410
C        PERFORM THE STEP INTEGRATION  BY SUCCESSIVE CALLS OF DIFSUB      7420
C                                                                         7430
C        DIFSUB IS A FORTUOI SUBROUTINE TO SOLVE A SYSTEM OF N SIMULTANE  7440
C        DIFFERENTIAL EQUATIONS                                           7450
C                                                                         7460
      DO 14 K=1,1000                                                      7470
      DO 9 I=1,NVAR                                                       7480
      YY1(I)=YY(1,I)                                                      7490
    9 CONTINUE                                                            7500
      T1=T                                                                7510
C                                                                         7520
      CALL DIFSBM(NVAR,T,YY,SAVE,CSAVE,H,HMIN,HMAX,EPS,MF,YMAX,ERROR,     7530
     &            KFLAG,JSTART,MAXDER,PW,IP)                              7540
C                                                                         7550
C        MONITOR VARIABLES AFTER EACH TIME-STEP TO CONTROL OUTPUT         7560
C        AND STORAGE OF TRAJECTORY AND TERMINATE TRAJECTORY IF            7570
C        PARTICLE BECOMES ENTRAINED IN THE VORTEX OR HITS THE GROUND      7580
C                                                                         7590
      DIAPL=YY(1,NVAR)/1.E-6                                              7600
      IF(NEVAP.EQ.1) YY(1,NVAR)=YY(1,NVAR)/1.E-6                          7610
      IF(NPRINT.EQ.1.AND.NDIST.EQ.0) WRITE (6,11) K,T,(YY(1,I),I=1,NVAR)  7620
   11 FORMAT(" ",I4,4X,14F9.5)                                            7630
      IF(NEVAP.EQ.1) YY(1,NVAR)=YY(1,NVAR)*1.E-6                          7640
      L=K+JJ                                                              7650
      IF(YY(1,3).LT.0.E0)GO TO 16                                         7660
      IF(NDIST.EQ.1) GO TO 10                                             7670
      WRITE(8,22) T,YY(1,1),YY(1,3)                                       7680
   22 FORMAT(3F13.6)                                                      7690
   10 CONTINUE                                                            7700
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      IF(NEVAP.EQ.1.AND.DIAPL.LT.15) GO TO 20                                7710
      IF(NPROP2.NE.1) GO TO 25                                               7720
       IF(NCW.EQ.1) YPROP=YY(1,10)                                           7730
      IF(YY1(1).LE.YPROP.AND.YY(1,1).GT.YPROP) LOOP=LOOP+1                   7740
      IF(LOOP.LT.2) GO TO 25                                                 7750
      IF(NPRINT.EQ.1.AND.NDIST.EQ.0) WRITE(6,30)                             7760
   30 FORMAT("*** TRAJECTORY TERMINATED, PROPELLER SLIPSTREAM ",             7770
     &       "ENTRAINMENT ***")                                              7780
      GO TO 20                                                               7790
   25 CONTINUE                                                               7800
      IF(YY(1,3).GT.YY1(3))GO TO 12                                          7810
      GO TO 14                                                               7820
   12 IF(ABS(YY(1,1)).GT.1.E0)GO TO 13                                       7830
      GO TO 14                                                               7840
   13 IF(YY(1,3).GT.ZZ0.AND.ABS(YY(1,1)).LT.ABS(YY1(1))) GO TO 18            7850
   14 CONTINUE                                                               7860
      K=K-1                                                                  7870
      WRITE (6,15)                                                           7880
   15 FORMAT("0","**** DO LOOP PARAMETER EXCEEDED IN SUB3D ****")            7890
      GO TO 20                                                               7900
   16 CONTINUE                                                               7910
      IF(NDIST.EQ.0.AND.NPRINT.EQ.1) WRITE (6,17)                            7920
   17 FORMAT("0","**** TRAJECTORY COMPLETED, Z LESS THAN ZERO ****")          7930
      CALL YZFIN(YY,YY1,NVAR,T,T1,L)                                         7940
      GO TO 20                                                               7950
   18 CONTINUE                                                               7960
      IF(NDIST.EQ.0.AND.NPRINT.EQ.1) WRITE (6,19)                            7970
   19 FORMAT("0","**** TRAJECTORY TERMINATED, VORTEX ENTRAINMENT ****")       7980
   20 CONTINUE                                                               7990
      JJ=JJ+K                                                                8000
      IRUN(ICOUNT)=K                                                         8010
      Y=YY(1,1)                                                              8020
      VD=YY(1,2)                                                             8030
      Z=YY(1,3)                                                              8040
      WD=YY(1,4)                                                             8050
      X=YY(1,5)                                                              8060
      UD=YY(1,6)                                                             8070
      IF(NEVAP.EQ.1) DIA=YY(1,NVAR)/1.E-6                                    8080
      IF(NEVAP.EQ.0) DIA=DIA1/1.E-6                                          8090
      RETURN                                                                 8100
      END                                                                    8110
C                                                                            8120
C        PEDERV IS REQUIRED BY DIFSUB, BUT NOT NEEDED FOR THIS METHOD        8130
C                                                                            8140
      SUBROUTINE PEDERV(A,B,C,D)                                             8150
      RETURN                                                                 8160
      END                                                                    8170
C                                                                            8180
C        DIFFUN IS A SUBROUTINE CALLED BY DIFSUB TO EVALUATE THE RIGHT-      8190
C        HAND SIDE OF THE SYSTEM OF DIFFERENTIAL EQUATIONS                   8200
C        RHS IS RETURNED TO DIFSUB IN ARRAY DY(NVAR)                         8210
C                                                                            8220
      SUBROUTINE DIFFUN(NVAR,T,YY,DY)                                        8230
      DIMENSION YY(13,NVAR),DY(NVAR)                                         8240
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                      8250
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      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT          8260
      COMMON /AREA3/ PSWB,PA,PV,SCN,DV                                      8270
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                              8280
      COMMON /AREA8/ DIA1                                                   8290
      IF(NEVAP.EQ.0) DIA=DIA1                                               8300
      Y=YY(1,1)                                                             8310
      VD=YY(1,2)                                                            8320
      Z=YY(1,3)                                                             8330
      WD=YY(1,4)                                                            8340
      IF(N3D.EQ.1) X=YY(1,5)                                                8350
      IF(N3D.EQ.1) UD=YY(1,6)                                               8360
C                                                                           8370
C        CROSSWIND MODEL                                                    8380
C                                                                           8390
      ZCW=Z                                                                 8400
      IF(ZCW.LT.0.) ZCW=0.                                                  8410
      ZCW=ZCW*B                                                             8420
      IF(NCW.EQ.0) VCW=0.                                                   8430
C                                                                           8440
C        BRANCH TO CORRECT SECTION OF CODE DEPENDING ON OPTIONS             8450
C        SELECTED                                                           8460
C                                                                           8470
       IF(N2D.EQ.2.OR.N3D.EQ.2) GO TO 45                                    8480
      IF(N3D.EQ.1) GO TO 15                                                 8490
      KK=0                                                                  8500
      IF(NVAR.EQ.11.OR.NVAR.EQ.10) GO TO 10                                 8510
      IF(NCW.EQ.1) GO TO 20                                                 8520
      IF(NTUN.EQ.1) GO TO 30                                                8530
      IF(NPROP2.EQ.1) GO TO 35                                              8540
      IF(NVAR.EQ.5.OR.NVAR.EQ.4) GO TO 40                                   8550
      WRITE (6,9)                                                           8560
    9 FORMAT (" ","***** NVAR INCORRECT *****")                             8570
   15 CONTINUE                                                              8580
      KK=6                                                                  8590
      IF(NVAR.GE.12) GO TO 10                                               8600
      IF(NVAR.GE.10) GO TO 20                                               8610
      IF(NVAR.GE.7.AND.NPROP2.EQ.1) GO TO 35                                8620
      IF(NVAR.GE.6) GO TO 40                                                8630
      WRITE(6,9)                                                            8640
   10 CONTINUE                                                              8650
C                                                                           8660
C         BOTH VORTICES AND PROP POSITIONS ARE                              8670
C        DETERMINED BY STEP INTEGRATION                                     8680
C        HERE NCW=1 AND NPROP2=1                                            8690
C                                                                           8700
      CALL VELTV(YY(1,5+KK),YY(1,6+KK),YY(1,7+KK),YY(1,8+KK),Y,Z,V1,W1)     8710
      CALL PROP2D(Y,Z,YY(1,9+KK),YY(1,10+KK),V2,W2)                         8720
      VA=V1+V2+(VCW*ZCW**.25)/U                                             8730
      WA=W1+W2                                                              8740
      IF(N3D.EQ.0) GO TO 17                                                 8750
      CALL BOUND(X,Y,Z,UA,W3)                                               8760
      CALL PROPX(Y,Z,YY(1,11),YY(1,12),UAP)                                 8770
      UA=UA+UAP                                                             8780
      WA=WA+W3                                                              8790
   17 CONTINUE                                                              8800
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      CALL VELTV(YY(1,5+KK),YY(1,6+KK),YY(1,7+KK),YY(1,8+KK),
     &           YY(1,9+KK),YY(1,10+KK),VP1,WP1)
      DY(9+KK)=VP1+(VCW*(YY(1,10+KK)*8)**.25)/U
      DY(10+KK)=WP1
      IF(YY(1,10+KK).LT.RP) DY(10+KK)=0.
      CALL VELC(YY(1,5+KK),YY(1,6+KK),YY(1,7+KK),YY(1,8+KK),V1,W1)
      DY(5+KK)=V1+(VCW*(YY(1,6+KK)*8)**.25)/U
      DY(6+KK)=W1
      CALL VELC(YY(1,7+KK),YY(1,8+KK),YY(1,5+KK),YY(1,6+KK),V1,W1)
      DY(7+KK)=-V1+(VCW*(YY(1,8+KK)*8)**.25)/U
      DY(8+KK)=-W1
      GO TO 50
   20 CONTINUE
C
C        NOW=1: VORTEX POSITIONS DETERMINED BY STEP INTEGRATION,
C        NO PROP
C
      CALL VELTV(YY(1,5+KK),YY(1,6+KK),YY(1,7+KK),YY(1,8+KK),Y,Z,V1,WA)
      VA=V1+(VCW*ZCW**.25)/U
      IF(N3D.EQ.0) GO TO 25
      CALL BOUND(X,Y,Z,UA,W1)
      WA=WA+W1
   25 CONTINUE
      CALL VELC(YY(1,5+KK),YY(1,6+KK),YY(1,7+KK),YY(1,8+KK),V1,W1)
      DY(5+KK)=V1+(VCW*(YY(1,6+KK)*8)**.25)/U
      DY(6+KK)=W1
      CALL VELC(YY(1,7+KK),YY(1,8+KK),YY(1,5+KK),YY(1,6+KK),V1,W1)
      DY(7+KK)=-V1+(VCW*(YY(1,8+KK)*8)**.25)/U
      DY(8+KK)=-W1
      GO TO 50
   30 CONTINUE
C
C        NTUN=1: NPROP2D=0 OR 1
C
      VP1=0.
      WP1=0.
      CALL TUNVEL(Y,Z,YY(1,5),YY(1,6),V1,W1)
      IF(NPROP2.EQ.1) CALL PROP2D(Y,Z,0.,YY(1,7),VP1,WP1)
      VA=V1+VP1+(VCW*ZCW**.25)/U
      WA=W1+WP1
      CALL VORTUN(YY(1,5),YY(1,6),DY(5),DY(6))
      IF(NPROP2.EQ.0) GO TO 50
      CALL TUNVEL(0.,YY(1,7),YY(1,5),YY(1,6),VDUM,DY(7))
      GO TO 50
   35 CONTINUE
C
C        NPROP2=1: WITHOUT CROSSWIND OR TUNNEL
C
      CALL VEL2D(T,0.,YY(1,5+KK),V1,W1)
      IF(YY(1,5+KK).LE.RP) W1=0.
