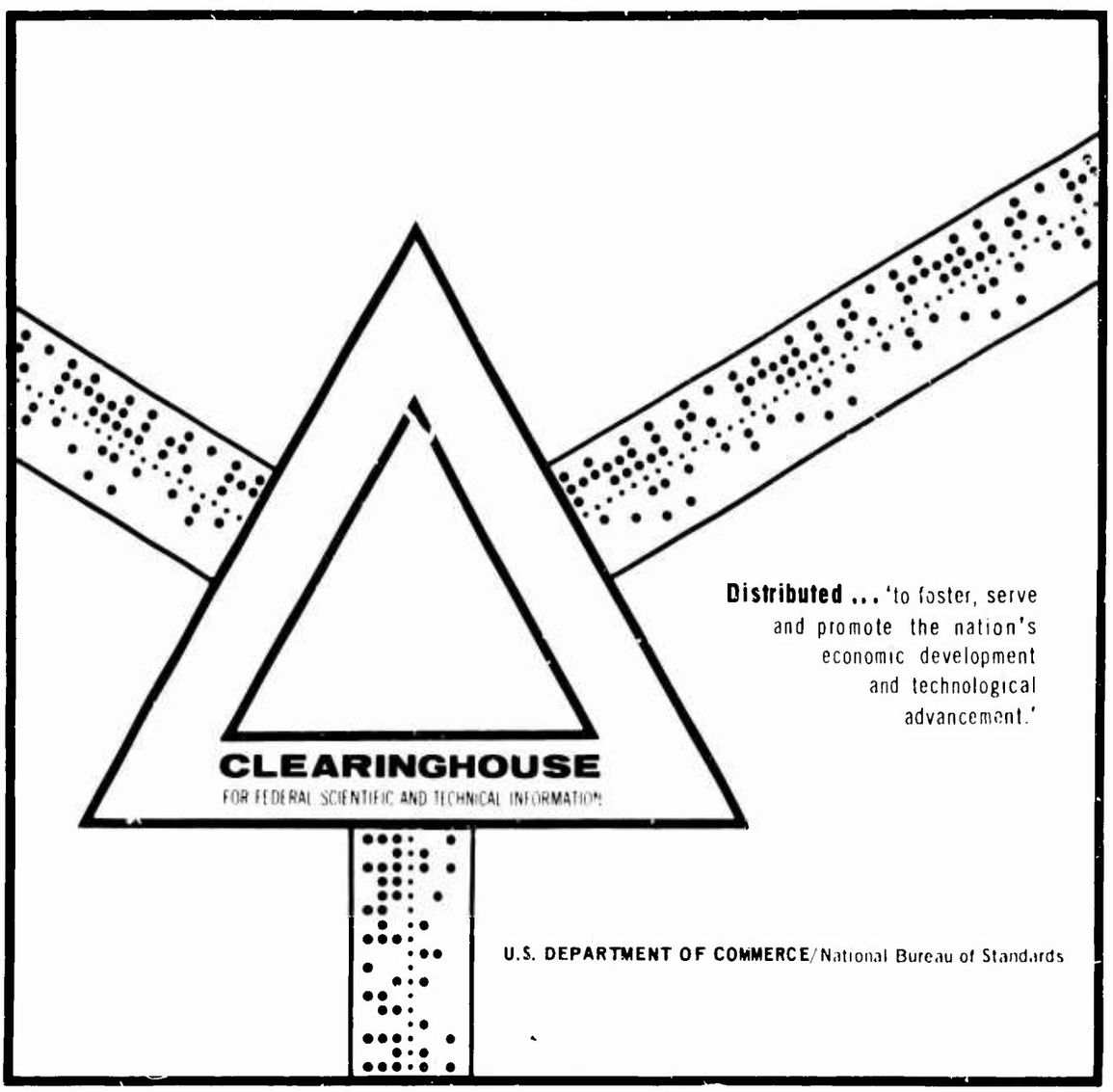
AIRCRAFT PARACHUTE FLARE SIMULATION

Joseph J. Angotti

Naval Ammunition Depot
Crane, Indiana

1 October 1969



RDTR No. 157
1 October 1969

AIRCRAFT PARACHUTE FLARE SIMULATION

NAVAL AMMUNITION DEPOT
CRANE, INDIANA

NAVAL AMMUNITION DEPOT
Crane, Indiana 47522

RDTR No. 157
1 October 1969

AIRCRAFT PARACHUTE FLARE SIMULATION

Prepared by Joseph J. Angotti
Joseph J. Angotti, Mathematical Statistician

Reviewed by Ralph D. Chipman
Ralph D. Chipman, Mathematical Statistician

Released by Jerry L. Kemp
Jerry L. Kemp, Supervisory Operations Research Analyst

RESEARCH AND DEVELOPMENT DEPARTMENT

TABLE OF CONTENTS

ABSTRACT

This report presents a computer program written in Fortran IV for the IBM 360 that is a simulation of the illumination on the ground during the descent of an aircraft parachute flare from ignition to burn out. The effect of air density on the velocity is taken into account by a numerical technique. The illumination on horizontal and vertical surfaces on the ground are considered. For the surface of interest the area consisting of those points having at least a certain value of illumination is computed. The program searches for the ignition altitude for which this area is maximized over the burn time, finds the ignition altitude for which the flare burns out at a chosen altitude, or simulates the descent with ignition at a chosen altitude. Atmospheric transmission is not considered in this report.

This study was supported by Naval Air Systems Command, AIRTASK NO. A35-532/323/69F17-546-502, Work Unit No. 2.

I. INTRODUCTION

This report presents a computer program written in Fortran IV for the IBM 360 that is a simulation of the descent of an aircraft parachute flare from ignition to burn out. The assumptions made in the simulation are:

1. The flare is considered to be a point source of light.
2. The candlepower of the flare is constant throughout the burning time.
3. The burning rate of the flare is constant throughout the burning time.
4. The flares descend vertically in a straight line.
5. The acceleration of gravity is constant and equals 32.174 ft/sec^2.
6. Air density variation with altitude above sea level is given by

$$\rho(H) = .07513 \exp(-.000031582\ H)$$

where $\rho(H)$ is the air density in lbs/ft^3 and H is the altitude in feet.

7. The drag force on the flare due to air resistance is proportional to the square of the velocity, i.e., $F = KV^2$.
8. The drag constant is not affected by the loss of mass.
9. The ground is a flat surface.

Two types of surfaces are considered. The first is a horizontal surface on the ground. The illumination on this surface is

$$E_H = \frac{I}{D^2} \cos \theta$$

where I is the candlepower, D is the distance from the flare to a point on the ground, and θ is the angle between the line D and the normal to the ground.

The second surface is a vertical surface at ground level. The illumination on this surface is

$$E_V = \frac{I}{D^2} \sin \theta .$$

The program searches for the ignition altitude which results in a burn out at a chosen altitude or which produces the maximum area illuminated to at least a chosen value over the burn time. A run also can be obtained for any chosen ignition altitude.

A listing of the program and a sample printout is in the appendix.

II. DERIVATION OF EQUATIONS

A. Determination of Altitude During Descent

For the case of variable mass, variable air density, and drag proportional to the square of the velocity, the differential equations of motion have no exact solutions. Therefore, there are no simple, closed-form mathematical expressions which can be used to calculate altitude as a function of time for a descending flare system. A numerical technique used in this program is a special one-dimensional case of the method used and tested by Chipman[1] in a two-dimensional flight computer program.

The initial velocity at ignition is calculated as the equilhirium velocity (V) for the given altitude. Equilibrium velocity is the velocity where the weight (W) is equal to the drag force, i.e., $W = KV^2$. Solving for V we get $V = \sqrt{W/K}$, where $K = \frac{\rho(H)C_D A}{2g}$. The air density, $\rho(H)$ in lbs/ft^3, is a function of altitude (H) above sea level in feet and is given by $\rho(H) = .07513 \exp(-.000031582\ H)$. C_D is the drag coefficient, A is the drag area in square feet, and g is the acceleration of gravity (32.174 ft/sec^2). The quantity $C_D A/2g$ is used in the computer program as DK (the drag constant). The next section describes a method of computing DK.

By substituting the expression for K into $V = \sqrt{W/K}$ we get the equation for the initial velocity: $V = -\sqrt{\frac{W}{\rho(H)DK}}$, where H is the ignition altitude above sea level. Since the positive direction is defined to be up, the descent velocity is made a negative quantity. To find the altitude and descent velocity during descent a numerical technique is used which involves making approximate computations over small intervals of time. Following is a description of the iteration scheme used in the program.

Let V equal the velocity at the beginning of an interval of time Δt. Two forces, drag in the positive direction and weight in the negative direction, are acting to produce an acceleration. The total force (F) is $-W+KV^2$. By substituting in the equation $a = F/m$ we get $a_1 = \frac{-W+KV^2}{W/g}$ or $a_1 = -g + \frac{KgV^2}{W}$ for the acceleration at the beginning of the interval.

Letting $Z = Kg/W$, we have $a_1 = -g + ZV^2$. Assuming this acceleration remains constant during the interval a first approximation to the velocity at the end of the interval, found by using the equation $V_f = V_i + at$, is $V_1 = V + a_1\Delta t$. Using this velocity the approximate acceleration at the end of the interval is $a_2 = -g + ZV_1^2$. A second approximation to the velocity at the end of the interval can be found by using

the average of the acceleration at the beginning of the interval and the approximate acceleration at the end of the interval. This gives

$$V_2 = V + \left(\frac{a_1 + a_2}{2}\right) \Delta t$$

The average of the velocity at the beginning of the interval and the second approximation for the velocity at the end of the interval is used for the average velocity over the interval. Using the equation $S = S_0 + \bar{v}t$, the altitude at the end of the iteration is $H = H_0 + \left(\frac{V+V_2}{2}\right) \Delta t$ where H_0 is the altitude at the beginning of the interval.

Within each interval, the air density, $\rho(H)$, is calculated based on the altitude at the beginning of the interval and the weight is corrected by subtracting the burning rate times Δt. The values at the end of an iteration replace the initial values and the process is repeated.

In the program Δt is set at 0.1 second. Since for a parachute system the descent rate is quite low, this time interval is short enough for good approximations. After every 100 iterations a printout of time, altitude, and descent velocity is given. This gives data for every 10 seconds until the end of the burning time. Time is equal to zero at ignition.

B. Computation of Drag Constant

To compute the drag constant DK, solve the equation for the initial velocity

$$V = \sqrt{\frac{W}{\rho(H)DK}}$$

for DK. We get

$$DK = \frac{W}{\rho(H)V^2}$$

This equation holds when the system is at its equilibrium velocity for a given altitude and weight, which is approximately true for a parachute system. Therefore, this equation can be used by assuming that the system will be at its average descent velocity and at its average altitude when half the composition is burned.

Example:

Weight of Flare and Suspension	21 pounds
Weight of Composition	17 pounds
Average Descent Rate	7.5 ft./sec.
Average Altitude (above sea level)	2,000 feet

The weight when one-half of the composition is burned is 12.5 pounds. The air density at 2000 feet equals .07053.

$$DK = \frac{W}{\rho(2000)V^2} = \frac{12.5 \text{ lbs.}}{.07053 \frac{\text{lb.}}{\text{ft}^3} \times (7.5 \text{ ft/sec})^2} = 3.1507 \text{ ft-sec}^2,$$

C. Area of Illumination for a Vertical Surface

For a fixed altitude H (in feet) and flare intensity I (in candles) the illumination E (in lumens/ft^2)

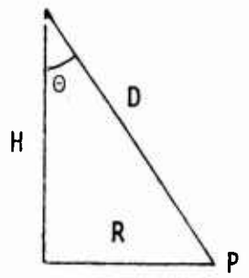


FIGURE 1

on a vertical surface at point P on the ground is given by

$$E_V = \frac{I}{D^2} \sin\Theta = \frac{I}{D^2} \cdot \frac{R}{D}$$

$$= \frac{IR}{(H^2+R^2)^{3/2}} \qquad (1)$$

This equation can be put in the form

$$R^6 + 3H^2R^4 + \left(\frac{3E_V{}^2H^4 - I^2}{E_V{}^2}\right) R^2 + H^6 = 0 \qquad (2)$$

which can be considered as a cubic equation in R^2. Choosing a value of E_V (say E_M), the condition (see reference 2) for two positive real roots is

$$H < \sqrt{\frac{I}{\sqrt{27}\, E_M}} = H_c \, . \qquad (3)$$

If the flare is above this altitude there will be no area illuminated to at least E_M and the radii are both set equal to zero. For $H < H_c$ the square root of the two positive real roots (R_1 and R_2) define an area on the ground in which the illumination on a vertical surface is greater than or equal to E_M.

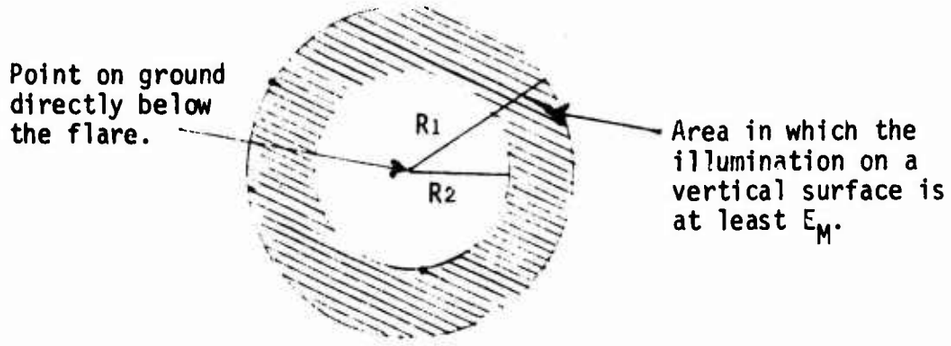


FIGURE 2

D. Area of Illumination for a Horizontal Surface

The illumination on a horizontal surface at point P is given by

$$E_H = \frac{I}{D^2} \cos \Theta = \frac{I}{D^2} \cdot \frac{H}{D}$$

$$= \frac{IH}{(H^2+R^2)^{3/2}} \qquad (4)$$

where H is the altitude of the flare. Choosing a value of E_H (say E_M) and solving on R we get

$$R = \sqrt{\left(\frac{iH}{E_M}\right)^{2/3} - H^2} \qquad (5)$$

This is the radius of the area in which a horizontal surface has an illumination of at least E_M.

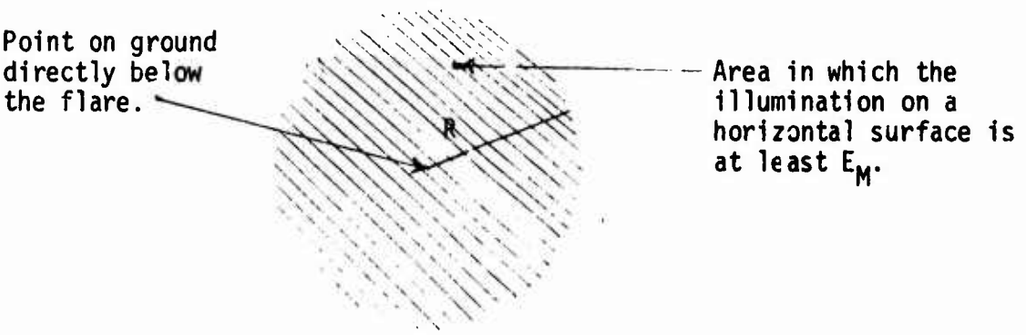
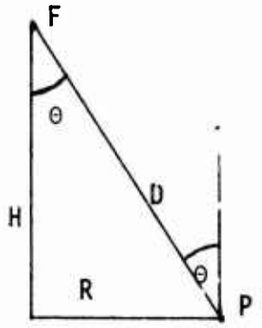


FIGURE 3

E. Optimum Ignition Altitude for a Horizontal Surface

The first step is to find the height for the particular flare intensity that will illuminate the maximum area to the required minimum illumination. This would be the ideal height to burn all of the flare. However, since the flare is descending during burning, this is impossible. Therefore, it seems reasonable that the ignition altitude should be above the optimum height

and the burn out altitude should be below the optimum heigl t by about the same amount to yield greatest efficiency. Since descent rate varies with alt: tude and remaining weight, the optimum ignition altitude cannot be computed exactly.



The illumination E_H at point P from a flare with intensity I at point F is $E_H = \frac{I}{D^2} \cos \Theta$. By substituting $\cos \Theta = H/D$, we have $E_H = IH/D^3$. Solving for D and squaring we get $D^2 = (HI/E_H)^{2/3}$. By substituting this into the equation $R = \sqrt{D^2-H^2}$ we get $R = \sqrt{\left(\frac{HI}{E_H}\right)^{2/3} - H^2}$. To maximize R for a given E_H (say E_M) and I we take the derivative of R with respect to H and equate to zero (see reference 3).

$$\frac{dR}{dH} = \frac{\frac{1}{3}\left(\frac{I}{E_M}\right)^{2/3} H^{-1/3} - H}{\sqrt{\left(\frac{HI}{E_M}\right)^{2/3} - H^2}} = 0$$

Solving for h we get the optimum height:

$$H_{opt} = \left[\frac{1}{3}\left(\frac{I}{E_M}\right)^{2/3}\right]^{3/4} = \frac{(I/E_M)^{1/2}}{3^{3/4}} = \frac{(I/E_M)^{1/2}}{2.279507} \qquad (7)$$

In the program the approximate ignition altitude is computed by adding to the optimum height the product of the estimated average descent rate and one-half the burning time. The range for the trial ignition altitudes is found by multiplying the approximate ignition altitude by 1.25 for the upper limit and multiplying by .75 for the lower limit. The difference of these two altitudes is divided by 20 to obtain the increment between trial ignition altitudes.

Calculations are made for ignition altitudes at the upper limit first. It is possible for the altitude to be high enough that there is no area illuminated to the minimum requirement. The integration of area versus time is done by a numerical technique (the trapezoidal rule). The height is found at regular time intervals during the descent by the method described in section A of part II. After every 100 iterations, the area which is illuminated to the minimum illumination is calculated. The value of area-time for each interval is computed by multiplying the time interval by the average of the area at the beginning of the interval and the

area at the end of the interval. The total integral of area versus time is found by summing over all the burning time. The number of iterations and the time of the iterations determine the time interval for integration.

The next trial ignition altitude is found by subtracting the distance that was calculated for the increment between trial ignition altitudes. The same procedure is repeated for this trial ignition altitude. When the integral of area over the burn time for the present drop becomes less than the integral for the previous drop the ignition altitude for the previous drop is the estimate the optimum ignition altitude for the given illumination level. The true optimum ignition altitude is then within the last increment of the estimate. A smaller interval can be found once the maximum value of the integral is past and a new set of twenty points computed.

In case the flare hits the ground while burning for any of the ignition altitudes, no lower ignition altitude is tried because the integral of area-time would only decrease.

III. INPUT TO PROGRAM

A. Data Format on Cards

Card	FORTRAN Name	Columns	Format
1	NPROG	1-2	I2
2	CD	1-10	E10.5
	TW	11-20	F10.0
	WC	21-30	F10.0
	DK	31-40	F10.0
	KOMPUT	41-45	I5
	VBAR	46-50	F5.0
	BT	51-55	F5.0
	TD	56-60	F5.0
	ITER	61-65	I5
	HV	66-70	F5.0
	ID1	71-74	A4
	ID2	75-78	A4
	ID3	79-80	A2
3	H1	1-10	F10.0
4	EMIN	1-10	F10.0
	HASL	11-20	F10.0
	KODE	21	I1

B. Explanation of Terms

The first data card contains the value of NPROG which is a code number used to designate the subroutine to be run.

NPROG	Subroutine
1	VSB1 (see section IV.B)
2	VSF1 (see section IV.B)
3	HSB1 (see section IV.B)
4	HSF1 (see section IV.B)
5	HSO (see section IV.B)

The second data card contains the flare parameters. The first parameter is the candlepower of the flare (CD). It is assumed to be a constant value from ignition to burnout. The next parameter is the total weight (TW) of the descending system. This includes the original amount of composition and the parachute system. The third parameter is the original amount of composition. Both weights are in pounds. The next parameter is the drag constant (DK). Section II.B shows how it is computed. The next variable (KOMPUT) provides two ways of reading in DK. If KOMPUT = 1 the value read in as DK is used for DK. If KOMPUT = 2 the value of DK is computed from the values of VBAR, the average velocity of the system (in feet/second), and HV, the altitude above sea level at which the system has an equilibrium velocity of VBAR ft/sec. The value of VBAR should be on the card when executing the subroutines VSB1, HSB1, and HSO since it is used to compute an estimate of the ignition altitude. The next parameter is the burn time (BT) of the flare measured in seconds. The variable TD is the time increment (in seconds) used in the calculation of the height of the flare. The variable ITER is the number of iterations used to calculate the height of the flare. The product of these two variables gives the time between printouts. The three variables ID1, ID2, ID3 are used to label the printout with 1 to 10 characters.

The third data card contains the variable H1. For the subroutines VSB1 and HSB1 this value is the burn out altitude. For the other subroutines, VSF1 and HSF1, it is the ignition altitude. This card is not required for the subroutine HS0. The altitude is measured in feet above the ground (not sea level).

The height of the ground above sea level (in feet) is the second variable on the fourth card. The first variable (EMIN) is the minimum illumination level required on the ground measured in lumens/sq.ft. The third variable (KODE) takes on integer values 0-9 and is used to obtain a run (with the same data) of one of the other subroutines, depending on which subroutine was just executed. When KODE takes on a positive value the following is indicated.

NPROG	Subroutine to be Run
1	HSB1
2	HSF1
3	VSB1
4	VSF1
5	VSF1 (at the optimum ignition altitude)

Thus, if the subroutine VSB1 is to be executed first and one wishes to obtain a run for the same data on HSB1, the value of KODE should be a positive integer between 1 and 9 and NPROG set to 1. No other subroutine will be executed if KODE = 0.

IV. DESCRIPTION OF COMPUTER PROGRAM

A. Main Program

The purpose of the main program is to read in the data and to call the indicated subroutines. The first card contains NPROG which is an integer used to indicate which subroutine is to be executed:

NPROG	Subroutine to be Executed
1	VSB1
2	VSF1
3	HSB1
4	HSF1
5	HSO

If a blank card is read the program stops.

The flare parameter card is read in next. If zero is read in as the value of ITER, the program will read in another value of NPROG. If ITER has a positive value the program then computes the drag constant and the burn rate of the flare.

The ignition altitude (if NPROG = 2 or 4) or the burn out altitude (if NPROG = 1 or 3) is then read in. This card is not needed for HSO (NPROG = 5). If zero is read in, the program will read in another flare parameter card. If a positive value is read in, the program will read in the illumination card containing the minimum illumination level, the height of the ground above sea level, and the value of

KODE. If zero is read in as the value of the illumination level the program will read in an ignition (or burn out) altitude card. If a positive value is read in, the program will call the indicated subroutine. After returning from the called subroutine the main program then executes the option indicated by the value of KODE. If KODE = 0 another illumination card is read. If KODE is a one digit, positive integer the following subroutine will be called depending on the value of NPROG.

NPROG	Subroutine to be Run
1	HSB1
2	HSF1
3	VSB1
4	VSF1
5	VSF1 (at the optimum ignition altitude)

Another illumination card is then read.

The program is set up so that a blank card can be used to control which data card is to be read in next. To stop the program after executing a set of data, four blank cards are needed. When setting up the data cards, it must be remembered what type of data card the program is looking for next. Section V shows the data set up for a sample run.

B. The Five Main Subroutines

The value of NPROG is used to indicate which of the five main subroutines is to be run by using the following code:

NPROG	Subroutine
1	VSB1
2	VSF1
3	HSB1
4	HSF1
5	HSO

The subroutines VSB1 and HSB1 search for the ignition altitude where the flare burns out at a specified altitude above the ground. VSB1 is for a vertical surface and HSB1 is for a hroizontal surface. One can be executed for a set of data just run on the other by use of the variable KODE (See section III). Both can determine the ignition altitude by the third trial by making a correction to the trial ignition altitude if the burnout altitude is missed by more than half a foot. Time is set to zero at ignition. If the flare hits the ground a correction is made to the ignition altitude and the procedure started over again.

The subroutines VSF1 and HSF1 give a printout for a specified ignition altitude and illumination level for a vertical and horizontal surface respectively. The variable KODE is used to obtain a run on one subroutine with the same set of data that was run on the other (see section III). The subroutines are ended if the flare hits the ground.

The subroutine HSO searches for the ignition altitude for which the integral of the illuminated area on a horizontal surface versus time from ignition to burn out is maximized. Section II.E describes the procedure used to obtain the estimate of the optimum ignition altitude. An increment within which the true optimum ignition altitude lies is also given. The variable KODE is used to obtain a run at the estimate of the optimum ignition altitude with the same data for a vertical surface.