      DY(5+KK)=W1
      CALL VEL2D(T,Y,Z,VA,WA)
      CALL PROP2D(Y,Z,0.,YY(1,5+KK),VP1,WP1)
      VA=VA+VP1
      WA=WA+WP1
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      IF(N3D.EQ.0) GO TO 37                                              9360
      CALL BOUND(X,Y,Z,UA,W2)                                            9370
      CALL PROPX(Y,Z,0.,YY(1,7),UAP)                                     9380
      UA=UA+UAP                                                          9390
      WA=WA+W2                                                           9400
   37 CONTINUE                                                           9410
      GO TO 50                                                           9420
   40 CONTINUE                                                           9430
C                                                                        9440
C        N2D=1 OR N3D=1: NO OPTIONS EXCEPT NEVAP MAY EQUAL 1             9450
C                                                                        9460
      CALL VEL2D(T,Y,Z,VA,WA)                                            9470
      IF(N3D.EQ.0) GO TO 50                                              9480
      CALL BOUND(X,Y,Z,UA,W1)                                            9490
      WA=WA+W1                                                           9500
      GO TO 50                                                           9510
C                                                                        9520
C        N2D=2 OR N3D=2                                                  9530
C        GET VELOCITY FROM USER SUPPLIED SUBROUTINE USERV                9540
C                                                                        9550
   45 CONTINUE                                                           9560
      CALL USERV(T,X,Y,Z,UA,VA,WA)                                       9570
   50 CONTINUE                                                           9580
C                                                                        9590
C        CALCULATE RHS OF DROPLET DYNAMICS EQUATIONS AND EVAPORATION     9600
C                                                                        9610
      IF(NEVAP.EQ.1) DIA=YY(1,NVAR)                                      9620
      R=U*((DA*DIA)*SQRT((VA-VD)**2+(WA-WD)**2))/VIS                     9630
      IF(N3D.EQ.1) R=U*((DA*DIA)*SQRT((UA-UD)**2+(VA-VD)**2              9640
     &                +(WA-WD)**2))/VIS                                  9650
      CDR=1.0+0.197*R**0.63+0.26E-3*R**1.38                              9660
      S=18.*(B*DA)/(DIA*DD)                                              9670
      RU=(DA*DIA*U)/VIS                                                  9680
      IF(NEVAP.EQ.0) GO TO 60                                            9690
      DY(NVAR)=-2.*(B/U)*(18.016/28.97)*(DV/DIA)*(DA/DD)*((PSWB-PV)      9700
     &          /(PA-PV))*(2.+.6*SCN**(1./3.)*R**.5)                     9710
   60 CONTINUE                                                           9720
      DY(1)=YY(1,2)                                                      9730
      DY(2)=((S*CDR)/RU)*(VA-VU)                                         9740
      DY(3)=YY(1,4)                                                      9750
      DY(4)=((S*CDR)/RU)*(WA-WD)-(B*G)/U**2                              9760
      IF(NEVAP.EQ.1) DY(2)=DY(2)-(3./DIA)*VD*DY(NVAR)                    9770
      IF(NEVAP.EQ.1) DY(4)=DY(4)-(3./DIA)*WD*DY(NVAR)                    9780
      IF(N3D.EQ.0) GO TO 70                                              9790
      DY(5)=YY(1,6)                                                      9800
      DY(6)=((S*CDR)/RU)*(UA-UD)                                         9810
      IF(NEVAP.EQ.1) DY(6)=DY(6)-(3./DIA)*UD*DY(NVAR)                    9820
   70 RETURN                                                             9830
      END                                                                9840
C                                                                        9850
C        SUBROUTINE USERV.....USER SUPPLIED                              9860
C                                                                        9870
C        WITH N2D=2 OR N3D=2 USERV IS CALLED BY DIFFUN FOR THE           9880
C        VELOCITY IN THE WAKE.  THIS ALLOWS THE USER TO REPLACE          9890
C        THE CODE'S WAKE MODEL WITH ONE OF THEIR OWN.  THE NEVAP         9900
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C        OPTION IS STILL AVAILABLE AS IS NDIST, NPRINT, AND NPLOT.          9910
C        THE PROPELLER AND TUNNEL MODELS ARE AVAILABLE TO THE               9920
C        USER BY INCLUDING THE PROPER INPUTS AND SUBROUTINE CALLS.          9930
C                                                                           9940
C        PASSED TO USERV IS THE NONDIMNSIONAL TIME,T, AND THE               9950
C        NONDIMENSIONAL POSITION X,Y,Z.  THE USER RETURNS THE               9960
C        CORRESPONDING NONDIMENSIONAL VELOCITIES UA,VA,WA.                  9970
C                                                                           9980
      SUBROUTINE USERV(T,X,Y,Z,UA,VA,WA)                                    9990
      RETURN                                                               10000
      END                                                                  10010
C                                                                          10020
C                                                                          10030
C        SUBROUTINE VEL2D: INPUT DIMENSIONLESS TIME AND POSITION(Y,Z)      10040
C        VEL2D RETURNS DIMENSIONLESS INDUCED VELOCITIES(UA,VA) FROM        10050
C        A VORTEX PAIR UNAFFECTED BY CROSSWIND                             10060
C                                                                          10070
      SUBROUTINE VEL2D(T,Y,Z,VA,WA)                                        10080
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                    10090
C                                                                          10100
C        CALCULATE THE POSITION OF THE VORTICES                            10110
C                                                                          10120
      C=3.141592654                                                        10130
      C1=1/(ZY0**2)+1/(ZZ0**2)                                             10140
      C2=-((C1*ZY0**2-2.0)/SQRT(C1*ZY0**2-1.0))                            10150
      C3= ((C1*ZZ0**2-2.0)/SQRT(C1*ZZ0**2-1.0))                            10160
      C4=C2*((4.E0*C*A)/(CL*C1))                                           10170
      C5=C3*((4.E0*C*A)/(CL*C1))                                           10180
      IF(T.GT.C4) GO TO 10                                                 10190
      ZY=SQRT((((((T*CL*C1)/(4.0*C*A))**2)*C1-(C2*T*CL*C1**2)/(2.0*C*      10200
     &    A)+C1*C2**2+4.0*C1)-SQRT(((((T*CL*C1)/(4.0*C*A))**2)*C1-(C2      10210
     &    *T*CL*C1**2)/(2.0*C*A)+C1*C2**2+4.0*C1)**2-4.0*C1**2*(((T*CL*C1  10220
     &    )/(4.0*C*A))**2-(C2*T*CL*C1)/(2.0*C*A)+C2**2+4.0)))/(2.0         10230
     &    *C1**2))                                                         10240
      GO TO 20                                                             10250
   10 ZY=SQRT((((((T*CL*C1)/(4.0*C*A))**2)*C1-(C2*T*CL*C1**2)/(2.0*C*      10260
     &    A)+C1*C2**2+4.0*C1)+SQRT(((((T*CL*C1)/(4.0*C*A))**2)*C1-(C2      10270
     &    *T*CL*C1**2)/(2.0*C*A)+C1*C2**2+4.0*C1)**2-4.0*C1**2*(((T*CL*C1  10280
     &    )/(4.0*C*A))**2-(C2*T*CL*C1)/(2.0*C*A)+C2**2+4.0)))/(2.0         10290
     &    *C1**2))                                                         10300
   20 IF(T.LT.C5) GO TO 30                                                 10310
      ZZ=SQRT((((((T*CL*C1)/(4.0*C*A))**2)*C1-(C3*T*CL*C1**2)/(2.0*C*      10320
     &    A)+C1*C3**2+4.0*C1)-SQRT(((((T*CL*C1)/(4.0*C*A))**2)*C1-(C3      10330
     &    *T*CL*C1**2)/(2.0*C*A)+C1*C3**2+4.0*C1)**2-4.0*C1**2*(((T*CL*C1  10340
     &    )/(4.0*C*A))**2-(C3*T*CL*C1)/(2.0*C*A)+C3**2+4.0)))/(2.0         10350
     &    *C1**2))                                                         10360
      GO TO 40                                                             10370
   30 ZZ=SQRT((((((T*CL*C1)/(4.0*C*A))**2)*C1-(C3*T*CL*C1**2)/(2.0*C*      10380
     &    A)+C1*C3**2+4.0*C1)+SQRT(((((T*CL*C1)/(4.0*C*A))**2)*C1-(C3      10390
     &    *T*CL*C1**2)/(2.0*C*A)+C1*C3**2+4.0*C1)**2-4.0*C1**2*(((T*CL*C1  10400
     &    )/(4.0*C*A))**2-(C3*T*CL*C1)/(2.0*C*A)+C3**2+4.0)))/(2.0         10410
     &    *C1**2))                                                         10420
   40 CONTINUE                                                             10430
C                                                                          10440
C        CALCULATE THE INDUCED VELOCITIES                                  10450
```

```
C                                                                       10460
      VA=(CL/(2.0*C*A))*((ZZ+Z)/((ZZ+Z)**2+(ZY-Y)**2)-(ZZ+Z)/((ZZ+Z)    10470
     &   **2+(ZY+Y)**2)-(ZZ-Z)/((ZZ-Z)**2+(ZY+Y)**2)+(ZZ-Z)/((ZZ-Z)**2  10480
     &   +(ZY-Y)**2))                                                   10490
      WA=(CL/(2.0*C*A))*((ZY-Y)/((ZZ+Z)**2+(ZY-Y)**2)+(ZY+Y)/((ZZ+Z)    10500
     &   **2+(ZY+Y)**2)-(ZY+Y)/((ZZ-Z)**2+(ZY+Y)**2)-(ZY-Y)/((ZZ-Z)**2  10510
     &   +(ZY-Y)**2))                                                   10520
      RETURN                                                            10530
      END                                                               10540
C                                                                       10550
C        SUBROUTINE BOUND: CALCULATES THE INDUCED VELOCITIES (UA,WA)    10560
C        DUE TO THE BOUND VORTEX AT A POINT (X,Y,Z)                     10570
C                                                                       10580
      SUBROUTINE BOUND(X,Y,Z,UA,WA)                                     10590
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 10600
      R5=SQRT(X**2+(ZZ0-Z)**2)                                          10610
      R6=SQRT(X**2+(ZZ0+Z)**2)                                          10620
      UA=1.-(CL/(4.*3.141592654*A))*(((1.-Y)/SQRT(R5**2+(1.-Y)**2)+     10630
     &   (1.+Y)/SQRT(R5**2+(1.+Y)**2))*((ZZ0-Z)/R5**2)+((1.-Y)/SQRT     10640
     &   (R6**2+(1.-Y)**2)+(1.+Y)/SQRT(R6**2+(1.+Y)**2))*((ZZ0+Z)       10650
     &   /R6**2))                                                       10660
      WA=(CL/(4.*3.141592654*A))*(-((1.-Y)/SQRT(R5**2+(1.-Y)**2)+       10670
     &   (1.+Y)/SQRT(R5**2+(1.+Y)**2))*(X/R5**2)+((1.-Y)/SQRT(R6**2    10680
     &   +(1.-Y)**2)+(1.+Y)/SQRT(R6**2+(1.+Y)**2))*(X/R6**2))           10690
      RETURN                                                            10700
      END                                                               10710
C                                                                       10720
C        SUBROUTINE PROPX: RETURNS THE X VELOCITY IN THE PROPELLER      10730
C        SLIPSTREAM UAP DUE TO A PROP CENTERED AT (YP,ZP) AT A          10740
C         POINT (Y,Z)                                                   10750
C                                                                       10760
      SUBROUTINE PROPX(Y,Z,YP,ZP,UAP)                                   10770
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 10780
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                          10790
      R1=SQRT((Y-YP)**2+(Z-ZP)**2)                                      10800
      IF(R1.LT.RP) GO TO 10                                             10810
      UAP=0.                                                            10820
      RETURN                                                            10830
   10 CONTINUE                                                          10840
      R2=R1/RP                                                          10850
      UAP=(PK1*(1.-R2)+PK2*R2**2IN(R2*3.141592654))/U                   10860
      RETURN                                                            10870
      END                                                               10880
C                                                                       10890
C                                                                       10900
C        SUBROUTINE PROP2D: RETURNS DIMENSIONLESS PROPELLER INDUCED     10910
C        VELOCITIES(V,W) AT POSITION (Y,Z) FOR A PROP AT (YP,ZP)        10920
C        (ALL POSITIONS DIMENSIONLESS)                                  10930
C                                                                       10940
      SUBROUTINE PROP2D(Y,Z,YP,ZP,V,W)                                  10950
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 10960
      COMMON /AREA5/ ZPROP2,PK1,PK2,PK3,PK4,RP                          10970
      R1=SQRT((Y-YP)**2+(Z-ZP)**2)                                      10980
      IF(R1.LT.RP) GO TO 10                                             10990
      V=0.                                                              11000
```

```
      W=0.                                                              11010
      RETURN                                                            11020
   10 CONTINUE                                                          11030
      R2=R1/RP                                                          11040
      SV1=(PK3*(1.0-R2)+PK4*R2*SIN(R2*3.141592654))/U                   11050
      V=((Z-ZP)/R1)*SV1                                                 11060
      W=((YP-Y)/R1)*SV1                                                 11070
      RETURN                                                            11080
      END                                                               11090
C                                                                       11100
C                                                                       11110
C        SUBROUTINE VELTV: RETURNS INDUCED VELOCITIES (V,W) AT          11120
C        POSITION (Y,Z) FOR VORTICES LOCATED AT (ZYR,ZZR) AND           11130
C        (ZYL,ZZL)   (ALL QUANTITIES DIMENSIONLESS)                     11140
C                                                                       11150
      SUBROUTINE VELTV(ZYR,ZZR,ZYL,ZZL,Y,Z,V,W)                         11160
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 11170
      COMPLEX GC,ZCR,ZCL,WZ,ZD                                          11180
      GAMMA=CL/(A*2.*3.141592654)                                       11190
      GC=CMPLX(0.,GAMMA)                                                11200
      ZD=CMPLX(Y,Z)                                                     11210
      ZCR=CMPLX(ZYR,ZZR)                                                11220
      ZCL=CMPLX(ZYL,ZZL)                                                11230
      WZ=-GC*(1./(ZD-ZCR)-1./(ZD-ZCL)+1./(ZD-CONJG(ZCL))                11240
     &   -1./(ZD-CONJG(ZCR)))                                           11250
      V=REAL(WZ)                                                        11260
      W=-AIMAG(WZ)                                                      11270
      RETURN                                                            11280
      END                                                               11290
C                                                                       11300
C                                                                       11310
C        SUBROUTINE VELC: RETURNS INDUCED VELOCITIES (V,W) ON A         11320
C        VORTEX CORE AT (Y1,Z1) AND (Y2,Z2)   (ALL QUANTITIES ARE       11330
C        DIMENSIONLESS)                                                 11340
C                                                                       11350
      SUBROUTINE VELC(Y1,Z1,Y2,Z2,V,W)                                  11360
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 11370
      COMPLEX GC,ZC1,ZC2,WZ                                             11380
      GAMMA=CL/(2.*3.141592654*A)                                       11390
      GC=CMPLX(0.,GAMMA)                                                11400
      ZC2=CMPLX(Y2,Z2)                                                  11410
      ZC1=CMPLX(Y1,Z1)                                                  11420
      WZ=-GC*(-1./(ZC1-ZC2)+1./(ZC1-CONJG(ZC2))-1./(ZC1-CONJG(ZC1)))    11430
      V=REAL(WZ)                                                        11440
      W=-AIMAG(WZ)                                                      11450
      RETURN                                                            11460
      END                                                               11470
C                                                                       11480
C                                                                       11490