The subroutine ROOTS determines the radii of the illuminated area for a vertical surface (see section II.C.). The subroutine HEADER is used to printout data. RHO computes the density of the air at a specified altitude above sea level. The subroutine RALPH is part of the iteration technique used to compute the altitude of the flare (see section II.A. and Chipman[1]).

V. SAMPLE RUNS FOR THE MK 45 AIRCRAFT PARACHUTE FLARE

A. Data Setup

Data for a sample run is shown in Table 1 on an 80-column card coding form. The data is set up according to the formats listed in section III.A. and is as follows:

Card 1:	NPROG	1	Subroutine VSB1 is to be run
Card 2:	CD =	1.65E+06	Candlepower of flare = 1.65×10^6
	TW =	22.5	Total weight of system (lbs)
	WC =	17.5	Weight of composition (lbs)
	DK =	3.14382	Drag Constant
	KOMPUT =	1	DK is to be the value of the drag constant. If KOMPUT = 2, the method of section II.B. would be used to compute DK.
	VBAR =	8.	Average descent velocity (ft/sec)
	BT =	180.	Burn time (sec)
	TD =	.1	Time increment (sec)
	ITER =	100	Number of iterations for the computation of the altitude of the flare
	HV	-	Altitude at which the system has VBAR as descent velocity. Not needed since KOMPUT = 1.
	ID1,ID2, ID3	MK 45-8	Run identification for printout
Card 3:	H1 =	300.	Burn out altitude (feet) since NPROG = 1
Card 4:	EMIN =	.02	Minimum illumination level (lumens/sq.ft)

	HASL =	0.	Ground is at sea level
	KODE =	1	Run on HSB1 with same data desired
Card 5:	EMIN =	.05	Another illumination level to be run on VSB1 for a burn out altitude of 300. The rest of the card is the same as card 4. Hence a run on HSB1 is desired.
Card 6:	EMIN =	.10	Another illumination level. The rest of the card is the same as cards 4 and 5.
Card 7:	Blank		This blank card indicates that there is no more illumination levels. The program will be waiting for a burn out altitude card.
Card 8:	Blank		No more burn out altitudes, program will be looking for a candle parameter card.
Card 9:	Blank		No more candle parameters, program will be looking for another value of NPROG.
Card 10:	NPROG =	5	The optimum ignition altitude subroutine (HSO) is to be run
Card 11:	Same as Card 2		
Card 12:	EMIN =	.02	Minimum illumination level
	HASL =	0.	Ground at sea level
	KODE =	1	A run on VSF1 with the same data is wanted. The ignition altitude will be the optimum ignition altitude.
Card 13:	Blank		No more illumination levels. Program will be expecting an ignition (or burn out) altitude. Next card should be blank.

Card 14	Blank	No more values of H1. The program will be looking for a candle parameter card.
Card 15	Blank	No more candle parameters. Program will be looking for another value of NPROG.
Card 16	Blank	No more subroutines to be run. Terminates program.

B. Description of Printout

A listing of the Fortran IV computer program written for the IBM 360 is given in Appendix A. A sample printout for the data setup in section V.A. is given in Appendix B.

On the printout CD is the flare intensity in candles. EMIN is the minimum illumination level in lumens/sq.ft. The total weight of the system (TW) is measured in pounds and includes the weight of the parachute. The weight of the composition (WC) is measured in pounds. It is used along with the burn time (BT) in seconds to determine the burn rate. The variable DK is used to determine the velocity of the flare and depends on the cross-sectional area of the parachute and its drag constant (see section II.A.). HASL is the height of the ground above sea level.

The time after ignition is given every ten seconds. The height of the flare and its velocity is given for each point in time. The radius (for horizontal surfaces) or the radii (for vertical surfaces) is given as well as the area which has the required minimum illumination. The integral of the area

illuminated versus time from ignition to each point in time is printed out. The average area illuminated since ingition is also computed and printed out for each point in time.

For burn out altitude of 300 feet, runs were obtained for minimum illumination levels of 0.02, 0.05, and 0.10 lumens/sq.ft. on both the vertical and horizontal surface subroutines (see section II). The optimum ignition altitude for a minimum illumination level of 0.02 lumens/sq.ft. was obtained as well as a printout for the vertical surface subroutine at the optimum ignition altitude.

9ND-NADC 5230/2 (6-65)

DATA PROCESSING 80-COLUMN CARD FORMAT

TABLE 1

DATA SET-UP FOR SAMPLE RUN

Card	Cols 1–10	Cols 11–20	Cols 21–30	Cols 31–40	Cols 41–50	Cols 51–60	Cols 61–70	Cols 71–80
1	1							
2	1.65E+06	22.5	17.5	3.14382	1 8.	180. .1	100	MK 45-8
3	300.							
4	.02		1					
5	.05		1					
6	.10		1					
B								
B								
B								
10	5							
11	1.65E+06	22.5	17.5	3.14382	1 8.	180. .1	100	MK 45-8
12	.02		1					
B								
B								
B								
B								

B indicates a blank card

References

1. Chipman, Ralph, "Two-Dimensional Flight Computer Program", RDTR No. 83, NAD Crane, Indiana, 21 September 1966.

2. Korn, Granino A. and Korn, Theresa M., "Mathematical Handbook for Scientists and Engineers", McGraw-Hill, New York, 1961.

3. Laswell, John E. "Study of the Optimum Suspension of a High Intensity Parachute Flare", RDTN No. 30, NAD Crane, Indiana, 1 May 1963.

APPENDIX A

COMPUTER PROGRAM LISTING

```
// JOB TE7P40    ILLUMINATING FLARE SIMULATION--JOSEPH J. ANGOTTI
// OPTION LINK
 PHASE TE7P40,S
// EXEC FORTRAN
```

```
C     ILLUMINATING FLARE SIMULATION PROGRAM
      COMMON T,TD,CD,EMIN,TW,WC,W,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
    1 FORMAT(E10.5,3F10.0,I5,3F5.0,I5,F5.0,2A4,A2)
  334 FORMAT(2F10.0,I1)
      G=32.174
      PI=3.141593
    6 READ(1,7)NPROG
    7 FORMAT(I2)
      IF(NPROG)8,8,9
    8 CALL EXIT
    9 READ(1,1)CD,TW,WC,DK,KOMPUT,VBAR,BT,TD,ITER,HV,ID1,ID2,ID3
      IF(ITER)6,6,10
   10 GO TO (20,22),KOMPUT
      GO TO 6
   22 DK=(TW-WC/2.)/RHO(HV)/VBAR/VBAR
   20 BR=WC/BT
      GO TO (11,11,11,11,12),NPROG
   11 READ(1,334)H1
      IF(H1)9,9,23
   23 GO TO (24,12,24,12,12),NPROG
   24 H2=H1
      H1=H1+VBAR*BT
   12 READ(1,334)EMIN,HASL,KODE
      IF(EMIN)11,11,13
   13 HC=SQRT(2.*CD/5.196152/EMIN)
      HOPT=SQRT(CD/EMIN)/2.27951
      GO TO (14,15,16,17,5),NPROG
      GO TO 8
   14 CALL VSB1
      GO TO 18
   15 CALL VSF1
      GO TO 18
   16 CALL HSB1
      GO TO 18
   17 CALL HSF1
      GO TO 18
    5 CALL HSO
   18 IF(KODE)12,12,19
   19 KODE=0
      GO TO (16,17,14,15,15),NPROG
      GO TO 8
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0080	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

CALLED SUBROUTINES

IJTAAFR	IJTACOM	IJTFXIT	EXIT	RHC	IJTSSQT	SQRT	VSB1	VSF1	HSB1
HSF1	HSO								

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00001	0078	00334	009A	00006	00BE	00007	00E0	00008	00F6
00009	0100	00010	018C	00022	018C	00020	01EE	00011	022A
00023	0258	00024	0288	00012	02A4	00013	02E0	00014	0356
00015	0366	00016	0376	00017	0386	00005	0396	00018	03A0
00019	03B0								

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 001192 ADDRESS BASE TABLE 03B8

// EXEC FORTRAN

```
      SUBROUTINE VSB1
      COMMON T,TD,CD,EMIN,[illegible],WC,W,DK,HV,[illegible],BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,TW,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
   43 ALT=H1
      SOBT=0.
      ABAR=0.
      AREA1=0.
      T=0.
      W=TW
      CALL HEADER(1)
      V=-SQRT(W/RHO(ALT+HASL)/DK)
      IF(HC-ALT)21,21,22
   21 ROOT(1)=0.
      ROOT(2)=0.
      CALL HEADER(6)
      GO TO 7
   22 CALL ROOTS
      IF(K)331,331,63
   63 CALL HEADER(6)
      AREA1=AREA2
    7 DO 8 IT=1,ITER
      CALL RALPH
      IF(ALT)88,88,85
   85 IF(T-BT+.0001)8,89,89
    8 V=V2
      IF(ALT)88,88,89
   88 ALT=0.
      ROOT(1)=SQRT(CD/EMIN)
      ROOT(2)=0.
      CALL HEADER(6)
      H1=H1*BT/T+H2+.5
      IH1=H1
      H1=IH1
      GO TO 43
   89 IF(HC-ALT)21,21,62
   62 CALL ROOTS
      IF(K)331,331,64
   64 CALL HEADER(6)
      AREA1=AREA2
      IF(T-BT+.0001)7,9,9
    9 DH=ALT-H2
      IF(ABS(DH)-.5)331,331,42
  331 RETURN
   42 H1=H1-DH+.5
      IH1=H1
      H1=IH1
      GO TO 43
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0080	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IT	00A4								

CALLED SUBROUTINES

IJTACOM HEADER IJTSSQT SQRT RHO ROOTS RALPH

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00043	006C	00021	00EE	00022	0112	00063	0120	00007	0142
00085	0164	00008	0180	00088	01AC	00089	0248	00062	025C
00064	0276	00009	02A4	00331	02C6	00042	02D8		

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 001024 ADDRESS BASE TABLE 0300

// EXEC FORTRAN

```
      SUBROUTINE VSF1
      COMMON T,TD,CD,EMIN,TW,WC,W,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
      ALT=H1
      SOBT=0.
      ABAR=0.
      AREA1=0.
      T=0.
      W=TW
      CALL HEADER(2)
      V=-SQRT(W/RHO(ALT+HASL)/DK)
      IF(HC-ALT)21,21,22
   21 ROOT(1)=0.
      ROOT(2)=0.
      CALL HEADER(6)
      GO TO 7
   22 CALL ROOTS
      IF(K)331,331,63
   63 CALL HEADER(6)
      AREA1=AREA2
    7 DO 8 IT=1,ITER
      CALL RALPH
      IF(ALT)88,88,85
   85 IF(T-BT+.0001)8,89,89
    8 V=V2
      IF(ALT)88,88,89
   88 ALT=0.
      ROOT(1)=SQRT(CD/EMIN)
      ROOT(2)=0.
      CALL HEADER(6)
      GO TO 331
   89 IF(HC-ALT)21,21,62
   62 CALL ROOTS
      IF(K)331,331,64
   64 CALL HEADER(6)
      AREA1=AREA2
      IF(T-BT+.0001)7,331,331
  331 RETURN
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0078	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
IT	0098								

CALLED SUBROUTINES

IJTACOM HEADER IJTSSQT SQRT RHO ROOTS RALPH

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00021	00EE	00022	0112	00063	012C	00007	0142	00085	0164
00008	0180	00088	01AC	00089	01EA	00062	01FE	00064	0218
00331	0246								

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 000768 ADDRESS BASE TABLE 0228

```
// EXEC FORTRAN
```

```
      SUBROUTINE HSB1
      COMMON T,TD,CD,EMIN,TW,WC,W,DK,MV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NAROG,KODE
      DOUBLE PRECISION T,TD
      EXPNT=2./3.
   43 ALT=H1
      SOBT=0.
      ABAR=0.
      AREA1=0.
      T=0.
      W=TW
      CALL HEADER(3)
      ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)16,16,17
   16 R=0.
      GO TO 18
   17 R=SQRT(ARG)
   18 V=-SQRT(W/RHO(ALT+HASL)/DK)
      CALL HEADER(7)
      AREA1=AREA2
    7 DO 8 IT=1,ITER
      CALL RALPH
      IF(ALT)88,88,85
   85 IF(T-BT+.0001)8,89,89
    8 V=V2
      IF(ALT)88,88,89
   88 ALT=0.
      R=0.
      CALL HEADER(7)
      H1=H1*BT/T+H2+.5
   87 IH1=H1
      H1=IH1
      GO TO 43
   89 ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)13,13,14
   13 R=0.
      GO TO 15
   14 R=SQRT(ARG)
   15 CALL HEADER(7)
      AREA1=AREA2
      IF(T-BT+.0001)7,9,9
    9 DH=ALT-H2
      IF(ABS(DH)-.5)331,331,42
   42 H1=H1-DH+.5
      GO TO 87
  331 RETURN
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	P1	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0080	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
EXPNT	00BC	ARG	00C0	IT	00C4				

CALLED SUBROUTINES

IJTACOM IJTARXR HEADER IJTSSOT SQRT RHO RALPH

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00043	0078	00016	00EC	00017	00FE	00018	0110	00007	013A
00085	017C	00008	0198	00086	01C4	00087	0202	00089	024A
00013	0284	00014	0296	00015	02A8	00009	02D6	00042	02F8
00331	0312								

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 001056 ADDRESS BASE TABLE 02F8

// EXEC FORTRAN

```
      SUBROUTINE HSF1
      COMMON T,TD,CD,EMIN,TW,WC,W,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
      EXPNT=2./3.
      ALT=H1
      SOBT=0.
      ABAR=0.
      AREA1=0.
      T=0.
      W=TW
      CALL HEADER(4)
      ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)16,16,17
   16 R=0.
      GO TO 18
   17 R=SQRT(ARG)
   18 V=-SQRT(W/RHO(ALT+HASL)/DK)
      CALL HEADER(7)
      AREA1=AREA2
    7 DO 8 IT=1,ITER
      CALL RALPH
      IF(ALT)88,88,85
   85 IF(T-BT+.0001)8,89,89
    8 V=V2
      IF(ALT)88,88,89
   88 ALT=0.
      R=0.
      CALL HEADER(7)
  331 RETURN
   89 ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)13,13,14
   13 R=0.
      GO TO 15
   14 R=SQRT(ARG)
   15 CALL HEADER(7)
      AREA1=AREA2
      IF(T-BT+.0001)7,331,331
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0078	R	0084
K	0088	IH1	008C	ITER	0090	KOMP	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
EXPNT	00AC	ARG	00B0	IT	00B4				

CALLED SUBROUTINES

IJTACOM IJTARXR HEADER IJTSSQT SQRT RHO RALPH

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00016	00EC	00017	00FE	0001A	0110	00007	015A	00085	017C
00008	0198	00088	01C4	00331	01E2	00089	01F4	00013	022E
00014	0240	00015	0252						

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 000848 ADDRESS BASE TABLE 0258

// EXEC FORTRAN

```
      SUBROUTINE HSC
      COMMON T,TD,CD,EMIN,TW,WC,K,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,RCOT(3),ARAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
   35 FORMAT(1HO,'OPTIMUM IGNITION ALTITUDE NOT FOUND')
   36 FORMAT(1H1)
   57 FORMAT(1HO,'OPTIMUM IGNITION ALTITUDE=',F11.0,2X,'(WITHIN',F5.0,
     1' FEET)')
      WRITE(3,36)
      HI=HOPT+BT*VBAR
      H1=HI
      HF=HOPT
      H2=HI
      SOB1=0.
      SOB2=0.
      SOBT=0.
      INCH=(HI-HF)/10.+.5
      NINC=INCH
      HIGN=HI
      EXPNT=2./3.
    2 T=0.
      ABAR=0.
      AREA1=0.
      W=TW
      ALT=HIGN
      CALL HEADER(5)
      ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)16,16,17
   16 R=0.
      GO TO 18
   17 R=SQRT(ARG)
   18 V=-SQRT(W/RHO(ALT+HASL)/DK)
      CALL HEADER(7)
      AREA1=AREA2
    7 DO 8 IT=1,ITER
      CALL RALPH
      IF(ALT)88,88,85
   85 IF(T-BT+.0001)8,89,89
    8 V=V2
      IF(ALT)88,88,89
   88 ALT=0.
      R=0.
      CALL HEADER(7)
      AREA1=AREA2
      GO TO 9
   89 ARG=(CD*ALT/EMIN)**EXPNT-ALT*ALT
      IF(ARG)13,13,14
   13 R=0.
      GO TO 15
   14 R=SQRT(ARG)
   15 CALL HEADER(7)
      AREA1=AREA2
      IF(T-BT+.0001)7,9,9
```

0002,

0002

```
00000669                  HESO
   99 IF(SD02-SDT)999,999,101
  999 IF(ALT)111,111,998
  998 HM1=HM2
      SD01=SD02
      HM2=HMEAN
      SD02=SDT
      IF(HMEAN-HF-.0001)111,111,12
  111 WRITE(3,35)
      KODE=0
      RETURN
  112 HMEAN=HMEAN+HINC
      SD01=0.
      GO TO 22
 1001 IF(HM1-HMEAN-.80)556,556,1005
  556 WRITE(3,57)HM2,HINC
      HM1=HM2
      RETURN
 1005 IF(SDOT-SD01)1006,1006,1007
 1007 HM1=HM2
      HM1=HM2
      SD01=SD02
      GO TO 1008
 1006 HM1=HM1
      HM2=HM1
      SD02=SD01
 1008 HME=HMEAN
      IINCH=HINC/.5+.5
      HINC=IINCH
      HMEAN=HM1+HINC
      SDOT=0.
      GO TO 22
      END
```

RDTR No. 157

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0080	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
HI	00E4	HF	00E8	SOB1	00EC	SOB2	00F0	INCH	00F4
HINC	00F8	HIGN	00FC	EXPNT	0100	ARG	0104	IT	0108

CALLED SUBROUTINES

IJTACOM	IJTARXR	HEADER	IJTSSQT	SQRT	RHC	RALPH

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00035	006C	00036	009C	00057	00A8	00002	01A4	00016	0210
00017	022[illegible]	00018	0234	00007	027E	00085	02A0	00008	02BC
00088	02E8	00089	0314	00013	034E	00014	0360	00015	0372
00009	03A0	00099	03B4	00098	03C4	00011	03F0	00012	042E
00101	044C	00056	0464	00105	049A	00107	04AE	00106	04D0
00108	04EC								

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 001700 ADDRESS BASE TABLE 0528

// EXEC FORTRAN

```
      SUBROUTINE ROOTS
      COMMON T,TC,CD,EMIN,TW,WC,W,DK,HV,ST,BR,VPAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,*PROD,KODE
      DOUBLE PRECISION T,TD
      DOUBLE PRECISION P,PQ,Q,A,B,ALPHA
      CP=CD
      H=ALT
      P=-CP*CP/EMIN/EMIN
      PQ=ALT*ALT*CD*CD/EMIN/EMIN
      Q=(27.*H*H*H*H*EMIN*EMIN-4.*CD*CD)/EMIN/EMIN/108.*CD*CD*CD*CD/EMIN
     1/EMIN/EMIN/EMIN
      IF(Q)1,2,3
    2 A=-(PQ/2.)**(1./3.)
      ROOT(1)=A+A-H*H
      ROOT(2)=-A-H*H
      IF(ROOT(1))3,3,13
   13 ROOT(1)=SQRT(ROOT(1))
      IF(ROOT(2))3,3,17
   17 ROOT(2)=SQRT(ROOT(2))
      N=2
      GO TO 35
    1 COSA=-H*H*EMIN*SQRT(27.)/(2.*CP)
      IF(ABS(COSA)-1.)18,18,19
   19 WRITE(3,20)
   20 FORMAT(1H ,'COSINE OUTSIDE OF RANGE (-1,+1)')
      GO TO 39
   18 ALPHA=(DATAN(-DSQRT(4.*CD*CD-H*H*H*H*EMIN*EMIN*27.)/H/H/EMIN/DSQRT
     1(27.))+3.141593)/3.
      ROOT(1)=2.*CD/EMIN/DSQRT(3.)*DCOS(ALPHA)-H*H
      ROOT(2)=-2.*CD/EMIN/DSQRT(3.)*DCOS(ALPHA+1.0471976)-H*H
      ROOT(3)=-2.*CD/EMIN/DSQRT(3.)*DCOS(ALPHA-1.0471976)-H*H
      IF(ROOT(1))21,21,22
   21 IF(ROOT(2))3,3,24
   24 ROOT(1)=SQRT(ROOT(2))
      IF(ROOT(3))3,3,28
   28 ROOT(2)=SQRT(ROOT(3))
      N=2
      GO TO 35
   22 ROOT(1)=SQRT(ROOT(1))
      IF(ROOT(2))29,29,30
   29 IF(ROOT(3))3,3,32
   32 ROOT(2)=SQRT(ROOT(3))
      N=2
      GO TO 35
   30 ROOT(2)=SQRT(ROOT(2))
      IF(ROOT(3))33,33,34
   33 N=2
      GO TO 35
   34 ROOT(3)=SQRT(ROOT(3))
      N=3
   35 IF (N)39,39,40
   40 GO TO (3,43,44),N
      GO TO 39
```

RDTE No. 157

```
06/06/69                    ROOTS
   43 IF(ROOT(1)-ROOT(2))47,46,46
   47 R1=ROOT(1)
      ROOT(1)=ROOT(2)
      ROOT(2)=R1
   46 K=1
      RETURN
   44 DO 48 I=1,N
      E=CD*ROOT(I)/SQRT(ROOT(I)*ROOT(I)+ALT*ALT)**3
   48 WRITE(3,49)I,ROOT(I),E,ALT
   49 FORMAT('0','ROOT(',I1,')=',E15.6,5X,'E=',E15.6,5X,'ALT=',E15.6)
   39 WRITE(3,41)P,PQ,Q
   41 FORMAT('0','P= ',E15.6,5X,'PQ= ',E15.6,5X,'Q= ',E15.6/)
    3 K=0
      ROOT(1)=0.
      ROOT(2)=0.
      RETURN
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0078	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
CP	0110	H	0114	P	0118	PQ	0120	Q	0128
A	0130	N	0138	COSA	013C	ALPHA	0140	R1	0148
I	014C	E	0150						

CALLED SUBROUTINES

IJTACOM IJTADXD IJTARXI IJTSSQT SQRT IJTLTAN DATAN IJTLSQT DSQRT IJTLSCN
DCOS

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00002	012C	00013	019A	00017	01C4	00001	01F0	00019	0234
00020	0248	00018	027A	00021	03FC	00024	0400	00028	0436
00022	0462	00029	048C	00032	049C	00030	04C8	00033	04F2
00034	0500	00035	0526	00040	0532	00043	0560	00047	0578
00046	0590	00044	05AE	00048	0606	00049	0658	00039	0688
00041	0684	00003	060E						

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 002192 ADDRESS BASE TABLE 06D0