C        SUBROUTINE VORTUN: RETURNS INDUCED VELOCITIES (VV,WW)          11500
C        AT A POINT (ZY,ZZ) FOR THE TUNNEL CASE WHERE VORTICES          11510
C        ARE LOCATED AT (ZY,ZZ) AND (ZY,-ZZ)  (ALL QUANTITIES ARE       11520
C        DIMENSIONLESS)                                                 11530
C                                                                       11540
      SUBROUTINE VORTUN(ZY,ZZ,VV,WW)                                    11550
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      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                  11560
      COMPLEX Z1,W,CONST                                                 11570
      C=3.141592654                                                      11580
      DTUN=D/B                                                           11590
      Z1=CMPLX(ZY,ZZ)                                                    11600
      GAMMA=CL/(2.*C*A)                                                  11610
      E=0.                                                               11620
      CONST=CMPLX(E,GAMMA)                                               11630
      W=(0.,0.)                                                          11640
C                                                                        11650
C        CALCULATING THE COMPLEX VELOCITY AT A VORTEX                    11660
C                                                                        11670
      DO 10 I=1,21                                                       11680
      N=I-11                                                             11690
      IF(N.EQ.0) GO TO 10                                                11700
      W=W+CONST*(-(1./(N*DTUN))+(1./(2.*ZY+N*DTUN))-(1./(2.*Z1           11710
     &           +N*DTUN))+(1./(Z1-CONJG(Z1)+N*DTUN)))                   11720
   10 CONTINUE                                                           11730
      W=W+CONST*((1./(2.*ZY))-(1./(2.*Z1))+(1./(Z1-CONJG(Z1))))          11740
      VV=REAL(W)                                                         11750
      WW=-AIMAG(W)                                                       11760
      RETURN                                                             11770
      END                                                                11780
C                                                                        11790
C        TUNVEL SOLVES FOR THE INDUCED VELOCITY (VA,WA) AT A POINT IN TH 11800
C        TUNNEL (YD,ZD) AND A GIVEN VORTEX POSITION (ZY,+-ZZ).           11810
C        (ALL QUANTITIES ARE DIMENSIONLESS)                              11820
C                                                                        11830
      SUBROUTINE TUNVEL(YD,ZD,ZY,ZZ,VA,WA)                               11840
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                  11850
      COMPLEX C,Z,CONST,W                                                11860
      CC=3.141592654                                                     11870
      GAMMA=(CL*U*B)/A                                                   11880
      CD=GAMMA/(2.*CC)                                                   11890
      E=0.                                                               11900
      CONST=CMPLX(E,CD)                                                  11910
      F=CC/D                                                             11920
      DYD=YD*B                                                           11930
      DZD=ZD*B                                                           11940
      DZY=ZY*B                                                           11950
      DZZ=ZZ*B                                                           11960
      C=CMPLX(DZY,DZZ)                                                   11970
      Z=CMPLX(DYD,DZD)                                                   11980
      W=-CONST*(((CSIN(F*Z))**2-(CSIN(F*CONJG(C)))**2)/((CSIN(F*Z))**2   11990
     &  -(CSIN(F*C))**2))*(((2.*F*CSIN(F*Z)*CCOS(F*Z))*((CSIN(F*C))**2   12000
     &  -(CSIN(F*CONJG(C)))**2))/((CSIN(F*Z))**2-(CSIN(F*CONJG(C)))**2   12010
     &  )**2)                                                            12020
      W=CONJG(W)/U                                                       12030
      VA=REAL(W)                                                         12040
      WA=AIMAG(W)                                                        12050
      RETURN                                                             12060
      END                                                                12070
C                                                                        12080
C        SUBROUTINE SWATH: CALCULATES THE DISTRIBUTION FROM EACH NOZZLE  12090
C        AND SUMS THESE UP TO GENERATE A TOTAL DISTRIBUTION AND          12100
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C        ESTIMATES THE DRIFT. IF NPRINT=1 EACH NOZZLE'S DISTRIBUTION      12110
C        AND DRIFT IS OUTPUT                                              12120
C                                                                         12130
      SUBROUTINE SWATH(NCOL,NROW,Q,DIAMN,STDEV,YNOZ,DWIDTH,               12140
     &                 NRUN,MET,WIDTH,DIST,DRIFT)                       12150
      DIMENSION TRAJ(15,100),YNOZ(100),SIZE(15,100),NRUN(100),DIST(1)     12160
      DIMENSION DRIFT(100),YI(15),C(4,15),SIZ(15),SIZ1(15)                12170
      DIMENSION DIAG(15,100),S(15,5),MET(100),XLIST(4),SLIST(4)           12180
      DIMENSION DIAMN(100),STDEV(100),Q(100),C1(4,15),DLIST(4)            12190
      EXTERNAL CINT,BINT                                                  12200
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT       12210
      COMMON /AREA9/ SIZ,SIZ1,NR,C1,DIAMNI,STDEVI                         12220
      COMMON /AREA10/ TRAJ,DIAG,SIZE                                      12230
      DATA S/75*0./                                                       12240
      KJ=0                                                                12250
      START=-WIDTH                                                        12260
      NWIDTH=100*WIDTH+1-START*100                                        12270
      DO 10 I=1,NCOL                                                      12280
      NR=NRUN(I)                                                          12290
      IF(NR.EQ.0) GO TO 200                                               12300
      IF(MET(I).EQ.1.OR.NR.LT.4) GO TO 100                                12310
C                                                                         12320
C        IF MET(I)=0 THE I'TH NOZZLE'S DISTRIBUTION IS CALCULATED         12330
C        USING A CUBIC SPLINE                                             12340
C                                                                         12350
      IF(NPRINT.EQ.0) GO TO 46                                            12360
      WRITE (6,40) YNOZ(I)                                                12370
   40 FORMAT("1","YNOZ=",F5.3)                                            12380
      WRITE (6,45)                                                        12390
   45 FORMAT("0",3(7X,"YG",11X,"DIA",5X,"CONCENTRATION"))                 12400
   46 CONTINUE                                                            12410
      DO 20 J=1,NR                                                        12420
      K=NR-J+1                                                            12430
      SIZ(J)=SIZE(K,I)                                                    12440
      SIZ1(J)=DIAG(K,I)                                                   12450
      YI(J)=1./(TRAJ(K,I)-YNOZ(I))                                        12460
   20 CONTINUE                                                            12470
      IBC=0                                                               12480
      AA=0.                                                               12490
      BB=0.                                                               12500
      IF(NEVAP.EQ.1) CALL CSPL(SIZ,SIZ1,NR,C1,S,IBC,AA,BB)                12510
      CALL CSPL(YI,SIZ,NR,C,S,IBC,AA,BB)                                  12520
      IF(ABS(TRAJ(NR,I)).LT.DWIDTH) GO TO 21                              12530
      DELTAY=1./(DWIDTH-YNOZ(I))                                          12540
      CALL CSFIND(YI,SIZ,NR,C,DELTAY,DRIFT(I),DUMI,DUMY)                  12550
   21 CONTINUE                                                            12560
C                                                                         12570
C        CALCULATE THE DISTRIBUTION AND ADD TO DIST ARRAY,                12580
C        OUTPUT TO 6 IF NPRINT=1                                          12590
C                                                                         12600
      NPTS=(TRAJ(1,I)-START)*100+1                                        12610
      NEND=NWIDTH                                                         12620
      IF(TRAJ(NR,I).LT.TRAJ(1,I)) NEND=1                                  12630
      NSTART=NPTS                                                         12640
      NSTOP=NEND                                                          12650
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      IF(NEND.NE.1) GO TO 25                                              12660
      NSTART=NEND                                                         12670
      NSTOP=NPTS                                                          12680
   25 CONTINUE                                                            12690
      DIAOLD=10000.                                                       12700
      DO 30 KKK=NSTART,NSTOP                                              12710
      KK=KKK                                                              12720
      IF(NEND.EQ.1) KK=NSTOP-(KKK-1)                                      12730
      YG=START+(KK-1)*.01                                                 12740
      DELTAY=1./(YG-YNOZ(I))                                              12750
      CALL CSFIND(YI,SIZ,NR,C,DELTAY,DIA,DDYG,DUMY)                       12760
      IF(DIA.GE.DIAOLD) WRITE(6,27) I,DIA                                 12770
   27 FORMAT("0","***  CUBIC SPLINE PROBLEM  NOZZLE NO.",I3,"  DIA=",      12780
     &       E13.6,"  ***")                                               12790
      DIAOLD=DIA                                                          12800
      IF(DIA.LT.DRIFT(I)) GO TO 35                                        12810
      IF(DIA.GT.SIZ(NR)) GO TO 30                                         12820
      DVDD=(EXP(-.5*((DIA-DIAMN(I))/STDEV(I))**2))                        12830
     &       /(STDEV(I)*SQRT(2.*3.141592654))                             12840
      IF(NEVAP.EQ.1) CALL CSFIND(SIZ,SIZ1,NR,C1,DIA,DIA1,DUMY,DUMMY)      12850
      IF(NEVAP.EQ.1) DVDD=DVDD*(DIA1**3/DIA**3)                           12860
      DYG=-1./((YG-YNOZ(I))**2)                                           12870
      DDYG=DDYG*DYG                                                       12880
      DIST1=ABS(Q(I)*DVDD*DDYG)                                           12890
      DIST(KK)=DIST1+DIST(KK)                                             12900
      IF(NPRINT.EQ.0) GO TO 30                                            12910
      IF(DIST1.LT.(1.E-4/Q(I))) GO TO 30                                  12920
      IF(KJ.EQ.3) KJ=0                                                    12930
      KJ=KJ+1                                                             12940
      XLIST(KJ)=YG                                                        12950
      DLIST(KJ)=DIST1                                                     12960
      SLIST(KJ)=DIA                                                       12970
      IF(KJ.EQ.3) WRITE(6,80) (XLIST(K1),SLIST(K1),DLIST(K1),K1=1,3)      12980
   80 FORMAT(" ",3(E15.6,2E13.6))                                         12990
   30 CONTINUE                                                            13000
   35 CONTINUE                                                            13010
      IF(KJ.NE.3.AND.NPRINT.EQ.1) WRITE(6,80) (XLIST(K1),SLIST(K1),       13020
     &                                DLIST(K1),K1=1,KJ)                   13030
      GO TO 200                                                           13040
  100 CONTINUE                                                            13050
C                                                                         13060
C        IF MET(I)=1 THE I'TH NOZZLE'S DISTRIBUTION IS CALCULATED         13070
C        USING A LINEAR FIT                                               13080
C                                                                         13090
      KJ=0                                                                13100
      IF(NR.LT.2) GO TO 200                                               13110
      IF(NPRINT.EQ.1) WRITE(6,105) YNOZ(I)                                13120
  105 FORMAT("1","YNOZ=",F5.3/"0",4(8X,"YG",7X,"CONCENTRATION")/)         13130
      DO 110 J=1,NR                                                       13140
      K=NR-J+1                                                            13150
      SIZ(J)=SIZE(K,I)                                                    13160
      SIZ1(J)=DIAG(K,I)                                                   13170
      YI(J)=TRAJ(K,I)                                                     13180
  110 CONTINUE                                                            13190
      IF(NEVAP.EQ.0) GO TO 115                                            13200
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      IF(NR.GE.4) GO TO 112                                                  13210
      WRITE(6,113) I                                                         13220
  113 FORMAT("0","*** INSUFFICIENT DATA TO CALCULATE DISTRIBUTION ***"/      13230
     &       " *** NOZZLE NO. ",I2," DISTRIBUTION SET = TO ZERO ***")        13240
      GO TO 300                                                              13250
  112 CONTINUE                                                               13260
      IBC=0.                                                                 13270
      AA=0.                                                                  13280
      BB=0.                                                                  13290
      CALL CSPL(SIZ,SIZ1,NR,C1,S,IBC,AA,BB)                                  13300
  115 CONTINUE                                                               13310
C                                                                            13320
C        CALCULATE DISTRIBUTION AND ADD TO DIST ARRAY.                       13330
C        IF NPRINT=1 OUTPUT TO 6                                             13340
C                                                                            13350
      YMIN=100                                                               13360
      YMAX=-100                                                              13370
      DO 120 K=1,NR                                                          13380
      IF(YI(K).LT.YMIN) YMIN=YI(K)                                           13390
      IF(YI(K).GT.YMAX) YMAX=YI(K)                                           13400
  120 CONTINUE                                                               13410
      ISTART=(YMIN-START)*100+1                                              13420
      DO 130 K=ISTART,NWIDTH                                                 13430
      YG=(K-1)*.01+START                                                     13440
      IF(ABS(YG).GT.DWIDTH) GO TO 130                                        13450
      DIST1=0.                                                               13460
      IF(YG.GT.YMAX) GO TO 199                                               13470
      J1=NR-1                                                                13480
      DO 140 J=1,J1                                                          13490
      IF(YG.LT.YI(J).AND.YG.LT.YI(J+1)) GO TO 140                            13500
      IF(YG.GT.YI(J).AND.YG.GT.YI(J+1)) GO TO 140                            13510
      SLOPE=(SIZ(J+1)-SIZ(J))/(YI(J+1)-YI(J))                                13520
      DIA=SIZ(J)+SLOPE*(YG-YI(J))                                            13530
      DVDD=(EXP(-.5*((DIA-DIAMN(I))/STDEV(I))**2))                           13540
     &       /(STDEV(I)*SQRT(2.*3.141592654))                                13550
      IF(NEVAP.EQ.0) GO TO 135                                               13560
      CALL CSFIND(SIZ,SIZ1,NR,C1,DIA,DIA1,DMY,DMMY)                          13570
      DVDD=DVDD*(DIA1**3/DIA**3)                                             13580
  135 CONTINUE                                                               13590
      DIST1=DIST1+Q(I)*ABS(SLOPE*DVDD)                                       13600
  140 CONTINUE                                                               13610
      DIST(K)=DIST1+DIST(K)                                                  13620
      IF(NPRINT.EQ.0) GO TO 130                                              13630
      IF(KJ.EQ.4) KJ=0                                                       13640
      KJ=KJ+1                                                                13650
      XLIST(KJ)=YG                                                           13660
      DLIST(KJ)=DIST1                                                        13670
      IF(KJ.EQ.4) WRITE(6,141) (XLIST(K1),DLIST(K1),K1=1,4)                  13680
  141 FORMAT(" ",4(E16.6,E14.6))                                             13690
  130 CONTINUE                                                               13700
  199 CONTINUE                                                               13710
      IF(KJ.NE.4.AND.NPRINT.EQ.1) WRITE(6,141) (XLIST(K1),DLIST(K1)          13720
     &                                ,K1=1,KJ)                              13730
  200 CONTINUE                                                               13740
C                                                                            13750
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C        DRIFT ESTIMATION                                                    13760
C                                                                            13770
      DRFT=DRIFT(I)                                                          13780
      IF(DRIFT(I).EQ.0) GO TO 300                                            13790
      IF(DRIFT(I).NE.SIZE(1+I)) GO TO 205                                    13800
      DRIFT(I)=100.                                                          13810
      GO TO 350                                                              13820
  205 CONTINUE                                                               13830
      AA=0.                                                                  13840
      BB=(DRIFT(I)-DIAMN(I))/STDEV(I)                                        13850
      ISEG=ABS(BB*20)/2                                                      13860
      ISEG=ISEG*2                                                            13870
      CALL SIMP(AA,BB,ISEG,CINT,ANS)                                         13880
      ANS=ANS*SQRT(1./(2.*3.141592654))                                      13890
      DRIFT(I)=(.50+ANS)*100.                                                13900
  300 CONTINUE                                                               13910
      IF(NEVAP.EQ.0) GO TO 350                                               13920
C                                                                            13930
C        INCLUDE THE EFFECT OF EVAPORATION IN THE DRIFT                      13940
C                                                                            13950
      IF(NR.GE.4) GO TO 320                                                  13960
      WRITE(6,330) I                                                         13970
  330 FORMAT("0","***INSUFFICIENT DATA TO ESTIMATE DRIFT ***"/               13980
     &       " *** NOZZLE NO. ",I2," DRIFT SET EQUAL TO ZERO ***")           13990
      DRIFT(I)=0.                                                            14000
      GO TO 10                                                               14010
  320 CONTINUE                                                               14020
      AA=DRFT                                                                14030
      BB=SIZ(NR)                                                             14040
      ISEG=IFIX((SIZ(NR)-SIZ(1))/20)*20                                      14050
      IF(ISEG.LT.2) ISEG=2                                                   14060
      DIAMNI=DIAMN(I)                                                        14070
      STDEVI=STDEV(I)                                                        14080
      CALL SIMP(AA,BB,ISEG,BINT,ANS)                                         14090
      EVAP=1.-ANS                                                            14100
      DRIFT(I)=EVAP*100.+DRIFT(I)                                            14110
  350 CONTINUE                                                               14120
      IF(NPRINT.EQ.1) WRITE (6,60) DRIFT(I)                                  14130
   60 FORMAT("0","DRIFT=",E14.6)                                             14140
   10 CONTINUE                                                               14150
      RETURN                                                                 14160
      END                                                                    14170
C                                                                            14180
C        SIMP IS A SIMPSON'S RULE INTEGRATION ROUTINE                        14190
C                                                                            14200
C        AA,BB  ARE THE LIMITS OF INTEGRATION                                14210
C        ISEG   IS THE EVEN NUMBER OF SEGMENTS AA TO BB IS DIVIDED INTO      14220
C        CINT   IS THE SUBROUTINE WHICH EVALUATES THE INTEGRAND              14230
C        ANS    RETURNS THE ANSWER                                           14240
C                                                                            14250
      SUBROUTINE SIMP(AA,BB,ISEG,CINT,ANS)                                   14260
      DELTA=(BB-AA)/ISEG                                                     14270
      ISEG1=ISEG-1                                                           14280
      SUM=0.                                                                 14290
      DO 10 I=1,ISEG1                                                        14300
```

```
      FAC=4.                                                            14310
      K=I/2                                                             14320
      IF((K*2).EQ.I) FAC=2.                                             14330
      X=AA+I*DELTA                                                      14340
      CALL CINT(X,Y)                                                    14350
      SUM=SUM+Y*FAC                                                     14360
   10 CONTINUE                                                          14370
      CALL CINT(AA,Y1)                                                  14380
      CALL CINT(BB,Y2)                                                  14390
      SUM=SUM+Y1+Y2                                                     14400
      ANS=(DELTA/3.)*SUM                                                14410
      RETURN                                                            14420
      END                                                               14430
C                                                                       14440
C        CINT EVALUATES INTEGRAND WHEN NEVAP=0                          14450
C                                                                       14460
      SUBROUTINE CINT(X,Y)                                              14470
      Y=EXP(-.50*X**2)                                                  14480
      RETURN                                                            14490
      END                                                               14500
C                                                                       14510
C        BINT EVALUATES INTEGRAND WHEN NEVAP=1                          14520
C                                                                       14530
      SUBROUTINE BINT(X,Y)                                              14540
      DIMENSION SIZ(15),SIZ1(15),C1(4,15)                               14550
      COMMON /AREA9/ SIZ,SIZ1,NR,C1,DIAMNI,STDEVI                       14560
      CALL CSFIND(SIZ,SIZ1,NR,C1,X,DIA1,DUMY,DUMMY)                     14570
      DIA=X                                                             14580
      DVOL=(EXP(-.5*((DIA-DIAMNI)/STDEVI)**2))                          14590
     &       /(STDEVI*SQRT(2.*3.141592654))                             14600
      Y=(DIA1/DIA)**3*DVOL                                              14610
      RETURN                                                            14620
      END                                                               14630
C                                                                       14640
C        INCON EVALUATES THE INITIAL VELOCITY OF THE DROPLET            14650
C                                                                       14660
C        TO CORRECT FOR THE EFFECT OF THE BOUND VORTEX THE DROPLET IS   14670
C        GIVEN AN INITIAL VELOCITY EQUAL TO ITS TERMINAL VELOCITY AT    14680
C        THAT POINT IN THE FLOW FIELD                                   14690
C                                                                       14700
      SUBROUTINE INCON(YY,DIA,NVAR)                                     14710
      DIMENSION YY(13,NVAR)                                             14720
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 14730
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT     14740
      C=3.141592654                                                     14750
      ZY=ZY0                                                            14760
      ZZ=ZZ0                                                            14770
      Y=YY(1,1)                                                         14780
      Z=YY(1,3)                                                         14790
      IF(NTUN.EQ.1) GO TO 5                                             14800
      VA=(CL/(2.0*C*A))*((ZZ+Z)/((ZZ+Z)**2+(ZY-Y)**2)-(ZZ+Z)/((ZZ+Z)    14810
     &   **2+(ZY+Y)**2)-(ZZ-Z)/((ZZ-Z)**2+(ZY+Y)**2)+(ZZ-Z)/((ZZ-Z)**2  14820
     &   +(ZY-Y)**2))                                                   14830
      WA=(CL/(2.0*C*A))*((ZY-Y)/((ZZ+Z)**2+(ZY-Y)**2)+(ZY+Y)/((ZZ+Z)    14840
     &   **2+(ZY+Y)**2)-(ZY+Y)/((ZZ-Z)**2+(ZY+Y)**2)-(ZY-Y)/((ZZ-Z)**2  14850
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     &    +(ZY-Y)**2))                                                    14860
    5 CONTINUE                                                           14870
      IF(NTUN.EQ.1) CALL TUNVEL(Y,Z,ZY,ZZ,VA,WA)                         14880
      S=18.*(R*DA)/(DIA*DD)                                              14890
      RU=(DA*DIA*U)/VIS                                                  14900
      VD=VA                                                              14910
      YY(1,2)=VA                                                         14920
      WDL=WA                                                             14930
      WDR=WA                                                             14940
      DO 10 J=1,100                                                      14950
      WDR=WDR+WA                                                         14960
      R=U*ABS(((DA*DIA)*(WA-WDR))/VIS)                                   14970
      CDR=1.0+0.197*R**0.63+0.26E-03*R**1.38                             14980
      FR=((S*CDR)/RU)*(WA-WDR)-(B*G)/U**2                                14990
      IF(FR.GT.0.E0)GO TO 40                                             15000
   10 CONTINUE                                                           15010
      WRITE (6,20)                                                       15020
   20 FORMAT("0","**** WDR EXCEEDED DO LOOP IN INCON ****")              15030
      WRITE (6,30)                                                       15040
   30 FORMAT("1","**** RIGHT ENDPOINT IN INCON INCORRECT ****")          15050
      YY(1,4)=0.E0                                                       15060
      GO TO 90                                                           15070
   40 CONTINUE                                                           15080
C                                                                        15090
C        SOLVE FOR THE VELOCITY BY THE METHOD OF BISECTION               15100
C                                                                        15110
      DO 50 I=1,500                                                      15120
      WDM=(WDL+WDR)/2.E0                                                 15130
      R=ABS(((DA*DIA)*(WA-WDM))/VIS)                                     15140
      R=R*U                                                              15150
      CDR=1.0+0.197*R**0.63+0.26E-03*R**1.38                             15160
      FM=((S*CDR)/RU)*(WA-WDM)-(B*G)/U**2                                15170
      FF=ABS(FM)                                                         15180
      IF(FF.LT.EPS)GO TO 70                                              15190
      IF(FM.GT.0.E0) WDR=WDM                                             15200
      IF(FM.LT.0.E0) WDL=WDM                                             15210
   50 CONTINUE                                                           15220
      WRITE (6,60)                                                       15230
   60 FORMAT("1","**** DO LOOP PARAMETER IN INCON EXCEEDED ****")        15240
      YY(1,4)=0.E0                                                       15250
      GO TO 90                                                           15260
   70 YY(1,4)=WDM                                                        15270
      IF(NDIST.EQ.0) WRITE (6,80) VD,WDM                                 15280
   80 FORMAT("0","INCON VALUES",T25,"VD=",E13.6,T45,"WD=",E13.6//)       15290
   90 RETURN                                                             15300
      END                                                                15310
C                                                                        15320
C        YZFIN EVALUATES THE DROPLET LOCATION AND VELOCITY               15330
C        WHEN IT INTERSECTS THE GROUND PLANE                             15340
C        VALUES FOR THE NEXT TO LAST TIME-STEP ARE IN THE ARRAY          15350
C        YY1 AND T1. THE VALUES FOR THE LAST STEP YY AND T ARE           15360
C        REPLACED BY THE LINEARLY INTERPOLATED FINAL VALUES              15370
C        TO BE RETURNED                                                  15380
C                                                                        15390
      SUBROUTINE YZFIN(YY,YY1,NVAR,T,T1,L)                               15400
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      DIMENSION YY(13,NVAR),YY1(NVAR),IRUN(50)                          15410
      COMMON /AREA1/ A,CL,B,U,G,ZY0,ZZ0,DA,VIS,VCW,D,DD                 15420
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT     15430
      COMMON /AREA6/ JJ,IRUN,ICOUNT                                     15440
      CONV=(0.E0-YY1(3))/(YY(1,3)-YY1(3))                               15450
      DO 10 I=1,NVAR                                                    15460
      YY(1,I)=(YY(1,I)-YY1(I))*CONV+YY1(I)                              15470
   10 CONTINUE                                                          15480
      YY(1,3)=0.                                                        15490
      T=((T-T1)*CONV)+T1                                                15500
      IF(NDIST.EQ.1) GO TO 20                                           15510
      WRITE(8,30) T,YY(1,1),YY(1,3)                                     15520
   30 FORMAT(3E13.6)                                                    15530
   20 RETURN                                                            15540
      END                                                               15550
C                                                                       15560
C     SUBROUTINE CSPL                                                   15570
C     CSPL FITS A CUBIC SPLINE THROUGH THE M INPUT POINTS (X,Y).        15580
C     THE EQUATION FOR THE CUBIC WHEN X IS GREATER THAN X(I) AND        15590
C     LESS THAN X(I+1) IS:                                              15600
C     Y(X)=C(1,I)*(X(I+1)-X)**3+C(2,I)*(X-X(I))**3+C(3,I)*              15610
C          (X(I+1)-X)+C(4,I)*(X-X(I))                                   15620
C                                                                       15630
C     PARAMETERS:                                                       15640
C                                                                       15650
C     X       AN ARRAY INPUT AND DIMENSIONED X(M) CONTAINING THE        15660
C             INDEPENDENT VARIABLE IN INCREASING ORDER                  15670
C     Y       AN ARRAY INPUT AND DIMENSIONED Y(M) CONTAINING THE        15680
C             DEPENDENT VARIABLE                                        15690
C     M       NUMBER OF (X,Y) INPUT                                     15700
C     C       AN ARRAY OUTPUT WITH DIMENSION C(4,M-1) CONTAINING        15710