// EXEC FORTRAN

```
      SUBROUTINE HEADER(N)
      COMMON T,TD,CD,EMIN,TW,WC,K,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,RCOT(3),ABAR,R
      COMMON K,IH1,ITER,KCMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
    7 FORMAT(1H1,30X,A4,A4,A2,20X,3HVSB)
    8 FORMAT(1H1,30X,A4,A4,A2,20X,3HVSF)
    9 FORMAT(1H1,30X,A4,A4,A2,20X,3HHSB)
   10 FORMAT(1H1,30X,A4,A4,A2,20X,3HHSF)
   11 FORMAT(1H1,30X,A4,A4,A2,20X,3HHSO)
   17 FORMAT(1H ,1PE15.5,0PF10.3,F10.0,F7.1,F10.0,F11.3,2(1PE18.5))
   18 FORMAT(1H ,1PE15.5,0PF11.3,F7.1,F10.0,F11.3,2(1PE18.5))
   44 FORMAT(1HO,25X,'CD',11X,'EMIN',13X,'TW',12X,'WC')
   43 FORMAT(1H ,16X,1PE15.4,0PF12.4,F16.2,F15.2)
  333 FORMAT(1HO,25X,'HC',13X,'BT',13X,'DK',12X,'HASL')
   34 FORMAT(1H ,16X,F13.1,2X,F12.1,3X,F15.5,5X,F6.0)
   35 FORMAT('0',7X,'AREA',8X,'RADIUS2',3X,'RADIUS1',2X,'TIME',4X,
     1'HEIGHT    VELOCITY   AREA-TIME INTEGRAL   AVERAGE AREA')
  444 FORMAT(1HO,22X,'OPT. ALT.',9X,'BT',13X,'DK',12X,'HASL')
   36 FORMAT('0',8X,'AREA',8X,'RADIUS',3X,'TIME',4X,'HEIGHT',4X,
     1'VELOCITY   AREA-TIME INTEGRAL   AVERAGE AREA')
      GO TO (1,2,3,4,5,14,15),N
      CALL EXIT
    1 WRITE(3,7)ID1,ID2,ID3
      GO TO 6
    2 WRITE(3,8)ID1,ID2,ID3
      GO TO 6
    3 WRITE(3,9)ID1,ID2,ID3
      GO TO 6
    4 WRITE(3,10)ID1,ID2,ID3
      GO TO 6
    5 WRITE(3,11)ID1,ID2,ID3
    6 WRITE(3,44)
      WRITE(3,33)CD,EMIN,TW,WC
      GO TO(12,12,13,13,13),N
      CALL EXIT
   12 WRITE(3,333)
      WRITE(3,34)HC,BT,DK,HASL
      WRITE (3,35)
      RETURN
   13 WRITE(3,444)
      WRITE(3,34)HOPT,BT,DK,HASL
      WRITE(3,36)
      RETURN
   14 AREA2=PI*(ROOT(1)*RCOT(1)-ROOT(2)*ROOT(2))
      GO TO 20
   15 AREA2=PI*R*R
   20 IF(T)21,21,22
   21 ABAR=0.
      GO TO 23
   22 SOBT=SOBT+TD*ITER*(AREA1+AREA2)/2.
      ABAR=SOBT/T
   23 NN=N-5
      GO TO (16,19),NN
```

```
      CALL EXIT
   16 WRITE(3,17)AREA2,RCCT(2),RCOT(1),T,ALT,V,SOBT,ABAR
      RETURN
   19 WRITE(3,18)AREA2,R,T,ALT,V,SOBT,ABAR
      RETURN
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0078	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
N	00C0	NN	00C4						

CALLED SUBROUTINES

IJTAAFR IJTACOM IJTFXIT EXIT

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
00007	008E	00008	00A8	00009	00C2	00010	00DC	00011	00F6
00017	0110	00018	0131	00044	0160	00033	0186	00333	01A4
00034	01CA	00035	01EA	00444	0256	00036	0282	00001	031C
00002	0352	00003	038A	00004	03C2	00005	03FA	00006	042C
00012	04AA	00013	0524	00014	0582	00015	05AB	00020	058C
00021	05CC	00022	05DE	00023	062E	00016	066A	00019	06CA

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 002036 ADDRESS BASE TABLE 06F0

```
// EXEC FORTRAN
```

```
FUNCTION RHO(H)
RHO=.07513*EXP(-3.1582E-5*H)
RETURN
END
```

06/06/69 RHO 0002

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
RHO	004C	H	0048						

CALLED SUBROUTINES

IJTACOM IJTEXPN EXP

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION
	COMPILATION	COMPLETE							

AMOUNT OF COMMON 000000 AMOUNT OF CORE 000244 ADDRESS BASE TABLE 0088

// EXEC FORTRAN

```
      SUBROUTINE RALPH
      COMMON T,TD,CD,EMIN,TW,WC,W,DK,HV,BT,BR,VBAR,DH,ALT,H1,H2,HC,HOPT
      COMMON AREA1,AREA2,SOBT,V1,V2,G,PI,V,HASL,ROOT(3),ABAR,R
      COMMON K,IH1,ITER,KOMPUT,ID1,ID2,ID3,NPROG,KODE
      DOUBLE PRECISION T,TD
      B=DK*RHO(ALT+HASL)*G/W
      A1=-G+B*V*V
      V1=V+TD*A1
      A2=-G+B*V1*V1
      V2=V+TD*((A1+A2)/2.)
      ALT=ALT+TD*((V+V2)/2.)
      T=T+TD
      W=W-BR*TD
      RETURN
      END
```

COMMON

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
T	0000	TD	0008	CD	0010	EMIN	0014	TW	0018
WC	001C	W	0020	DK	0024	HV	0028	BT	002C
BR	0030	VBAR	0034	DH	0038	ALT	003C	H1	0040
H2	0044	HC	0048	HOPT	004C	AREA1	0050	AREA2	0054
SOBT	0058	V1	005C	V2	0060	G	0064	PI	0068
V	006C	HASL	0070	ROOT	0074	ABAR	0078	R	0084
K	0088	IH1	008C	ITER	0090	KOMPUT	0094	ID1	0098
ID2	009C	ID3	00A0	NPROG	00A4	KODE	00A8		

SCALARS

SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION	SYMBOL	LOCATION
B	004C	A1	0050	A2	0054				

CALLED SUBROUTINES

IJTACOM RHO

LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION	LABEL	LOCATION

COMPILATION COMPLETE AMOUNT OF COMMON 000172 AMOUNT OF CORE 000392 ADDRESS BASE TABLE 0118