C             THE DESIRED COEFFICIENTS                                  15720
C     S       A WORK ARRAY DIMENSIONED S(M,5)                           15730
C     IBC     =0  SECOND DERIVATIVE OF Y WRT X SET EQUAL TO A AT        15740
C                 X(1) AND B AT X(M)                                    15750
C             =1  FIRST DERIVATIVE OF Y WRT X SET EQUAL TO A AT         15760
C                 X(1) AND B AT X(M)                                    15770
C     A,B     INPUT VALUE OF FIRST OR SECOND DERIVATIVE DEPENDING       15780
C             ON IBC                                                    15790
C                                                                       15800
C     PROGRAMED BY M. BRAGG   AARL/OSU   MARCH,1980                     15810
C                                                                       15820
      SUBROUTINE CSPL(X,Y,M,C,S,IBC,A,B)                                15830
      DIMENSION X(1),Y(1),C(4,1),S(M,5)                                 15840
      DO 2 K2=1,5                                                       15850
      DO 1 K1=1,M                                                       15860
    1 S(K1,K2)=0.                                                       15870
    2 CONTINUE                                                          15880
      IF(IBC.NE.0) GO TO 10                                             15890
      S(1,2)=1.                                                         15900
      S(M,2)=1.                                                         15910
      S(1,4)=A                                                          15920
      S(M,4)=B                                                          15930
      GO TO 20                                                          15940
   10 CONTINUE                                                          15950
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      S(1,2)=2.                                                          15960
      S(1,3)=1.                                                          15970
      S(1,4)=6.*((Y(2)-Y(1))/((X(2)-X(1))**2))-(6.*A/(X(2)-X(1)))        15980
      S(M,1)=1.                                                          15990
      S(M,2)=2.                                                          16000
      S(M,4)=6.*((Y(M-1)-Y(M))/((X(M)-X(M-1))**2))+(6.*B/(X(M)-X(M-1)))  16010
   20 CONTINUE                                                           16020
      M1=M-1                                                             16030
       DO 30 I=2,M1                                                      16040
      DX=X(I+1)-X(I)                                                     16050
      DX1=X(I)-X(I-1)                                                    16060
      S(I,1)=DX1/DX                                                      16070
      S(I,2)=(2.*DX+2.*DX1)/DX                                           16080
      S(I,3)=1.                                                          16090
      S(I,4)=6.*(((Y(I+1)-Y(I))/DX**2)-((Y(I)-Y(I-1))/(DX*DX1)))         16100
   30 CONTINUE                                                           16110
C                                                                        16120
C     USE THOMAS ALGORITHUM TO SOLVE TRI-DIAGONAL SYSTEM                 16130
C                                                                        16140
      DO 40 I=2,M                                                        16150
      S(I,2)=S(I,2)-S(I,1)*S(I-1,3)/S(I-1,2)                             16160
      S(I,4)=S(I,4)-S(I,1)*S(I-1,4)/S(I-1,2)                             16170
   40 CONTINUE                                                           16180
      S(M,5)=S(M,4)/S(M,2)                                               16190
      DO 50 I=2,M                                                        16200
      J=M-I+1                                                            16210
      S(J,5)=(S(J,4)-S(J,3)*S(J+1,5))/S(J,2)                             16220
   50 CONTINUE                                                           16230
      DO 60 I=1,M1                                                       16240
      DX=X(I+1)-X(I)                                                     16250
      C(1,I)=S(I,5)/(6.*DX)                                              16260
      C(2,I)=S(I+1,5)/(6.*DX)                                            16270
      C(3,I)=(Y(I)/DX)-((S(I,5)*DX)/6.)                                  16280
      C(4,I)=(Y(I+1)/DX)-((S(I+1,5)*DX)/6.)                              16290
   60 CONTINUE                                                           16300
      RETURN                                                             16310
      END                                                                16320
C                                                                        16330
C     SUBROUTINE CSFIND                                                  16340
C                                                                        16350
C     SCFIND USES THE X,Y,M,C FROM A CALL TO CSPL AND RETURNS FOR        16360
C     ANY INDEPENDENT VARIABLE XX: THE CUBIC SPLINE VALUE OF THE         16370
C     DEPENDENT VARIABLE YY, THE FIRST DERIVATIVE YP, AND THE            16380
C     SECOND DERIVATIVE Y2P.                                             16390
C                                                                        16400
      SUBROUTINE CSFIND(X,Y,M,C,XX,YY,YP,Y2P)                            16410
      DIMENSION X(1),Y(1),C(4,1)                                         16420
      M1=M-1                                                             16430
      IF(X(1).GT.X(M)) GO TO 20                                          16440
      DO 10 I=1,M1                                                       16450
      IF(X(I).LE.XX.AND.X(I+1).GT.XX) GO TO 40                           16460
   10 CONTINUE                                                           16470
      IF(XX.LT.X(1)) I=1                                                 16480
      IF(XX.GE.X(M)) I=M1                                                16490
      GO TO 40                                                           16500
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```
   20 CONTINUE                                                          16510
      DO 30 I=1,M1                                                      16520
      IF(X(I).GE.XX.AND.X(I+1).LT.XX) GO TO 40                          16530
   30 CONTINUE                                                          16540
      IF(XX.GT.X(1)) I=1                                                16550
      IF(XX.LT.X(M)) I=M1                                               16560
   40 CONTINUE                                                          16570
      YY=C(1,I)*(X(I+1)-XX)**3+C(2,I)*(XX-X(I))**3+C(3,I)*(X(I+1)-XX)   16580
     &   +C(4,I)*(XX-X(I))                                              16590
      YP=-3.*C(1,I)*(X(I+1)-XX)**2+3.*C(2,I)*(XX-X(I))**2-C(3,I)        16600
     &   +C(4,I)                                                        16610
      Y2P=6.*C(1,I)*(X(I+1)-XX)+6.*C(2,I)*(XX-X(I))                     16620
      RETURN                                                            16630
      END                                                               16640
C                                                                       16650
C        SUBROUTINE PLOT1                                               16660
C                                                                       16670
C        PLOT1 IS CALLED IF NPLOT=1 AND PLOTS PARTICLE TRAJECTORIES     16680
C        IF NDIST=0 AND THE FINAL DISTRIBUTION IF NDIST=1               16690
C                                                                       16700
      SUBROUTINE PLOT1(TITLE)                                           16710
      DIMENSION IRUN(50),YPLOT(1001),ZPLOT(1001),TITLE(13)              16720
      COMMON /AREA2/ N2D,N3D,NEVAP,EPS,NPROP2,NCW,NTUN,NDIST,NPRINT     16730
      COMMON /AREA6/ JJ,IRUN,ICOUNT                                     16740
      NTOT=JJ                                                           16750
      REWIND 8                                                          16760
      CALL PLOTF(120.4)                                                 16770
      IF(NDIST.EQ.1) GO TO 200                                          16780
      DO 10 I=1,NTOT                                                    16790
      READ(8,16) T,YPLOT(I),ZPLOT(I)                                    16800
   16 FORMAT(3F13.6)                                                    16810
   10 CONTINUE                                                          16820
      ZMAX=0.                                                           16830
      DO 20 I=1,NTOT                                                    16840
      IF(ZPLOT(I).GT.ZMAX) ZMAX=ZPLOT(I)                                16850
   20 CONTINUE                                                          16860
      YPLOT(NTOT+1)=0.                                                  16870
      NTOT1=NTOT+1                                                      16880
      CALL SCALE(YPLOT,8.,NTOT1,FY,DY)                                  16890
      FZ=0.                                                             16900
      DZ=DY                                                             16910
      IZ=ZMAX/DY+1.                                                     16920
      IF(IZ.LE.6) GO TO 30                                              16930
      CALL SCALE(ZPLOT,6.,NTOT,FZ,DZ)                                   16940
      DY=DZ                                                             16950
   30 CONTINUE                                                          16960
      AIZ=IZ                                                            16970
      CALL PLOT(0.5,1.5,-3)                                             16980
      CALL AXIS(0.,0.,'2Y/B',-4,8.,0.,FY,DY)                            16990
      CALL AXIS(0.,0.,'2Z/B',4,AIZ,90.,FZ,DZ)                           17000
      CALL SYMBOL(1.0,6.5,.14,TITLE,0.,36)                              17010
      K=1                                                               17020
      DO 40 I=1,ICOUNT                                                  17030
      II=IRUN(I)+K-1                                                    17040
      DO 50 J=K,II                                                      17050
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      JJ=J-K+1                                                          17060
      YPLOT(JJ)=YPLOT(J)                                                17070
      ZPLOT(JJ)=ZPLOT(J)                                                17080
   50 CONTINUE                                                          17090
      NLAST=IRUN(I)                                                     17100
      CALL LINE(YPLOT,FY,DY,ZPLOT,FZ,DZ,NLAST,0,1)                     17110
      K=K+IRUN(I)                                                       17120
   40 CONTINUE                                                          17130
      CALL PLOT(11.,-1.5,999)                                           17140
      RETURN                                                            17150
  200 CONTINUE                                                          17160
      YMAX=-100.                                                        17170
      YMIN=100.                                                         17180
      DO 220 I=1,JJ                                                     17190
      READ(8,230) YPLOT(I),ZPLOT(I)                                     17200
  230 FORMAT(2F13.6)                                                    17210
      IF(ZPLOT(I).GT.1.E-2.AND.YPLOT(I).LT.YMIN) YMIN=YPLOT(I)          17220
      IF(ZPLOT(I).GT.1.E-2.AND.YPLOT(I).GT.YMAX) YMAX=YPLOT(I)          17230
  220 CONTINUE                                                          17240
      CALL PLOT(0.,1.5,-3)                                              17250
      K=0                                                               17260
      DO 210 I=1,JJ                                                     17270
      IF(YPLOT(I).LT.YMIN) GO TO 210                                    17280
      IF(YPLOT(I).GT.YMAX) GO TO 210                                    17290
      K=K+1                                                             17300
      YPLOT(K)=YPLOT(I)                                                 17310
      ZPLOT(K)=ZPLOT(I)                                                 17320
  210 CONTINUE                                                          17330
      CALL SCALE(YPLOT,8.,K,FX,DX)                                      17340
      CALL SCALE(ZPLOT,6.,K,FD,DD)                                      17350
      CALL AXIS(0.,0.,'2Y/B',-4,8.,0.,FX,DX)                            17360
      CALL AXIS(0.,0.,'CONCENTRATION',13,6.,90.,FD,DD)                  17370
      CALL SYMBOL(1.0,6.5,.14,TITLE,0.,36)                              17380
      CALL LINE(YPLOT,FX,DX,ZPLOT,FD,DD,K,0,1)                          17390
      CALL PLOT(11.,-1.5,999)                                           17400
      RETURN                                                            17410
      END                                                               17420
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C* THIS SUBROUTINE INTEGRATES A SET OF N ORDINARY DIFFERENTIAL FIRST   *      10
C* ORDER EQUATIONS OVER ONE STEP OF LENGTH H AT EACH CALL.  H CAN BE   *      20
C* SPECIFIED BY THE USER FOR EACH STEP, BUT IT MAY BE INCREASED OR     *      30
C* DECREASED BY DIFSUB WITHIN THE RANGE HMIN TO HMAX IN ORDER TO       *      40
C* ACHIEVE AS LARGE A STEP AS POSSIBLE WHILE NOT COMMITTING A SINGLE   *      50
C* STEP ERROR WHICH IS LARGER THAN EPS IN THE L-2 NORM, WHERE EACH     *      60
C* COMPONENT OF THE ERROR IS DIVIDED BY THE COMPONENTS OF YMAX.        *      70
C*                                                                     *      80
C* THE PROGRAM REQUIRES FOUR SUBROUTINES NAMED                         *      90
C*    DIFFUN(N,T,Y,DY)    --USER-SUPPLIED--                                 100
C*    DECOMP(N,M,PW,IP)       --RENAMED TO NDI01Z IN THIS SOURCE--    *     110
C*    SOLVE(N,M,PW,CSAVE(1,1),IP)  --RENAMED TO NDI02Z--              *     120
C*    PEDERV(T,Y,PW,M)      --USER-SUPPLIED--                         *     130
C* THE FIRST, DIFFUN, EVALUATES THE DERIVATIVES OF THE DEPENDENT       *     140
C* VARIABLES STORED IN Y(1,I) FOR I = 1 TO N, AND STORES THE           *     150
C* DERIVATIVES IN THE ARRAY DY.  THE NEXT TWO ARE CALLED ONLY IF THE   *     160
C* METHOD FLAG MF IS SET TO 1 OR 2 FOR STIFF METHODS.  DECOMP IS A     *     170
C* STANDARD LU DECOMPOSITION WITH PIVOTING THAT DECOMPOSES THE MATRIX  *     180
C* PW, LEAVING THE PIVOTS IN THE INTEGER ARRAY IP.  M IS THE DECLARED  *     190
C* SIZE OF PW.  IP(N) IS SET TO 0 IF PW IS SINGULAR.  SOLVE PERFORMS   *     200
C* BACK SUBSTITUTION ON THE CONTENTS OF CSAVE(I,1), LEAVING THE        *     210
C* RESULTS THERE.                                                            220
C* PEDERV IS USED ONLY IF MF IS 1, AND COMPUTES THE PARTIAL            *     230
C* DERIVATIVES OF THE DIFFERENTIAL EQUATIONS AS DESCRIBED UNDER THE    *     240
C* MF PARAMETER.                                                       *     250
C*                                                                     *     260
C* THE TEMPORARY STORAGE SPACE IS PROVIDED BY THE CALLER IN THE        *     270
C* INTEGER ARRAY IP, THE  ARRAY PW, AND THE                            *     280
C* ARRAYS SAVE AND CSAVE.  THE ARRAY PW IS USED ONLY TO HOLD           *     290
C* THE MATRIX OF THE SAME NAME, AND SAVE IS USED TO SAVE THE VALUES    *     300
C* OF Y IN CASE A STEP HAS TO BE REPEATED, BUT CSAVE IS USED TO HOLD   *     310
C* SEVERAL ARRAYS.  THE REGIONS USED ARE                               *     320
C*    CSAVE(I,1)    IS USED MAINLY TO HOLD THE CORRECTION TERMS IN THE *     330
C*                  CORRECTOR LOOP, AND HOLDS THE DERIVATIVES DURING   *     340
C*                  JACOBIAN EVALUATIONS.                              *     350
C*    CSAVE(I,2)    IS USED TO SAVE THE VALUES OF THE SUMS OF ALL OF THE*     360
C*                  CORRECTION TERMS IN THE PREVIOUS STEP AFTER THEY   *     370
C*                  HAVE BEEN ACCUMULATED IN THE ARRAY ERROR IN THE    *     380
C*                  CURRENT STEP.  THIS ENABLES THE BACKWARDS DIFFERENCE*     390
C*                  OF ERROR TO BE FORMED.  IT IS USED TO ESTIMATE THE *     400
C*                  STEP SIZE FOR ONE ORDER HIGHER THAN CURRENT.       *     410
C*    CSAVE(I,3)    IS USED TO STORE THE DERIVATIVES WHEN THEY ARE     *     420
C*                  COMPUTED BY DIFFUN.                                *     430
C*                                                                     *     440
C* THE PARAMETERS TO THE SUBROUTINE DIFSBM HAVE                        *     450
C* THE FOLLOWING MEANINGS..                                            *     460
C*                                                                     *     470
C*   N        THE NUMBER OF FIRST ORDER DIFFERENTIAL EQUATIONS.  N     *     480
C*              MAY BE DECREASED ON LATER CALLS IF THE NUMBER OF       *     490
C*              ACTIVE EQUATIONS REDUCES, BUT IT MUST NOT BE           *     500
C*              INCREASED WITHOUT CALLING WITH JSTART = 0.             *     510
C*   T        THE INDEPENDENT VARIABLE.                              *     520
C*   Y        A 13 BY N ARRAY CONTAINING THE DEPENDENT VARIABLES AND  *     530
C*              THEIR SCALED DERIVATIVES.  Y(J+1,I) CONTAINS         *     540
C*              THE J-TH DERIVATIVE OF Y(I) SCALED BY                *     550
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C*              H**J/FACTORIAL(J) WHERE H IS THE CURRENT                *     560
C*              STEP SIZE. ONLY Y(1,I) NEED BE PROVIDED BY              *     570
C*              THE CALLING PROGRAM ON THE FIRST ENTRY.                 *     580
C*                IF IT IS DESIRED TO INTERPOLATE TO NON MESH POINTS     *     590
C*              THESE VALUES CAN BE USED.  IF THE CURRENT STEP SIZE     *     600
C*              IS H AND THE VALUE AT T + E IS NEEDED, FORM             *     610
C*              S = E/H, AND THEN COMPUTE                               *     620
C*                                  NQ                                  *     630
C*                Y(I)(T+E) =  SUM  Y(J+1,I)*S**J                       *     640
C*                               J=0                                    *     650
C*    SAVE      A BLOCK OF AT LEAST 13*N FLOATING POINT LOCATIONS.      *     660
C*    CSAVE     N*3 FLOATING POINT LOCATIONS USED BY THE SUBROUTINES.   *     670
C*    H         THE STEP SIZE TO BE ATTEMPTED ON THE NEXT STEP.         *     680
C*              H MAY BE ADJUSTED UP OR DOWN BY THE PROGRAM             *     690
C*              IN ORDER TO ACHEIVE AN ECONOMICAL INTEGRATION.          *     700
C*              HOWEVER, IF THE H PROVIDED BY THE USER DOES             *     710
C*              NOT CAUSE A LARGER ERROR THAN REQUESTED, IT             *     720
C*              WILL BE USED.  TO SAVE COMPUTER TIME, THE USER IS       *     730
C*              ADVISED TO USE A FAIRLY SMALL STEP FOR THE FIRST        *     740
C*              CALL.  IT WILL BE AUTOMATICALLY INCREASED LATER.        *     750
C*    HMIN      THE MINIMUM STEP SIZE THAT WILL BE USED FOR THE         *     760
C*              INTEGRATION.  NOTE THAT ON STARTING THIS MUST BE        *     770
C*              MUCH SMALLER THAN THE AVERAGE H EXPECTED SINCE          *     780
C*              A FIRST ORDER METHOD IS USED INITIALLY.                 *     790
C*    HMAX      THE MAXIMUM SIZE TO WHICH THE STEP WILL BE INCREASED    *     800
C*    EPS       THE ERROR TEST CONSTANT.  SINGLE STEP ERROR ESTIMATES   *     810
C*              DIVIDED BY  YMAX(I)  MUST BE LESS THAN THIS             *     820
C*              IN THE EUCLIDEAN NORM. THE STEP AND/OR ORDER IS         *     830
C*              ADJUSTED TO ACHEIVE THIS.                               *     840
C*    MF        THE METHOD INDICATOR. THE FOLLOWING ARE ALLOWED..       *     850
C*                        0   AN ADAMS PREDICTOR CORRECTOR IS USED.     *     860
C*                        1   A MULTI-STEP METHOD SUITABLE FOR STIFF     *     870
C*                              SYSTEMS IS USED. IT WILL ALSO WORK FOR  *     880
C*                              NON STIFF SYSTEMS.  HOWEVER THE USER    *     890
C*                              MUST PROVIDE A SUBROUTINE PEDERV WHICH  *     900
C*                              EVALUATES THE PARTIAL DERIVATIVES OF    *     910
C*                              THE DIFFERENTIAL EQUATIONS WITH RESPECT *     920
C*                              TO THE Y'S.   THIS IS DONE BY CALL      *     930
C*                              PEDERV(T,Y,PW,M). PW IS AN N BY N ARRAY *     940
C*                              WHICH MUST BE SET TO THE PARTIAL OF     *     950
C*                              THE I-TH EQUATION WITH RESPECT          *     960
C*                              TO THE J DEPENDENT VARIABLE IN PW(I,J). *     970
C*                              PW IS ACTUALLY STORED IN AN M BY M      *     980
C*                              ARRAY WHERE M IS THE VALUE OF N USED ON *     990
C*                              THE FIRST CALL TO THIS PROGRAM.         *    1000
C*                        2   THE SAME AS CASE 1, EXCEPT THAT THIS      *    1010
C*                              SUBROUTINE COMPUTES THE PARTIAL         *    1020
C*                              DERIVATIVES BY NUMERICAL DIFFERENCING   *    1030
C*                              OF THE DERIVATIVES. HENCE PEDERV IS     *    1040
C*                              NOT CALLED.                             *    1050
C*    YMAX      AN ARRAY OF  N LOCATIONS WHICH CONTAINS THE MAXIMUM     *    1060
C*              OF EACH Y SEEN SO FAR.  IT SHOULD NORMALLY BE SET TO    *    1070
C*              1 IN EACH COMPONENT BEFORE THE FIRST ENTRY. (SEE THE    *    1080
C*              DESCRIPTION OF EPS.)                                    *    1090
C*    ERROR     AN ARRAY OF  N ELEMENTS WHICH CONTAINS THE ESTIMATED    *    1100
```

```
C*              ONE STEP ERROR IN EACH COMPONENT.                       *    1110
C*    KFLAG   A COMPLETION CODE WITH THE FOLLOWING MEANINGS..           *    1120
C*                    +1  THE STEP WAS SUCCESFUL.                       *    1130
C*                    -1  THE STEP WAS TAKEN WITH H = HMIN, BUT THE     *    1140
C*                          REQUESTED ERROR WAS NOT ACHIEVED.           *    1150
C*                    -2  THE MAXIMUM ORDER SPECIFIED WAS FOUND TO      *    1160
C*                          BE TOO LARGE.                               *    1170
C*                    -3  CORRECTOR CONVERGENCE COULD NOT BE            *    1180
C*                          ACHIEVED FOR H .GT. HMIN.                   *    1190
C*                    -4  THE REQUESTED ERROR IS SMALLER THAN CAN       *    1200
C*                          BE HANDLED FOR THIS PROBLEM.                *    1210
C*    JSTART  AN INPUT INDICATOR WITH THE FOLLOWING MEANINGS..          *    1220
C*                    -1  REPEAT THE LAST STEP WITH A NEW H             *    1230
C*                     0  PERFORM THE FIRST STEP.  THE FIRST STEP       *    1240
C*                          MUST BE DONE WITH THIS VALUE OF JSTART      *    1250
C*                          SO THAT THE SUBROUTINE CAN INITIALIZE       *    1260
C*                          ITSELF.                                     *    1270
C*                    +1  TAKE A NEW STEP CONTINUING FROM THE LAST.     *    1280
C*              JSTART IS SET TO NQ, THE CURRENT ORDER OF THE METHOD     *    1290
C*              AT EXIT.  NQ IS ALSO THE ORDER OF THE MAXIMUM           *    1300
C*              DERIVATIVE AVAILABLE.                                   *    1310
C*    MAXDER  THE MAXIMUM DERIVATIVE THAT SHOULD BE USED IN THE         *    1320
C*              METHOD.  SINCE THE ORDER IS EQUAL TO THE HIGHEST        *    1330
C*              DERIVATIVE USED, THIS RESTRICTS THE ORDER. IT MUST      *    1340
C*              BE LESS THAN 13 FOR ADAMS AND 7 FOR STIFF METHODS.      *    1350
C*    PW      A BLOCK OF AT LEAST N**2 FLOATING POINT LOCATIONS.        *    1360
C*    IP      A BLOCK OF AT LEAST N INTEGERS.                           *    1370
C*************************************************************************  1380
      SUBROUTINE DIFSBM (N,T,Y,SAVE,CSAVE,H,HMIN,HMAX,EPS,MF,YMAX,ERROR,     1390
     1KFLAG,JSTART,MAXDER,PW,IP)                                             1400
      DIMENSION Y(13,1), YMAX(1), SAVE(13,1), ERROR(1), PW(1), A(13), PE     1410
     1RTST(12,2,3), CSAVE(N,3), IP(1)                                        1420
C*************************************************************************  1430
C* THE COEFFICIENTS IN PERTST ARE USED IN SELECTING THE STEP AND           *  1440
C* ORDER, THEREFORE ONLY ABOUT ONE PERCENT ACCURACY IS NEEDED.             *  1450
C*************************************************************************  1460
      DATA PERTST/2.,4.5,7.333,10.42,13.7,17.15,1.,1.,1.,1.,1.,1.,2.,12.     1470
     1,24.,37.89,53.33,70.08,87.97,100.9,126.7,147.3,168.8,191.4,3.,6.,9     1480
     2.167,12.5,15.98,1.,1.,1.,1.,1.,1.,1.,12.,24.,37.89,53.33,70.08,87.     1490
     397,100.9,126.7,147.3,168.9,191.4,211.,1.,1.,.5,.1667,.04133,.00826     1500
     47,1.,1.,1.,1.,1.,1.,1.,2.,1.,.3157,.07407,.0139,.0021818,.00029        1510
     5,.000035,.0000037,.00000035/                                           1520
      DATA A(2)/-1.0/                                                        1530
      IRET=1                                                                 1540
      KFLAG=1                                                                1550
      IF (JSTART.LE.0) GO TO 50                                              1560
C*************************************************************************  1570
C* BEGIN BY SAVING INFORMATION FOR POSSIBLE RESTARTS AND CHANGING           *  1580
C* H BY THE FACTOR R IF THE CALLER HAS CHANGED H.  ALL VARIABLES           *  1590
C* DEPENDENT ON H MUST ALSO BE CHANGED.                                    *  1600
C* E IS A COMPARISON FOR ERRORS OF THE CURRENT ORDER NQ. EUP IS            *  1610
C* TO TEST FOR INCREASING THE ORDER, EDWN FOR DECREASING THE ORDER.        *  1620
C* HNEW IS THE STEP SIZE THAT WAS USED ON THE LAST CALL.                   *  1630
C*************************************************************************  1640
   10 DO 20 I=1,N                                                          1650
```

```
      DO 20 J=1,K                                                       1660
   20   SAVE(J,I)=Y(J,I)                                                1670
      HOLD=HNEW                                                         1680
      IF (H.EQ.HOLD) GO TO 40                                           1690
   30 IRET=1                                                            1700
      GO TO 750                                                         1710
   40 NQOLD=NQ                                                          1720
      TOLD=T                                                            1730
      IF (JSTART.GT.0) GO TO 300                                        1740
      GO TO 80                                                          1750
   50 IF (JSTART.EQ.-1) GO TO 70                                        1760
C*********************************************************************** 1770
C* ON THE FIRST CALL, THE ORDER IS SET TO 1 AND THE INITIAL            * 1780
C* DERIVATIVES ARE CALCULATED.                                         * 1790
C*********************************************************************** 1800
      RR=1.0                                                            1810
      NQ=1                                                              1820
      N3=N                                                              1830
      N4=N**2                                                           1840
      CALL DIFFUN (N,T,Y,CSAVE(1,3))                                    1850
      DO 60 I=1,N                                                       1860
   60   Y(2,I)=CSAVE(I,3)*H                                             1870
      HNEW=H                                                            1880
      K=2                                                               1890
      GO TO 10                                                          1900
C*********************************************************************** 1910
C* REPEAT LAST STEP BY RESTORING SAVED INFORMATION.                    * 1920
C*********************************************************************** 1930
   70 IF (NQ.EQ.NQOLD) JSTART=1                                         1940
      T=TOLD                                                            1950
      NQ=NQOLD                                                          1960
      K=NQ+1                                                            1970
      GO TO 30                                                          1980
C*********************************************************************** 1990
C* SET THE COEFFICIENTS THAT DETERMINE THE ORDER AND THE METHOD        * 2000
C* TYPE.  CHECK FOR EXCESSIVE ORDER.  THE LAST TWO STATEMENTS OF       * 2010
C* THIS SECTION  SET IWEVAL .GT.0 IF PW IS TO BE RE-EVALUATED          * 2020
C* BECAUSE OF THE ORDER CHANGE, AND THEN REPEAT THE INTEGRATION        * 2030
C* STEP IF IT HAS NOT YET BEEN DONE (IRET = 1) OR SKIP TO A FINAL      * 2040
C* SCALING BEFORE EXIT IF IT HAS BEEN COMPLETED (IRET = 2).            * 2050
C*********************************************************************** 2060
   80 IF (MF.EQ.0) GO TO 90                                             2070
      IF (NQ.GT.6) GO TO 100                                            2080
      GO TO (230,240,250,260,270,280), NQ                               2090
   90 IF (NQ.GT.12) GO TO 100                                           2100
      GO TO (110,120,130,140,150,160,170,180,190,200,210,220), NQ       2110
  100 KFLAG=-2                                                          2120
      RETURN                                                            2130
C*********************************************************************** 2140
C* THE FOLLOWING COEFFICIENTS SHOULD BE DEFINED TO THE MAXIMUM         * 2150
C* ACCURACY PERMITTED BY THE MACHINE.  THEY ARE, IN THE ORDER USED..   * 2160
C*                                                                     * 2170
C* -1                                                                  * 2180
C* -1/2,-1/2                                                           * 2190
C* -5/12,-3/4,-1/6                                                     * 2200
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C* -3/8,-11/12,-1/3,-1/24                                                    *     2210
C* -251/720,-25/24,-35/72,-5/48,-1/120                                       *     2220
C* -95/288,-137/120,-5/8,-17/96,-1/40,-1/720                                 *     2230
C* -19087/60480,-49/40,-203/270,-49/192,-7/144,-7/1440,-1/5040               *     2240
C* -5257/17280,-363/280,-469/540,-967/2880,-7/90,-23/2160,-1/1260,                  2250
C*      -1/40320                                                                  2260
C* -1070017/3628800,-761/560,-29531/30240,-267/640,-1069/9600,-3/160,              2270
C*      -13/6720,-1/8960,-1/362880                                                2280
C* -4165506/14515200,-7129/5040,-6515/6048,-4523/9072,-19/128,                     2290
C*       -3013/1036800,-5/1344,-29/96768,-1/72576,-1/3628800                      2300
C* -134211265/479001600,-7381/5040,-177133/151200,-84095/145152,                   2310
C*      -341693/1814400,-8591/207360,-7513/1209600,-121/193536,                   2320
C*           -11/272160,-11/7257600,-1/39916800                                   2330
C* -262747265/958003200,-83711/55440,-190553/151200,-341747/518400,                2340
C*      -139381/604800,-2567907/47900160,-1903/201600,-10831/9676800,             2350
C*           -11/120960,-1/207369,-1/6652800,-1/479001600                         2360
C*                                                                       *     2370
C*                                                                       *     2380
C* -1                                                                    *     2390
C* -2/3,-1/3                                                             *     2400
C* -12/25,-7/10,-1/5,-1/50                                               *     2410
C* -120/274,-225/274,-85/274,-15/274,-1/274                              *     2420
C* -180/441,-58/63,-15/36,-25/252,-3/252,-1/1764                         *     2430
C*************************************************************************     2440
  110 A(1)=-1.0                                                                2450
      GO TO 290                                                                2460
  120 A(1)=-.50000000000                                                       2470
      A(3)=-0.500000000                                                        2480
      GO TO 290                                                                2490
  130 A(1)=-0.4166666666666667                                                 2500
      A(3)=-0.750000000                                                        2510