```
// EXEC LNKEDT
```

```
JOB   TE7P40     06/06/69   TAPE LINKAGE EDITOR DIAGNOSTIC OF INPUT

ACTION TAKEN     MAP
LIST      PHASE TE7P40,S
LIST     AUTOLINK   IJTAAFR
LIST     AUTOLINK   IJTACOM
LIST     AUTOLINK   IJTACON
LIST     AUTOLINK   IJTADXD
LIST     AUTOLINK   IJTAPST
LIST     AUTOLINK   IJTARXI
LIST     AUTOLINK   IJTARXR
LIST     AUTOLINK   IJTEXPN
LIST     AUTOLINK   IJTFIOS
LIST     AUTOLINK   IJTFXIT
LIST     AUTOLINK   IJTLEXP
LIST     AUTOLINK   IJTLLOG
LIST     AUTOLINK   IJTLSCN
LIST     AUTOLINK   IJTLSQT
LIST     AUTOLINK   IJTLTAN
LIST     AUTOLINK   IJTSLOG
LIST     AUTOLINK   IJTSSQT
LIST      ENTRY
```

06/06/69	PHASE	XFR-AD	LOCORE	HICORE	ESD TYPE	LABEL	LOADED	REL-FR
COMMON					COM		001800	000DAC
	TE7P40		001880	00495F	CSECT	FORTMAIN	001880	001880
					CSECT	IJTAAFR	004578	004578
					CSECT	IJTACOM	004618	004618
					ENTRY	IJTSAVE	004828	
					CSECT	IJTFXIT	006128	006128
					ENTRY	EXIT	00612E	
					CSECT	RHO	0042F8	0042F8
					CSECT	IJTSSQT	006888	006888
					ENTRY	SQRT	00688E	
					CSECT	VSB1	001058	001058
					CSECT	VSF1	002158	002158
					CSECT	HSB1	002458	002458
					CSECT	HSF1	002878	002878
					CSECT	HSO	0028C8	0028C8
					CSECT	HEADER	003800	003800
					CSECT	ROOTS	003270	003270
					CSECT	RALPH	0043F0	0043F0
					CSECT	IJTARXR	005950	005950
					CSECT	IJTADXD	005770	005770
					CSECT	IJTARXI	0058C8	0058C8
					CSECT	IJTLTAN	006678	006678
					ENTRY	DATAN	00667E	
					CSECT	IJTLSQT	0065E8	0065E8
					ENTRY	DSQRT	0065EE	
					CSECT	IJTLSCN	006478	006478
					ENTRY	DCOS	00647E	
					* ENTRY	DSIN	006498	
					CSECT	IJTEXPN	005A20	005A20
					ENTRY	EXP	005A24	
					CSECT	IJTACON	004E28	004E28
					* ENTRY	FCVFI	004E28	

06/06/69	PHA E	XFR-AD	LOCORE	HICORE	ESD TYPE	LABEL	LOADED	REL-FR
					* ENTRY	FCVFO	004E2C	
					* ENTRY	FCVEI	004E30	
					* ENTRY	FCVEO	004E34	
					* ENTRY	FCVII	004E38	
					* ENTRY	FCVIO	004E3C	
					* ENTRY	FCVDI	004FD0	
					* ENTRY	FCVDO	0051C0	
					CSECT	IJTFIOS	005B38	005B38
					ENTRY	UNITABE	006064	
					* ENTRY	DOIOXXE	005E72	
					* ENTRY	GETUNTE	005D84	
					* ENTRY	OPENUNE	005DD2	
					* ENTRY	SETLGUE	005E42	
					* ENTRY	CCWNO1E	005F30	
					CSECT	IJTAPST	005838	005838
					CSECT	IJTLLOG	006308	006308
					ENTRY	DLOG	006326	
					* ENTRY	DLOG10	006310	
					CSECT	IJTLEXF	006140	006140
					ENTRY	DEXP	006146	
					CSECT	[illegible]	006780	006780
					ENTRY	ALOG	006782	
					* ENTRY	ALOG10	006738	

TE7P4[illegible]

// EXEC

APPENDIX B

PROGRAM PRINTOUT

MK 45-8 VSB

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

HC	BT	DK	HASL
5635.1	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
2.44763E 08	64.	8827.	0.0	1740.	-10.032	0.0	0.0
2.46377E 08	54.	8856.	10.0	1641.	-9.803	2.45570E 09	2.45570E 08
2.47857E 08	45.	8882.	20.0	1544.	-9.564	4.92687E 09	2.46344E 08
2.49211E 08	37.	8907.	30.0	1449.	-9.321	7.41221E 09	2.47074E 08
2.50444E 08	31.	8929.	40.0	1358.	-9.073	9.91048E 09	2.47762E 08
2.51564E 08	25.	8949.	50.0	1268.	-8.820	1.24205E 10	2.48410E 08
2.52578E 08	20.	8967.	60.0	1181.	-8.562	1.49412E 10	2.49020E 08
2.53491E 08	16.	8983.	70.0	1097.	-8.297	1.74716E 10	2.49594E 08
2.54309E 08	13.	8997.	80.0	1015.	-8.026	2.00106E 10	2.50132E 08
2.55039E 08	11.	9010.	90.0	936.	-7.747	2.25573E 10	2.50637E 08
2.55686E 08	9.	9022.	100.0	860.	-7.459	2.51109E 10	2.51109E 08
2.56256E 08	7.	9032.	110.0	787.	-7.162	2.76706E 10	2.51551E 08
2.56755E 08	6.	9040.	120.0	717.	-6.853	3.02357E 10	2.51964E 08
2.57187E 08	5.	9048.	130.0	650.	-6.532	3.28054E 10	2.52349E 08
2.57559E 08	5.	9054.	140.0	586.	-6.195	3.53791E 10	2.52708E 08
2.57875E 08	4.	9060.	150.0	526.	-5.842	3.79563E 10	2.53042E 08
2.58141E 08	4.	9065.	160.0	470.	-5.467	4.05364E 10	2.53352E 08
2.58362E 08	4.	9069.	170.0	417.	-5.067	4.31189E 10	2.53640E 08
2.58542E 08	4.	9072.	180.0	368.	-4.639	4.57034E 10	2.53908E 08

MK 45-8 VSB

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

HC	BT	DK	HASL
5635.1	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
2.45880E 08	57.	8847.	0.0	1672.	-10.021	0.0	0.0
2.47425E 08	47.	8875.	10.0	1573.	-9.792	2.46652E 09	2.46652E 08
2.48838E 08	39.	8900.	20.0	1476.	-9.554	4.94783E 09	2.47392E 08
2.50126E 08	32.	8923.	30.0	1382.	-9.311	7.44265E 09	2.48088E 08
2.51298E 08	26.	8944.	40.0	1290.	-9.064	9.94977E 09	2.48744E 08
2.52358E 08	21.	8963.	50.0	1201.	-8.811	1.24680E 10	2.49361E 08
2.53313E 08	17.	8980.	60.0	1114.	-8.553	1.49964E 10	2.49940E 08
2.54170E 08	14.	8995.	70.0	1029.	-8.288	1.75338E 10	2.50483E 08
2.54935E 08	11.	9008.	80.0	948.	-8.017	2.00793E 10	2.50992E 08
2.55613E 08	9.	9020.	90.0	869.	-7.739	2.26321E 10	2.51467E 08
2.56211E 08	7.	9031.	100.0	793.	-7.451	2.51912E 10	2.51912E 08
2.56734E 08	6.	9040.	110.0	720.	-7.154	2.77559E 10	2.52326E 08
2.57187E 08	5.	9048.	120.0	650.	-6.846	3.03255E 10	2.52712E 08
2.57577E 08	5.	9055.	130.0	583.	-6.525	3.28993E 10	2.53072E 08
2.57908E 08	4.	9061.	140.0	520.	-6.189	3.54767E 10	2.53405E 08
2.58186E 08	4.	9065.	150.0	459.	-5.836	3.80572E 10	2.53715E 08
2.58416E 08	4.	9070.	160.0	403.	-5.461	4.06402E 10	2.54001E 08
2.58603E 08	4.	9073.	170.0	350.	-5.061	4.32253E 10	2.54266E 08
2.58752E 08	4.	9075.	180.0	302.	-4.634	4.58121E 10	2.54511E 08

MK 45-8 VSB

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

HC	BT	DK	HASL
5635.1	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
2.45912E 08	57.	8848.	0.0	1670.	-10.021	0.0	0.0
2.47455E 08	47.	8875.	10.0	1571.	-9.792	2.46684E 09	2.46684E 08
2.48866E 08	39.	8900.	20.0	1474.	-9.553	4.94843E 09	2.47422E 08
2.50153E 08	32.	8923.	30.0	1380.	-9.311	7.44353E 09	2.48118E 08
2.51322E 08	26.	8944.	40.0	1288.	-9.063	9.95090E 09	2.48772E 08
2.52380E 08	21.	8963.	50.0	1199.	-8.811	1.24694E 10	2.49388E 08
2.53334E 08	17.	8980.	60.0	1112.	-8.553	1.49980E 10	2.49966E 08
2.54190E 08	14.	8995.	70.0	1027.	-8.288	1.75356E 10	2.50508E 08
2.54953E 08	11.	9009.	80.0	946.	-8.017	2.00813E 10	2.51016E 08
2.55629E 08	9.	9021.	90.0	867.	-7.738	2.26342E 10	2.51491E 08
2.56226E 08	7.	9031.	100.0	791.	-7.451	2.51935E 10	2.51935E 08
2.56747E 08	6.	9040.	110.0	718.	-7.154	2.77583E 10	2.52348E 08
2.57199E 08	5.	9048.	120.0	648.	-6.846	3.03281E 10	2.52734E 08
2.57587E 08	5.	9055.	130.0	581.	-6.525	3.29020E 10	2.53092E 08
2.57917E 08	4.	9061.	140.0	518.	-6.189	3.54795E 10	2.53425E 08
2.58194E 08	4.	9066.	150.0	457.	-5.835	3.80601E 10	2.53734E 08
2.58423E 08	4.	9070.	160.0	401.	-5.461	4.06432E 10	2.54020E 08
2.58609E 08	4.	9073.	170.0	348.	-5.061	4.32283E 10	2.54284E 08
2.58757E 08	4.	9076.	180.0	300.	-4.634	4.58151E 10	2.54529E 08

MK 45-8 HSB

CD	EMIN	TW	WC
1.6500E-06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
7.50407E 07	4887.	0.0	1670.	-10.021	0.0	0.0
7.27006E 07	4811.	10.0	1571.	-9.792	7.38706E 08	7.38706E 07
7.02882E 07	4730.	20.0	1474.	-9.553	1.45365E 09	7.26825E 07
6.78084E 07	4646.	30.0	1380.	-9.311	2.14413E 09	7.14711E 07
6.52650E 07	4558.	40.0	1288.	-9.063	2.80950E 09	7.02375E 07
6.26631E 07	4466.	50.0	1199.	-8.811	3.44914E 09	6.89828E 07
6.00081E 07	4370.	60.0	1112.	-8.553	4.06250E 09	6.77083E 07
5.73051E 07	4271.	70.0	1027.	-8.288	4.64906E 09	6.64151E 07
5.45599E 07	4167.	80.0	946.	-8.017	5.20838E 09	6.51047E 07
5.17768E 07	4060.	90.0	867.	-7.738	5.74006E 09	6.37784E 07
4.89624E 07	3948.	100.0	791.	-7.451	6.24375E 09	6.24375E 07
4.61239E 07	3832.	110.0	718.	-7.154	6.71918E 09	6.10835E 07
4.32684E 07	3711.	120.0	648.	-6.846	7.16614E 09	5.97179E 07
4.04036E 07	3586.	130.0	581.	-6.525	7.58450E 09	5.83423E 07
3.75410E 07	3457.	140.0	518.	-6.189	7.97422E 09	5.69587E 07
3.46910E 07	3323.	150.0	457.	-5.835	8.33538E 09	5.55692E 07
3.18687E 07	3185.	160.0	401.	-5.461	8.66818E 09	5.41761E 07
2.90933E 07	3043.	170.0	348.	-5.061	8.97298E 09	5.27823E 07
2.63887E 07	2898.	180.0	300.	-4.634	9.25039E 09	5.13911E 07

MK 45-8 VS8

CD	EMIN	TW	WC
1.6500E 06	0.0500	22.50	17.50

HC	BT	DK	HASL
3563.9	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.01519E 07	143.	5359.	0.0	1670.	-10.021	0.0	0.0
9.17574E 07	119.	5406.	10.0	1571.	-9.792	9.09546E 08	9.09546E 07
9.32166E 07	98.	5448.	20.0	1474.	-9.553	1.83442E 09	9.17208E 07
9.45400E 07	80.	5486.	30.0	1380.	-9.311	2.77320E 09	9.24400E 07
9.57370E 07	65.	5521.	40.0	1288.	-9.063	3.72458E 09	9.31146E 07
9.68161E 07	52.	5552.	50.0	1199.	-8.811	4.68735E 09	9.37469E 07
9.77855E 07	42.	5579.	60.0	1112.	-8.553	5.66035E 09	9.43392E 07
9.86524E 07	33.	5604.	70.0	1027.	-8.288	6.64254E 09	9.48934E 07
9.94240E 07	26.	5626.	80.0	946.	-8.017	7.63292E 09	9.54115E 07
1.00107E 08	20.	5645.	90.0	867.	-7.738	8.63058E 09	9.58953E 07
1.00708E 08	15.	5662.	100.0	791.	-7.451	9.63464E 09	9.63464E 07
1.01232E 08	11.	5677.	110.0	718.	-7.154	1.06443E 10	9.67667E 07
1.01686E 08	9.	5689.	120.0	648.	-6.846	1.16589E 10	9.71578E 07
1.02076E 08	6.	5700.	130.0	581.	-6.525	1.26777E 10	9.75211E 07
1.02407E 08	5.	5709.	140.0	516.	-6.189	1.37002E 10	9.78583E 07
1.02684E 08	4.	5717.	150.0	457.	-5.835	1.47256E 10	9.81707E 07
1.02914E 08	3.	5724.	160.0	401.	-5.461	1.57536E 10	9.84600E 07
1.03100E 08	3.	5729.	170.0	348.	-5.061	1.67837E 10	9.87274E 07
1.03248E 08	3.	5733.	180.0	300.	-4.634	1.78154E 10	9.89745E 07

MK 45-8 HSB

CD	EMIN	TW	WC
1.6500E 06	0.0500	22.50	17.50

OPT. ALT.	BT	DK	HASL
2520.1	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
3.67336E 07	3419.	0.0	1670.	-10.021	0.0	0.0
3.59244E 07	3382.	10.0	1571.	-9.792	3.63290E 08	3.63290E 07
3.50378E 07	3340.	20.0	1474.	-9.553	7.18101E 08	3.59050E 07
3.40776E 07	3294.	30.0	1380.	-9.311	1.06368E 09	3.54559E 07
3.30494E 07	3243.	40.0	1288.	-9.063	1.39931E 09	3.49828E 07
3.19561E 07	3189.	50.0	1199.	-8.811	1.72434E 09	3.44868E 07
3.08028E 07	3131.	60.0	1112.	-8.553	2.03813E 09	3.39689E 07
2.95941E 07	3069.	70.0	1027.	-8.288	2.34012E 09	3.34303E 07
2.83344E 07	3003.	80.0	946.	-8.017	2.62976E 09	3.28720E 07
2.70287E 07	2933.	90.0	867.	-7.738	2.90658E 09	3.22953E 07
2.56820E 07	2859.	100.0	791.	-7.451	3.17013E 09	3.17013E 07
2.42994E 07	2781.	110.0	718.	-7.154	3.42004E 09	3.10912E 07
2.28866E 07	2699.	120.0	648.	-6.846	3.65597E 09	3.04664E 07
2.14495E 07	2613.	130.0	581.	-6.525	3.87765E 09	2.98280E 07
1.99957E 07	2523.	140.0	518.	-6.189	4.08487E 09	2.91776E 07
1.85328E 07	2429.	150.0	457.	-5.835	4.27752E 09	2.85168E 07
1.70703E 07	2331.	160.0	401.	-5.461	4.45553E 09	2.78471E 07
1.56201E 07	2230.	170.0	348.	-5.061	4.61898E 09	2.71705E 07
1.41969E 07	2126.	180.0	300.	-4.634	4.76806E 09	2.64892E 07

MK 45-8 VSB

CD	EMIN	TW	WC
1.6500E 06	0.1000	22.50	17.50

HC	BT	DK	HASL
2520.1	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
3.76879E 07	296.	3476.	0.0	1670.	-10.021	0.0	0.0
3.94702E 07	243.	3553.	10.0	1571.	-9.792	3.85790E 08	3.85790E 07
4.10572E 07	200.	3621.	20.0	1474.	-9.553	7.88427E 08	3.94213E 07
4.24732E 07	163.	3680.	30.0	1380.	-9.311	1.20608E 09	4.02026E 07
4.37371E 07	132.	3734.	40.0	1288.	-9.063	1.63713E 09	4.09283E 07
4.48645E 07	106.	3780.	50.0	1199.	-8.811	2.08014E 09	4.16028E 07
4.58686E 07	84.	3822.	60.0	1112.	-8.553	2.53380E 09	4.22300E 07
4.67603E 07	66.	3859.	70.0	1027.	-8.288	2.99695E 09	4.28135E 07
4.75495E 07	52.	3891.	80.0	946.	-8.017	3.46850E 09	4.33562E 07
4.82448E 07	40.	3919.	90.0	867.	-7.738	3.94747E 09	4.38608E 07
4.88541E 07	30.	3944.	100.0	791.	-7.451	4.43296E 09	4.43296E 07
4.93846E 07	23.	3965.	110.0	718.	-7.154	4.92415E 09	4.47650E 07
4.98429E 07	17.	3983.	120.0	648.	-6.846	5.42029E 09	4.51691E 07
5.02354E 07	12.	3999.	130.0	581.	-6.525	5.92068E 09	4.55437E 07
5.05681E 07	9.	4012.	140.0	518.	-6.189	6.42469E 09	4.58907E 07
5.08466E 07	6.	4023.	150.0	457.	-5.835	6.93177E 09	4.62118E 07
5.10767E 07	4.	4032.	160.0	401.	-5.461	7.44138E 09	4.65086E 07
5.12634E 07	3.	4040.	170.0	348.	-5.061	7.95308E 09	4.67828E 07
5.14120E 07	2.	4045.	180.0	300.	-4.634	8.46646E 09	4.70359E 07

MK -5-8 HSB

LD	EMIN	TW	WC
1.6500E 06	0.1000	22.50	17.50

OPT. ALT.	BT	DK	HASL
1782.0	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
1.98986E 07	2517.	0.0	1670.	-10.021	0.0	0.0
1.97625E 07	2508.	10.0	1571.	-9.792	1.98305E 08	1.98305E 07
1.95463E 07	2494.	20.0	1474.	-9.553	3.94849E 08	1.97424E 07
1.92546E 07	2476.	30.0	1380.	-9.311	5.88853E 08	1.96284E 07
1.88916E 07	2452.	40.0	1288.	-9.063	7.79584E 08	1.94896E 07
1.84613E 07	2424.	50.0	1199.	-8.811	9.66349E 08	1.93270E 07
1.79680E 07	2392.	60.0	1112.	-8.553	1.14849E 09	1.91416E 07
1.74160E 07	2355.	70.0	1027.	-8.288	1.32541E 09	1.89345E 07
1.68096E 07	2313.	80.0	946.	-8.017	1.49654E 09	1.87068E 07
1.61531E 07	2268.	90.0	867.	-7.738	1.66136E 09	1.84595E 07
1.54510E 07	2218.	100.0	791.	-7.451	1.81938E 09	1.81938E 07
1.47082E 07	2164.	110.0	718.	-7.154	1.97017E 09	1.79107E 07
1.39292E 07	2106.	120.0	648.	-6.846	2.11336E 09	1.76113E 07
1.31196E 07	2044.	130.0	581.	-6.525	2.24860E 09	1.72969E 07
1.22850E 07	1977.	140.0	518.	-6.189	2.37563E 09	1.69688E 07
1.14317E 07	1908.	150.0	457.	-5.835	2.49421E 09	1.66281E 07
1.05667E 07	1834.	160.0	401.	-5.461	2.60420E 09	1.62763E 07
9.69899E 06	1757.	170.0	348.	-5.061	2.70553E 09	1.59149E 07
8.83899E 06	1677.	180.0	300.	-4.634	2.79822E 09	1.55457E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.13598E 07	5393.	0.0	5425.	-10.633	0.0	0.0
9.25275E 07	5427.	10.0	5319.	-10.389	9.19437E 08	9.19436E 07
9.35845E 07	5458.	20.0	5216.	-10.135	1.85000E 09	9.24998E 07
9.45370E 07	5486.	30.0	5116.	-9.877	2.79060E 09	9.30201E 07
9.53896E 07	5510.	40.0	5019.	-9.613	3.74024E 09	9.35059E 07
9.61497E 07	5532.	50.0	4924.	-9.345	4.69793E 09	9.39586E 07
9.68170E 07	5551.	60.0	4831.	-9.070	5.66277E 09	9.43794E 07
9.74008E 07	5568.	70.0	4742.	-8.789	6.63385E 09	9.47693E 07
9.79047E 07	5582.	80.0	4655.	-8.501	7.61038E 09	9.51297E 07
9.83356E 07	5595.	90.0	4571.	-8.205	8.59158E 09	9.54620E 07
9.86984E 07	5605.	100.0	4491.	-7.899	9.57675E 09	9.57675E 07
9.89962E 07	5614.	110.0	4413.	-7.584	1.05652E 10	9.60474E 07
9.92363E 07	5620.	120.0	4339.	-7.256	1.15564E 10	9.63032E 07
9.94228E 07	5626.	130.0	4268.	-6.916	1.25497E 10	9.65359E 07
9.95637E 07	5630.	140.0	4200.	-6.559	1.35446E 10	9.67472E 07
9.96614E 07	5632.	150.0	4136.	-6.184	1.45407E 10	9.69382E 07
9.97210E 07	5634.	160.0	4076.	-5.787	1.55376E 10	9.71102E 07
9.97508E 07	5635.	170.0	4020.	-5.363	1.65350E 10	9.72646E 07
9.97551E 07	5635.	180.0	3969.	-4.909	1.75325E 10	9.74029E 07

MK 45-8 HSC

CL	EMIN	TW	WC
1.6500 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.29339E 07	5439.	0.0	5281.	-10.609	0.0	0.0
9.39837E 07	5470.	10.0	5176.	-10.366	9.34588E 08	9.34588E 07
9.49270E 07	5497.	20.0	5073.	-10.112	1.87914E 09	9.39571E 07
9.57632E 07	5521.	30.0	4973.	-9.854	2.83259E 09	9.44197E 07
9.65060E 07	5542.	40.0	4875.	-9.592	3.79394E 09	9.48484E 07
9.71546E 07	5561.	50.0	4781.	-9.324	4.76224E 09	9.52448E 07
9.77188E 07	5577.	60.0	4689.	-9.050	5.73660E 09	9.56100E 07
9.82001E 07	5591.	70.0	4599.	-8.769	6.71619E 09	9.59456E 07
9.86030E 07	5602.	80.0	4513.	-8.482	7.70021E 09	9.62526E 07
9.89379E 07	5612.	90.0	4429.	-8.186	8.68791E 09	9.65323E 07
9.92060E 07	5619.	100.0	4349.	-7.882	9.67863E 09	9.67863E 07
9.94146E 07	5625.	110.0	4271.	-7.567	1.06717E 10	9.70157E 07
9.95686E 07	5630.	120.0	4197.	-7.240	1.16666E 10	9.72220E 07
9.96718E 07	5633.	130.0	4126.	-6.900	1.26628E 10	9.74065E 07
9.97343E 07	5634.	140.0	4059.	-6.545	1.36599E 10	9.75705E 07
9.97571E 07	5635.	150.0	3995.	-6.171	1.46573E 10	9.77155E 07
9.97461E 07	5635.	160.0	3935.	-5.774	1.56548E 10	9.78427E 07
9.97112E 07	5634.	170.0	3880.	-5.351	1.66521E 10	9.79537E 07
9.96552E 07	5632.	180.0	3829.	-4.899	1.76490E 10	9.80497E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.43493E 07	5480.	0.0	5137.	-10.585	0.0	0.0
9.52813E 07	5507.	10.0	5032.	-10.342	9.48153E 08	9.48153E 07
9.61054E 07	5531.	20.0	4929.	-10.089	1.90509E 09	9.52543E 07
9.68288E 07	5552.	30.0	4830.	-9.832	2.86976E 09	9.56586E 07
9.74599E 07	5570.	40.0	4732.	-9.570	3.84120E 09	9.60300E 07
9.80001E 07	5585.	50.0	4638.	-9.303	4.81850E 09	9.63700E 07
9.84571E 07	5598.	60.0	4546.	-9.029	5.80078E 09	9.66797E 07
9.88348E 07	5609.	70.0	4457.	-8.750	6.78724E 09	9.69606E 07
9.91394E 07	5618.	80.0	4371.	-8.463	7.77711E 09	9.72138E 07
9.93775E 07	5624.	90.0	4287.	-8.168	8.76969E 09	9.74410E 07
9.95515E 07	5629.	100.0	4207.	-7.864	9.76434E 09	9.76433E 07
9.96696E 07	5633.	110.0	4130.	-7.550	1.07604E 10	9.78222E 07
9.97355E 07	5634.	120.0	4056.	-7.224	1.17575E 10	9.79788E 07
9.97565E 07	5635.	130.0	3985.	-6.885	1.27549E 10	9.81148E 07
9.97377E 07	5634.	140.0	3918.	-6.530	1.37524E 10	9.82313E 07
9.96841E 07	5633.	150.0	3854.	-6.157	1.47495E 10	9.83300E 07
9.96062E 07	5631.	160.0	3795.	-5.762	1.57459E 10	9.84122E 07
9.95046E 07	5628.	170.0	3739.	-5.339	1.67415E 10	9.84794E 07
9.93868E 07	5625.	180.0	3688.	-4.888	1.77360E 10	9.85331E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 0[illegible]	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.56044E 07	5517.	0.0	4993.	-10.561	0.0	0.0
9.64146E 07	5540.	10.0	4888.	-10.319	9.60095E 08	9.60095E 07
9.71201E 07	5560.	20.0	4786.	-10.066	1.92777E 09	9.63884E 07
9.77317E 07	5578.	30.0	4686.	-9.810	2.90203E 09	9.67343E 07
9.82489E 07	5592.	40.0	4589.	-9.548	3.88193E 09	9.70483E 07
9.86793E 07	5605.	50.0	4495.	-9.282	4.86657E 09	9.73314E 07
9.90300E 07	5614.	60.0	4403.	-9.009	5.85511E 09	9.75852E 07
9.93048E 07	5622.	70.0	4314.	-8.730	6.84678E 09	9.78112E 07
9.95102E 07	5628.	80.0	4228.	-8.444	7.84086E 09	9.80107E 07
9.96498E 07	5632.	90.0	4145.	-8.150	8.83666E 09	9.81851E 07
9.97294E 07	5634.	100.0	4065.	-7.846	9.83355E 09	9.83355E 07
9.97579E 07	5635.	110.0	3988.	-7.533	1.08310E 10	9.84635E 07
9.97355E 07	5634.	120.0	3914.	-7.208	1.18284E 10	9.85704E 07
9.96733E 07	5633.	130.0	3844.	-6.870	1.28255E 10	9.86576E 07
9.95764E 07	5630.	140.0	3777.	-6.516	1.38217E 10	9.87267E 07
9.94475E 07	5626.	150.0	3714.	-6.143	1.48169E 10	9.87790E 07
9.92948E 07	5622.	160.0	3654.	-5.749	1.58106E 10	9.88160E 07
9.91272E 07	5617.	170.0	3599.	-5.328	1.68027E 10	9.88392E 07
9.89484E 07	5612.	180.0	3548.	-4.877	1.77930E 10	9.88503E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.66978E 07	5548.	0.0	4849.	-10.537	0.0	0.0
9.73865E 07	5568.	10.0	4744.	-10.295	9.70422E 08	9.70421E 07
9.79747E 07	5584.	20.0	4642.	-10.044	1.94723E 09	9.73614E 07
9.84698E 07	5599.	30.0	4543.	-9.788	2.92945E 09	9.76483E 07
9.88748E 07	5610.	40.0	4446.	-9.527	3.91617E 09	9.79043E 07
9.91965E 07	5619.	50.0	4352.	-9.261	4.90653E 09	9.81306E 07
9.94394E 07	5626.	60.0	4261.	-8.989	5.89971E 09	9.83284E 07
9.96104E 07	5631.	70.0	4172.	-8.710	6.89495E 09	9.84993E 07
9.97146E 07	5634.	80.0	4086.	-8.425	7.89157E 09	9.86447E 07
9.97549E 07	5635.	90.0	4003.	-8.131	8.88892E 09	9.87658E 07
9.97406E 07	5635.	100.0	3923.	-7.829	9.88640E 09	9.88640E 07
9.96766E 07	5633.	110.0	3847.	-7.516	1.08835E 10	9.89407E 07
9.95673E 07	5630.	120.0	3773.	-7.192	1.18797E 10	9.89975E 07
9.94210E 07	5626.	130.0	3703.	-6.854	1.28746E 10	9.90357E 07
9.92431E 07	5621.	140.0	3636.	-6.501	1.38680E 10	9.90568E 07
9.90382E 07	5615.	150.0	3573.	-6.130	1.48594E 10	9.90624E 07
9.88143E 07	5608.	160.0	3514.	-5.736	1.58486E 10	9.90539E 07
9.85781E 07	5602.	170.0	3458.	-5.316	1.68356E 10	9.90328E 07
9.83369E 07	5595.	180.0	3407.	-4.866	1.78202E 10	9.90008E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.76238E 07	5574.	0.0	4705.	-10.513	0.0	0.0