      A(4)=-0.1666666666666667                                                 2520
      GO TO 290                                                                2530
  140 A(1)=-0.3750000000000                                                    2540
      A(3)=-0.9166666666666667                                                 2550
      A(4)=-0.3333333333333333                                                 2560
      A(5)=-0.0416666666666667                                                 2570
      GO TO 290                                                                2580
  150 A(1)=-0.3486111111111111                                                 2590
      A(3)=-1.0416666666666667                                                 2600
      A(4)=-0.4861111111111111                                                 2610
      A(5)=-0.1041666666666667                                                 2620
      A(6)=-0.008333333333333333                                               2630
      GO TO 290                                                                2640
  160 A(1)=-0.3298611111111111                                                 2650
      A(3)=-1.1416666666666667                                                 2660
      A(4)=-0.625000000                                                        2670
      A(5)=-0.1770833333333333                                                 2680
      A(6)=-0.0250000000                                                       2690
      A(7)=-0.001388888888888889                                               2700
      GO TO 290                                                                2710
  170 A(1)=-0.3155919312169312                                                 2720
      A(3)=-1.225000000                                                        2730
      A(4)=-0.7518518518518519                                                 2740
      A(5)=-0.2552083333333333                                                 2750
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      A(6)=-0.04861111111111111                                          2760
      A(7)=-0.004861111111111111                                         2770
      A(8)=-0.0001984126984126984                                        2780
      GO TO 290                                                          2790
  180 A(1)=-0.3042245370370370                                           2800
      A(3)=-1.296428571428485                                            2810
      A(4)=-0.8685185185185185                                           2820
      A(5)=-0.3357638888888888                                           2830
      A(6)=-0.0777777777777777                                           2840
      A(7)=-0.0106481481481815                                           2850
      A(8)=-0.0007936507936507937                                        2860
      A(9)=-0.0000248015873015873                                        2870
      GO TO 290                                                          2880
  190 A(1)=-0.2948680004409171                                           2890
      A(3)=-1.358928571428857                                            2900
      A(4)=-0.976554232804233                                            2910
      A(5)=-0.4171875000                                                 2920
      A(6)=-0.1113541666666667                                           2930
      A(7)=-0.0187500000                                                 2940
      A(8)=-0.0019345238095238809                                        2950
      A(9)=-0.0001116071428571143                                        2960
      A(10)=-0.00000275573192239859                                      2970
      GO TO 290                                                          2980
  200 A(1)=-0.2869754464285714                                           2990
      A(3)=-1.41448412698413                                             3000
      A(4)=-1.07721560846561                                             3010
      A(5)=-0.498567019400353                                            3020
      A(6)=-0.148437500000                                               3030
      A(7)=-0.0290605709876543                                           3040
      A(8)=-0.0037202380952381                                           3050
      A(9)=-0.0002996858466560847                                        3060
      A(10)=-0.0000137786596119929                                       3070
      A(11)=-0.00000027557319223986                                      3080
      GO TO 290                                                          3090
  210 A(1)=-0.280189564439367                                            3100
      A(3)=-1.46448412698413                                             3110
      A(4)=-1.17151455026455                                             3120
      A(5)=-0.579358190035273                                            3130
      A(6)=-0.188322861552028                                            3140
      A(7)=-0.0414303626543210                                           3150
      A(8)=-0.0052111447989418                                           3160
      A(9)=-0.0006252066798941180                                        3170
      A(10)=-0.0000404174015285126                                       3180
      A(11)=-0.00000151565255731922                                      3190
      A(12)=-0.000000025052108385441?                                    3200
      GO TO 290                                                          3210
  220 A(1)=-0.274265540031599                                            3220
      A(3)=-1.50993867243867                                             3230
      A(4)=-1.26027116402116                                             3240
      A(5)=-0.659234182098765                                            3250
      A(6)=-0.230458002645503                                            3260
      A(7)=-0.0556972461052322                                           3270
      A(8)=-0.0094394841269841?                                          3280
      A(9)=-0.0011192749669312?                                          3290
      A(10)=-0.000090939153491534                                        3300
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      A(11)=-0.000004822530864197531                                    3310
      A(12)=-0.000000150312650312650                                    3320
      A(13)=-0.000000002007675698786811                                 3330
      GO TO 290                                                         3340
  230 A(1)=-1.000000000                                                 3350
      GO TO 290                                                         3360
  240 A(1)=-0.6666666666666667                                          3370
      A(3)=-0.3333333333333333                                          3380
      GO TO 290                                                         3390
  250 A(1)=-0.5454545454545455                                          3400
      A(3)=A(1)                                                         3410
      A(4)=-0.09090909090909091                                         3420
      GO TO 290                                                         3430
  260 A(1)=-0.480000000                                                 3440
      A(3)=-0.700000000                                                 3450
      A(4)=-0.200000000                                                 3460
      A(5)=-0.020000000                                                 3470
      GO TO 290                                                         3480
  270 A(1)=-0.437956204379562                                           3490
      A(3)=-0.8211678832116788                                          3500
      A(4)=-0.3102189781021898                                          3510
      A(5)=-0.0547445255474526                                          3520
      A(6)=-0.003649635036496350                                        3530
      GO TO 290                                                         3540
  280 A(1)=-0.4081632653061225                                          3550
      A(3)=-0.9206349206349206                                          3560
      A(4)=-0.4166666666666667                                          3570
      A(5)=-0.0992063492063492                                          3580
      A(6)=-0.0119047619047619                                          3590
      A(7)=-0.000566893424036282                                        3600
  290 K=NQ+1                                                            3610
      IDOUB=K                                                           3620
      MTYP=(4-MF)/2                                                     3630
      ENQ2=.5/FLOAT(NQ+1)                                               3640
      ENQ3=.5/FLOAT(NQ+2)                                               3650
      ENQ1=0.5/FLOAT(NQ)                                                3660
      PEPSH=EPS                                                         3670
      EUP=(PERTST(NQ,MTYP,2)*PEPSH)**2                                  3680
      E=(PERTST(NQ,MTYP,1)*PEPSH)**2                                    3690
      EDWN=(PERTST(NQ,MTYP,3)*PEPSH)**2                                 3700
      IF (EDWN.EQ.0) GO TO 780                                          3710
      BND=(EPS*ENQ3)**2                                                 3720
      IWEVAL=MF                                                         3730
      GO TO (300,670), IRET                                             3740
C*************************************************************************3750
C* THIS SECTION COMPUTES THE PREDICTED VALUES BY EFFECTIVELY           *  3760
C* MULTIPLYING THE SAVED INFORMATION BY THE PASCAL TRIANGLE            *  3770
C* MATRIX.                                                            *  3780
C*************************************************************************3790
  300 T=T+H                                                             3800
      DO 310 J=2,K                                                      3810
        DO 310 J1=J,K                                                   3820
        J2=K-J1+J-1                                                     3830
        DO 310 I=1,N                                                    3840
  310   Y(J2,I)=Y(J2,I)+Y(J2+1,I)                                       3850
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C*********************************************************************      3860
C*   UP TO 2 CORRECTOR ITERATIONS ARE TAKEN.  CONVERGENCE IS TESTED BY *      3870
C*   REQUIRING THE L2 NORM OF CHANGES TO BE LESS THAN BND WHICH IS     *      3880
C*   DEPENDENT ON THE ERROR TEST CONSTANT.                             *      3890
C*      THE SUM OF THE CORRECTIONS IS ACCUMULATED IN THE ARRAY         *      3900
C*   ERROR(I).  IT IS EQUAL TO THE K-TH DERIVATIVE OF Y MULTIPLIED     *      3910
C*   BY  H**K/(FACTORIAL(K-1)*A(K)), AND IS THEREFORE PROPORTIONAL     *      3920
C*   TO THE ACTUAL ERRORS TO THE LOWEST POWER OF H PRESENT. (H**K)     *      3930
C*********************************************************************      3940
      DO 320 I=1,N                                                           3950
  320   ERROR(I)=0.0                                                         3960
      DO 430 L=1,2                                                           3970
        CALL DIFFUN (N,T,Y,CSAVE(1,3))                                       3980
C*********************************************************************      3990
C*   IF THERE HAS BEEN A CHANGE OF ORDER OR THERE HAS BEEN TROUBLE     *      4000
C*   WITH CONVERGENCE, PW IS RE-EVALUATED PRIOR TO STARTING THE        *      4010
C*   CORRECTOR ITERATION IN THE CASE OF STIFF METHODS.  IWEVAL IS      *      4020
C*   THEN SET TO -1 AS AN INDICATOR THAT IT HAS BEEN DONE.             *      4030
C*********************************************************************      4040
        IF (IWEVAL.LT.1) GO TO 390                                           4050
        IF (MF.EQ.2) GO TO 360                                               4060
        CALL PDERV (T,Y,PW,N3)                                               4070
        R=A(1)*H                                                             4080
        DO 330 I=1,N4                                                        4090
  330     PW(I)=PW(I)*R                                                      4100
C*********************************************************************      4110
C* ADD THE IDENTITY MATRIX TO THE JACOBIAN AND DECOMPOSE INTO LU = PW *      4120
C*********************************************************************      4130
  340   DO 350 I=1,N                                                         4140
  350     PW(I*(N3+1)-N3)=1.0+PW(I*(N3+1)-N3)                                4150
        IWEVAL=-1                                                            4160
        CALL NDI01Z (N,N3,PW,IP)                                             4170
        IF (IP(N).NE.0) GO TO 390                                            4180
        GO TO 440                                                            4190
C*********************************************************************      4200
C* EVALUATE THE JACOBIAN INTO PW BY NUMERICAL DIFFERENCING.  R IS THE *      4210
C* CHANGE MADE TO THE ELEMENT OF Y.  IT IS EPS RELATIVE TO Y WITH     *      4220
C* A MINIMUM OF EPS**2.  F STORES THE UNCHANGED VALUE OF Y.           *      4230
C*********************************************************************      4240
  360   DO 380 J=1,N                                                         4250
          F=Y(1,J)                                                           4260
          R=EPS*AMAX1(EPS,ABS(F))                                            4270
          Y(1,J)=Y(1,J)+R                                                    4280
          D=A(1)*H/R                                                         4290
          CALL DIFFUN (N,T,Y,CSAVE(1,1))                                     4300
          DO 370 I=1,N                                                       4310
  370       PW(I+(J-1)*N3)=(CSAVE(I,1)-CSAVE(I,3))*D                         4320
  380     Y(1,J)=F                                                           4330
        GO TO 340                                                            4340
  390   DO 400 I=1,N                                                         4350
  400     CSAVE(I,1)=Y(2,I)-CSAVE(I,3)*H                                     4360
        IF (MF.EQ.0) GO TO 410                                               4370
        CALL NDI02Z (N,N3,PW,CSAVE(1,1),IP)                                  4380
C*********************************************************************      4390
C* CORRECT AND COMPARE DEL, THE L2 NORM OF CHANGE/YMAX, WITH BND.     *      4400
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C* ESTIMATE THE VALUE OF THE L2 NORM OF THE NEXT CORRECTION BY          *    4410
C* BR**2*DEL AND COMPARE WITH BND.  IF EITHER IS LESS, THE CORRECTOR     *    4420
C* IS SAID TO HAVE CONVERGED.                                           *    4430
C***********************************************************************    4440
  410   DEL=0.0                                                              4450
        DO 420 I=1,N                                                         4460
          Y(1,I)=Y(1,I)+A(1)*CSAVE(I,1)                                      4470
          Y(2,I)=Y(2,I)-CSAVE(I,1)                                           4480
          ERROR(I)=ERROR(I)+CSAVE(I,1)                                       4490
          DEL=DEL+(CSAVE(I,1)/YMAX(I))**2                                    4500
  420     CONTINUE                                                           4510
        IF (L.GE.2) BR=AMAX1(.9*BR,DEL/DEL1)                                 4520
        DEL1=DEL                                                             4530
        IF (AMIN1(DEL,BR*DEL*2.0).LE.BND) GO TO 480                          4540
  430   CONTINUE                                                             4550
C***********************************************************************    4560
C* THE CORRECTOR ITERATION FAILED TO CONVERGE IN 2 TRIES.  VARIOUS      *    4570
C* POSSIBILITIES ARE CHECKED FOR.  IF H IS ALREADY HMIN AND             *    4580
C* THIS IS EITHER ADAMS METHOD OR THE STIFF METHOD IN WHICH THE         *    4590
C* MATRIX PW HAS ALREADY BEEN RE-EVALUATED, A NO CONVERGENCE EXIT       *    4600
C* IS TAKEN.  OTHERWISE THE MATRIX PW IS RE-EVALUATED AND/OR THE        *    4610
C* STEP IS REDUCED TO TRY AND GET CONVERGENCE.                          *    4620
C***********************************************************************    4630
  440 T=TOLD                                                                 4640
      IF (ABS(H).LE.HMIN*1.00001.AND.(IWEVAL-MTYP).LT.-1) GO TO 450          4650
      IF ((MF.EQ.0).OR.(IWEVAL.NE.0)) H=H*0.25                               4660
      IWEVAL=MF                                                              4670
      IRET=2                                                                 4680
      GO TO 750                                                              4690
  450 KFLAG=-3                                                               4700
      NQ=NQOLD                                                               4710
  460 DO 470 I=1,N                                                           4720
        DO 470 J=1,K                                                         4730
  470   Y(J,I)=SAVE(J,I)                                                     4740
      H=HOLD                                                                 4750
      JSTART=NQ                                                              4760
      RETURN                                                                 4770
C***********************************************************************    4780
C* THE CORRECTOR CONVERGED AND CONTROL IS PASSED TO STATEMENT 520       *    4790
C* IF THE ERROR TEST IS O.K.,  AND TO 540 OTHERWISE.                    *    4800
C* IF THE STEP IS O.K. IT IS ACCEPTED. IF IDOUB HAS BEEN REDUCED        *    4810
C* TO ONE,  A TEST IS MADE TO SEE IF THE STEP CAN BE INCREASED          *    4820
C* AT THE CURRENT ORDER OR BY GOING TO ONE HIGHER OR ONE LOWER.         *    4830
C* SUCH A CHANGE IS ONLY MADE IF THE STEP CAN BE INCREASED BY AT        *    4840
C* LEAST 1.1.  IF NO CHANGE IS POSSIBLE IDOUB IS SET TO 8 TO            *    4850
C* PREVENT FUTHER TESTING FOR 8 STEPS.                                  *    4860
C* IF A CHANGE IS POSSIBLE, IT IS MADE AND IDOUB IS SET TO              *    4870
C* NQ + 1     TO PREVENT FURTHER TESING FOR THAT NUMBER OF STEPS.       *    4880
C* IF THE ERROR WAS TOO LARGE, THE OPTIMUM STEP SIZE FOR THIS OR        *    4890
C* LOWER ORDER IS COMPUTED, AND THE STEP RETRIED.  IF IT SHOULD         *    4900
C* FAIL TWICE MORE IT IS AN INDICATION THAT THE DERIVATIVES THAT        *    4910
C* HAVE ACCUMULATED IN THE Y ARRAY HAVE ERRORS OF THE WRONG ORDER       *    4920
C* SO THE FIRST DERIVATIVES ARE RECOMPUTED AND THE ORDER IS SET         *    4930
C* TO 1.                                                                *    4940
C***********************************************************************    4950
```

```
  480 D=0.0                                                              4960
      DO 490 I=1,N                                                       4970
  490   D=D+(ERROR(I)/YMAX(I))**2                                        4980
      IWEVAL=0                                                           4990
      IF (D.GT.E) GO TO 530                                              5000
      IF (K.LT.3) GO TO 510                                              5010
C*********************************************************************  5020
C* COMPLETE THE CORRECTION OF THE HIGHER ORDER DERIVATIVES AFTER A     *  5030
C* SUCCESSFUL STEP.                                                    *  5040
C*********************************************************************  5050
      DO 500 J=3,K                                                       5060
        DO 500 I=1,N                                                     5070
  500   Y(J,I)=Y(J,I)+A(J)*ERROR(I)                                      5080
  510 KFLAG=+1                                                           5090
      HNEW=H                                                             5100
      IF (IDOUB.LE.1) GO TO 540                                          5110
      IDOUB=IDOUB-1                                                      5120
      IF (IDOUB.GT.1) GO TO 690                                          5130
      DO 520 I=1,N                                                       5140
  520   CSAVE(I,2)=ERROR(I)                                              5150
      GO TO 690                                                          5160
C*********************************************************************  5170
C* REDUCE THE FAILURE FLAG COUNT TO CHECK FOR MULTIPLE FAILURES.       *  5180
C* RESTORE T TO ITS ORIGINAL VALUE AND TRY AGAIN UNLESS THERE HAVE     *  5190
C* THREE FAILURES.  IN THAT CASE THE DERIVATIVES ARE ASSUMED TO HAVE   *  5200
C* ACCUMULATED ERRORS SO A RESTART FROM THE CURRENT VALUES OF Y IS     *  5210
C* TRIED. THIS IS CONTINUED UNTIL SUCCESS OR H = HMIN.                 *  5220
C*********************************************************************  5230
  530 KFLAG=KFLAG-2                                                      5240
      IF (ABS(H).LE.(HMIN*1.00001)) GO TO 740                            5250
      T=TOLD                                                             5260
      IF (KFLAG.LE.-5) GO TO 710                                         5270
C*********************************************************************  5280
C* PR1, PR2, AND PR3  WILL CONTAIN THE AMOUNTS BY WHICH THE STEP SIZE  *  5290
C* CHOULD BE DIVIDED AT ORDER ONE LOWER, AT THIS ORDER, AND AT ORDER   *  5300
C* ONE HIGHER RESPECTIVELY.                                            *  5310
C*********************************************************************  5320
  540 PR2=(D/E)**ENQ2*1.2                                                5330
      PR3=1.E+20                                                         5340
      IF ((NQ.GE.MAXDER).OR.(KFLAG.LE.-1)) GO TO 560                     5350
      D=0.0                                                              5360
      DO 550 I=1,N                                                       5370
  550   D=D+((ERROR(I)-CSAVE(I,2))/YMAX(I))**2                           5380
      PR3=(D/EUP)**ENQ3*1.4                                              5390
  560 PR1=1.E+20                                                         5400
      IF (NQ.LE.1) GO TO 580                                             5410
      D=0.0                                                              5420
      DO 570 I=1,N                                                       5430
  570   D=D+(Y(K,I)/YMAX(I))**2                                          5440
      PR1=(D/EDWN)**ENQ1*1.3                                             5450
  580 CONTINUE                                                           5460
      IF (PR2.LE.PR3) GO TO 640                                          5470
      IF (PR3.LT.PR1) GO TO 650                                          5480
  590 R=1.0/AMAX1(PR1,1.E-4)                                             5490
      NEWQ=NQ-1                                                          5500
```

```
  600 IDOUB=8                                                          5510
      IF ((KFLAG.EQ.1).AND.(R.LT.(1.1))) GO TO 690                     5520
      IF (NEWQ.LE.NQ) GO TO 620                                        5530
C*****************************************************************   5540
C* COMPUTE ONE ADDITIONAL SCALED DERIVATIVE IF ORDER IS INCREASED.  *   5550
C*****************************************************************   5560
      DO 610 I=1,N                                                     5570
  610   Y(NEWQ+1,I)=ERROR(I)*A(K)/FLOAT(K)                             5580
  620 K=NEWQ+1                                                         5590
      IF (KFLAG.EQ.1) GO TO 660                                        5600
      H=H*R                                                            5610
      IRET=3                                                           5620
      GO TO 750                                                        5630
  630 IF (NEWQ.EQ.NQ) GO TO 300                                        5640
      NQ=NEWQ                                                          5650
      GO TO 80                                                         5660
  640 IF (PR2.GT.PR1) GO TO 590                                        5670
      NEWQ=NQ                                                          5680
      R=1.0/AMAX1(PR2,1.E-4)                                           5690
      GO TO 500                                                        5700
  650 R=1.0/AMAX1(PR3,1.E-4)                                           5710
      NEWQ=NQ+1                                                        5720
      GO TO 600                                                        5730
  660 IRET=2                                                           5740
      R=AMIN1(R,HMAX/ABS(H))                                           5750
      H=H*R                                                            5760
      HNEW=H                                                           5770
      IF (NQ.EQ.NEWQ) GO TO 670                                        5780
      NQ=NEWQ                                                          5790
      GO TO 80                                                         5800
  670 R1=1.0                                                           5810
      DO 680 J=2,K                                                     5820
        R1=R1*R                                                        5830
        DO 680 I=1,N                                                   5840
  680   Y(J,I)=Y(J,I)*R1                                               5850
      IDOUB=K                                                          5860
  690 DO 700 I=1,N                                                     5870
  700   YMAX(I)=AMAX1(YMAX(I),ABS(Y(1,I)))                             5880
      JSTART=NQ                                                        5890
      RETURN                                                           5900
  710 IF (NQ.GT.1) GO TO 720                                           5910
      IF (ABS(H).LE.2.*HMIN) GO TO 780                                 5920
      GO TO 540                                                        5930
  720 R=H/HOLD                                                         5940
      DO 730 I=1,N                                                     5950
        Y(1,I)=SAVE(1,I)                                               5960
  730   Y(2,I)=SAVE(2,I)*R                                             5970
      NQ=1                                                             5980
      KFLAG=1                                                          5990
      GO TO 80                                                         6000
  740 KFLAG=-1                                                         6010
      HNEW=H                                                           6020
      JSTART=NQ                                                        6030
      RETURN                                                           6040
C*****************************************************************   6050
```

```
C* THIS SECTION SCALES ALL VARIABLES CONNECTED WITH H AND RETURNS      *
C* TO THE ENTERING SECTION.                                            *
C**********************************************************************
  750 H=SIGN(AMAX1(HMIN,AMIN1(ABS(H),HMAX)),H)
      R1=1.0
      DO 760 J=2,K
        R=H/HOLD
        R1=R1*R
        DO 760 I=1,N
  760   Y(J,I)=SAVF(J,I)*R1
      DO 770 I=1,N
  770   Y(1,I)=SAVF(1,I)
      IDOUB=K
      GO TO (40,300,630), IRET1
  780 KFLAG=-4
      GO TO 460
      END
      SUBROUTINE NDI01Z (N,NDIM,A,IP)
C--MOLER'S "DECOMP".
C
C    MATRIX TRIANGULARIZATION BY GAUSSIAN ELIMINATION.
C
C   INPUT...
C     N = ORDER OF MATRIX
C     NDIM = DECLARED DIMENSION OF ARRAY A.
C     A = MATRIX TO BE TRIANGULARIZED. (FOR STIFF METHODS, A IS SINGLE
C                 PRECISION;  ALL OTHER VARIABLES ARE DOUBLE PRECISION.)
C   OUTPUT...
C     A(I,J), I.LE.J  = UPPER TRIANGULAR FACTOR, U.
C     A(I,J),   I.GT.J   = MULTIPLIERS  = LOWER TRIANGULAR FACTOR, I-L.
C     IP(K),  K.LT.N = INDEX OF K-TH PIVOT ROW.
C     IP(N)  = (-1)**(NUMBER OF INTERCHANGES) OR 0.
C   USE 'SOLVE' (NDI02Z)  TO OBTAIN SOLUTION OF LINEAR SYSTEM.
C   DETERM(A) = IP(N)*A(1,1)*A(2,2)*...*A(N,N).
C   IF IP(N) = 0, A IS SINGULAR, SOLVE WILL DIVIDE BY ZERO.
C
      DIMENSION A(NDIM,NDIM), IP(NDIM)
      IP(N)=1
      DO 50 K=1,N
        IF (K.EQ.N) GO TO 50
        KP1=K+1
        M=K
        DO 10 I=KP1,N
          IF (ABS(A(I,K)).GT.ABS(A(M,K))) M=I
   10     CONTINUE
        IP(K)=M
        IF (M.NE.K) IP(N)=-IP(N)
        T=A(M,K)
        A(M,K)=A(K,K)
        A(K,K)=T
        IF (T.EQ.0) GO TO 50
        DO 20 I=KP1,N
   20     A(I,K)=-A(I,K)/T
        DO 40 J=KP1,N
          T=A(M,J)
```

```
          A(M,J)=A(K,J)                                                  6610
          A(K,J)=T                                                       6620
          IF (T.EQ.0.) GO TO 40                                          6630
          DO 30 I=KP1,N                                                  6640
   30       A(I,J)=A(I,J)+A(I,K)*T                                       6650
   40     CONTINUE                                                       6660
   50   IF (A(K,K).EQ.0.) IP(N)=0                                        6670
   60   CONTINUE                                                         6680
        RETURN                                                           6690
        END                                                              6700
        SUBROUTINE NDI02Z (N,NDIM,A,B,IP)                                6710
C--MOLER'S "SOLVE".                                                      6720
C                                                                        6730
C    SOLUTION OF LINEAR SYSTEM, A*X = B.                                 6740
C                                                                        6750
C    INPUT...                                                            6760
C      N = ORDER OF MATRIX.                                              6770
C      NDIM = DECLARED DIMENSION OF ARRAY A.                             6780
C      A = TRIANGULARIZED MATRIX OBTAINED FROM 'DECOMP' (NDI01Z).        6790
C      B = RIGHT HAND SIDE VECTOR.                                       6800
C      IP = PIVOT VECTOR OBTAINED FROM 'DECOMP'.                         6810
C    OUTPUT...                                                           6820
C      B = SOLUTION VECTOR, X.                                           6830
        DIMENSION A(NDIM,NDIM), B(NDIM), IP(NDIM)                        6840
        IF (N.EQ.1) GO TO 30                                             6850
        NM1=N-1                                                          6860
        DO 20 K=1,NM1                                                    6870
          KP1=K+1                                                        6880
          M=IP(K)                                                        6890
          T=B(M)                                                         6900
          B(M)=B(K)                                                      6910
          B(K)=T                                                         6920
          DO 10 I=KP1,N                                                  6930
   10     B(I)=B(I)+A(I,K)*T                                             6940
        DO 20 KB=1,NM1                                                   6950
          KM1=N-KB                                                       6960
          K=KM1+1                                                        6970
          B(K)=B(K)/A(K,K)                                               6980
          T=-B(K)                                                        6990
          DO 20 I=1,KM1                                                  7000
   20     B(I)=B(I)+A(I,K)*T                                             7010
   30 B(1)=B(1)/A(1,1)                                                   7020
        RETURN                                                           7030
        END                                                              7040
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16 Abstract

A computer program has been developed to predict the trajectory, ground deposition, and drift of liquid sprays injected into the wake of an aircraft in ground effect The program uses a horseshoe vortex wake model and includes the effects of liquid droplet evaporation, crosswind, the propeller slipstream, ground effect, and tunnel walls on small scale models. This paper is intended as a user's guide and includes several sample cases demonstrating the various user options. A complete listing of the FORTRAN computer program is provided.

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