9.81925E 07	5591.	10.0	4600.	-10.272	9.79081E 08	9.79081E 07
9.86640E 07	5604.	20.0	4499.	-10.021	1.96336E 09	9.81682E 07
9.90421E 07	5615.	30.0	4400.	-9.766	2.95189E 09	9.83965E 07
9.93354E 07	5623.	40.0	4303.	-9.505	3.94378E 09	9.85945E 07
9.95474E 07	5629.	50.0	4209.	-9.240	4.93819E 09	9.87639E 07
9.96820E 07	5633.	60.0	4118.	-8.968	5.93434E 09	9.89056E 07
9.97493E 07	5635.	70.0	4030.	-8.691	6.93149E 09	9.90213E 07
9.97488E 07	5635.	80.0	3944.	-8.406	7.92898E 09	9.91122E 07
9.96939E 07	5633.	90.0	3861.	-8.113	8.92619E 09	9.91799E 07
9.95834E 07	5630.	100.0	3782.	-7.811	9.92258E 09	9.92258E 07
9.94287E 07	5626.	110.0	3705.	-7.499	1.09176E 10	9.92512E 07
9.92299E 07	5620.	120.0	3632.	-7.176	1.19109E 10	9.92577E 07
9.89994E 07	5614.	130.0	3562.	-6.839	1.29021E 10	9.92467E 07
9.87379E 07	5606.	140.0	3495.	-6.487	1.38908E 10	9.92197E 07
9.84566E 07	5598.	150.0	3432.	-6.116	1.48767E 10	9.91782E 07
9.81589E 07	5590.	160.0	3373.	-5.723	1.58598E 10	9.91238E 07
9.78555E 07	5581.	170.0	3318.	-5.304	1.68399E 10	9.90581E 07
9.75518E 07	5572.	180.0	3267.	-4.855	1.78169E 10	9.89828E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.68982E 07	5554.	0.0	4820.	-10.532	0.0	0.0
9.75610E 07	5573.	10.0	4715.	-10.290	9.72296E 08	9.72296E 07
9.81267E 07	5589.	20.0	4613.	-10.039	1.95073E 09	9.75367E 07
9.85973E 07	5602.	30.0	4514.	-9.783	2.93435E 09	9.78118E 07
9.89812E 07	5613.	40.0	4417.	-9.523	3.92225E 09	9.80561E 07
9.92802E 07	5622.	50.0	4323.	-9.257	4.91355E 09	9.82710E 07
9.95034E 07	5628.	60.0	4232.	-8.985	5.90746E 09	9.84577E 07
9.96503E 07	5632.	70.0	4143.	-8.706	6.90323E 09	9.86176E 07
9.97350E 07	5634.	80.0	4057.	-8.421	7.90016E 09	9.87519E 07
9.97554E 07	5635.	90.0	3975.	-8.128	8.89761E 09	9.88623E 07
9.97218E 07	5634.	100.0	3895.	-7.825	9.89499E 09	9.89499E 07
9.96416E 07	5632.	110.0	3818.	-7.513	1.08918E 10	9.90164E 07
9.95144E 07	5628.	120.0	3745.	-7.189	1.18876E 10	9.90632E 07
9.93509E 07	5624.	130.0	3674.	-6.851	1.28819E 10	9.90916E 07
9.91564E 07	5618.	140.0	3608.	-6.498	1.38744E 10	9.91032E 07
9.89353E 07	5612.	150.0	3545.	-6.127	1.48649E 10	9.90993E 07
9.86959E 07	5605.	160.0	3485.	-5.734	1.58531E 10	9.90816E 07
9.84468E 07	5598.	170.0	3430.	-5.313	1.68388E 10	9.90516E 07
9.81912E 07	5591.	180.0	3379.	-4.864	1.78220E 10	9.90108E 07

MK 45-8 HSD

CD	EMIN	TW	WC
1.65(E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.70908E 07	5559.	0.0	4791.	-10.527	0.0	0.0
9.77305E 07	5578.	10.0	4686.	-10.286	9.74106E 08	9.74106E 07
9.82712E 07	5593.	20.0	4585.	-10.034	1.95411E 09	9.77057E 07
9.87203E 07	5606.	30.0	4485.	-9.779	2.93907E 09	9.79691E 07
9.90804E 07	5616.	40.0	4389.	-9.518	3.92808E 09	9.82019E 07
9.93590E 07	5624.	50.0	4295.	-9.252	4.92027E 09	9.84054E 07
9.95580E 07	5629.	60.0	4203.	-8.981	5.91485E 09	9.85809E 07
9.96863E 07	5633.	70.0	4115.	-8.702	6.91107E 09	9.87296E 07
9.97488E 07	5635.	80.0	4029.	-8.417	7.90825E 09	9.88531E 07
9.97518E 07	5635.	90.0	3946.	-8.124	8.90575E 09	9.89528E 07
9.96994E 07	5633.	100.0	3866.	-7.822	9.90300E 09	9.90300E 07
9.95963E 07	5630.	110.0	3790.	-7.510	1.08995E 10	9.90861E 07
9.94516E 07	5626.	120.0	3716.	-7.186	1.19947E 10	9.91226E 07
9.92732E 07	5621.	130.0	3646.	-6.848	1.28883E 10	9.91411E 07
9.90600E 07	5615.	140.0	3579.	-6.495	1.38800E 10	9.91428E 07
9.88252E 07	5609.	150.0	3516.	-6.124	1.48694E 10	9.91295E 07
9.85724E 07	5601.	160.0	3457.	-5.731	1.58564E 10	9.91026E 07
9.83085E 07	5594.	170.0	3402.	-5.311	1.68408E 10	9.90636E 07
9.80407E 07	5586.	180.0	3351.	-4.862	1.78226E 10	9.90142E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.72757E 07	5565.	0.0	4762.	-10.522	0.0	0.0
9.78924E 07	5582.	10.0	4657.	-10.281	9.75841E 08	9.75840E 07
9.84104E 07	5597.	20.0	4556.	-10.030	1.95735E 09	9.78677E 07
9.88355E 07	5609.	30.0	4456.	-9.774	2.94358E 09	9.81195E 07
9.91724E 07	5619.	40.0	4360.	-9.514	3.93362E 09	9.83406E 07
9.94285E 07	5626.	50.0	4266.	-9.248	4.92662E 09	9.85325E 07
9.96058E 07	5631.	60.0	4174.	-8.976	5.92179E 09	9.86965E 07
9.97150E 07	5634.	70.0	4086.	-8.698	6.91839E 09	9.88342E 07
9.97564E 07	5635.	80.0	4000.	-8.413	7.91575E 09	9.89469E 07
9.97376E 07	5634.	90.0	3918.	-8.120	8.91322E 09	9.90357E 07
9.96664E 07	5632.	100.0	3838.	-7.818	9.91023E 09	9.91023E 07
9.95450E 07	5629.	110.0	3761.	-7.506	1.09063E 10	9.91480E 07
9.93850E 07	5625.	120.0	3688.	-7.182	1.19009E 10	9.91744E 07
9.91875E 07	5619.	130.0	3618.	-6.845	1.28938E 10	9.91830E 07
9.89580E 07	5612.	140.0	3551.	-6.492	1.38845E 10	9.91751E 07
9.87076E 07	5605.	150.0	3488.	-6.121	1.48728E 10	9.91523E 07
9.84397E 07	5598.	160.0	3429.	-5.728	1.58586E 10	9.91161E 07
9.81611E 07	5590.	170.0	3373.	-5.309	1.68416E 10	9.90681E 07
9.78831E 07	5582.	180.0	3322.	-4.860	1.78218E 10	9.90100E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.69372E 07	5555.	0.0	4814.	-10.531	0.0	0.0
9.75979E 07	5574.	10.0	4709.	-10.289	9.72676E 08	9.72676E 07
9.81566E 07	5590.	20.0	4607.	-10.038	1.95145E 09	9.75724E 07
9.86226E 07	5603.	30.0	4508.	-9.782	2.93534E 09	9.78448E 07
9.90021E 07	5614.	40.0	4411.	-9.522	3.92347E 09	9.80867E 07
9.92969E 07	5622.	50.0	4317.	-9.256	4.91496E 09	9.82992E 07
9.95141E 07	5628.	60.0	4226.	-8.984	5.90902E 09	9.84836E 07
9.96596E 07	5632.	70.0	4137.	-8.705	6.90488E 09	9.86412E 07
9.97377E 07	5634.	80.0	4052.	-8.420	7.90186E 09	9.87733E 07
9.97568E 07	5635.	90.0	3969.	-8.127	8.89933E 09	9.88815E 07
9.97178E 07	5634.	100.0	3889.	-7.825	9.89671E 09	9.89671E 07
9.96319E 07	5632.	110.0	3812.	-7.512	1.08935E 10	9.90314E 07
9.95017E 07	5628.	120.0	3739.	-7.188	1.18891E 10	9.90760E 07
9.93351E 07	5623.	130.0	3669.	-6.851	1.28833E 10	9.91023E 07
9.91355E 07	5617.	140.0	3602.	-6.498	1.38757E 10	9.91118E 07
9.89140E 07	5611.	150.0	3539.	-6.126	1.48659E 10	9.91060E 07
9.86717E 07	5604.	160.0	3479.	-5.733	1.58538E 10	9.90864E 07
9.84180E 07	5597.	170.0	3424.	-5.313	1.68393E 10	9.90545E 07
9.81619E 07	5590.	180.0	3373.	-4.864	1.78222E 10	9.90120E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.69763E 07	5556.	0.0	4808.	-10.530	0.0	0.0
9.76321E 07	5575.	10.0	4703.	-10.288	9.73042E 08	9.73042E 07
9.81887E 07	5591.	20.0	4601.	-10.037	1.95215E 09	9.76073E 07
9.86505E 07	5604.	30.0	4502.	-9.781	2.93634E 09	9.78780E 07
9.90231E 07	5614.	40.0	4405.	-9.521	3.92471E 09	9.81177E 07
9.93137E 07	5623.	50.0	4311.	-9.255	4.91639E 09	9.83278E 07
9.95268E 07	5629.	60.0	4220.	-8.983	5.91059E 09	9.85099E 07
9.96664E 07	5632.	70.0	4131.	-8.705	6.90656E 09	9.86651E 07
9.97405E 07	5635.	80.0	4046.	-8.419	7.90359E 09	9.87948E 07
9.97539E 07	5635.	90.0	3963.	-8.126	8.90106E 09	9.89006E 07
9.97136E 07	5634.	100.0	3883.	-7.824	9.89839E 09	9.89839E 07
9.96224E 07	5631.	110.0	3806.	-7.511	1.08951E 10	9.90461E 07
9.94889E 07	5627.	120.0	3733.	-7.187	1.18906E 10	9.90885E 07
9.93173E 07	5623.	130.0	3663.	-6.850	1.28847E 10	9.91127E 07
9.91169E 07	5617.	140.0	3596.	-6.497	1.38768E 10	9.91202E 07
9.88904E 07	5611.	150.0	3533.	-6.126	1.48669E 10	9.91124E 07
9.86456E 07	5604.	160.0	3473.	-5.733	1.58545E 10	9.90909E 07
9.83892E 07	5596.	170.0	3418.	-5.312	1.68397E 10	9.90571E 07
9.81308E 07	5589.	180.0	3367.	-4.863	1.78223E 10	9.90128E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.70176E 07	5557.	0.0	4802.	-10.529	0.0	0.0
9.76663E 07	5576.	10.0	4697.	-10.288	9.73420E 08	9.73420E 07
9.82182E 07	5591.	20.0	4595.	-10.036	1.95284E 09	9.76421E 07
9.86757E 07	5604.	30.0	4496.	-9.780	2.93731E 09	9.79104E 07
9.90443E 07	5615.	40.0	4399.	-9.520	3.92591E 09	9.81478E 07
9.93284E 07	5623.	50.0	4305.	-9.254	4.91777E 09	9.83554E 07
9.95376E 07	5629.	60.0	4214.	-8.982	5.91210E 09	9.85350E 07
9.96733E 07	5633.	70.0	4125.	-8.704	6.90815E 09	9.86879E 07
9.97434E 07	5635.	80.0	4040.	-8.419	7.90523E 09	9.88154E 07
9.97532E 07	5635.	90.0	3957.	-8.125	8.90272E 09	9.89191E 07
9.97096E 07	5634.	100.0	3877.	-7.823	9.90003E 09	9.90003E 07
9.96129E 07	5631.	110.0	3801.	-7.511	1.08966E 10	9.90603E 07
9.94764E 07	5627.	120.0	3727.	-7.187	1.18921E 10	9.91007E 07
9.93016E 07	5622.	130.0	3657.	-6.849	1.28860E 10	9.91228E 07
9.90983E 07	5616.	140.0	3590.	-6.496	1.38780E 10	9.91283E 07
9.88669E 07	5610.	150.0	3527.	-6.125	1.48678E 10	9.91186E 07
9.86195E 07	5603.	160.0	3468.	-5.732	1.58552E 10	9.90951E 07
9.83625E 07	5596.	170.0	3412.	-5.312	1.68401E 10	9.90596E 07
9.80995E 07	5588.	180.0	3361.	-4.863	1.78224E 10	9.90135E 07

MK 45-8 HSO

CD	EMIN	TW	WC
1.65005 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.70590E 07	5558.	0.0	4796.	-10.528	0.0	0.0
9.77005E 07	5577.	10.0	4691.	-10.287	9.73798E 08	9.73798E 07
9.82477E 07	5592.	20.0	4589.	-10.035	1.95254E 09	9.76769E 07
9.86983E 07	5605.	30.0	4490.	-9.780	2.93827E 09	9.79423E 07
9.90649E 07	5615.	40.0	4394.	-9.519	3.92708E 09	9.81771E 07
9.93449E 07	5623.	50.0	4299.	-9.253	4.91913E 09	9.83826E 07
9.95501E 07	5629.	60.0	4208.	-8.981	5.91360E 09	9.85601E 07
9.96818E 07	5633.	70.0	4119.	-8.703	6.90976E 09	9.87109E 07
9.97481E 07	5635.	80.0	4034.	-8.418	7.90691E 09	9.88364E 07
9.97521E 07	5635.	90.0	3951.	-8.125	8.90441E 09	9.89379E 07
9.97029E 07	5634.	100.0	3871.	-7.822	9.90168E 09	9.90168E 07
9.96051E 07	5631.	110.0	3795.	-7.510	1.08982E 10	9.90747E 07
9.94632E 07	5627.	120.0	3721.	-7.186	1.18936E 10	9.91130E 07
9.92856E 07	5622.	130.0	3651.	-6.849	1.28873E 10	9.91331E 07
9.90772E 07	5616.	140.0	3584.	-6.496	1.38791E 10	9.91365E 07
9.88453E 07	5609.	150.0	3521.	-6.125	1.48687E 10	9.91248E 07
9.85950E 07	5602.	160.0	3462.	-5.731	1.58559E 10	9.90995E 07
9.83316E 07	5595.	170.0	3406.	-5.311	1.68406E 10	9.90621E 07
9.80681E 07	5587.	180.0	3356.	-4.862	1.78225E 10	9.90141E 07

MK 45-8 HSO

CD	EMIN	TH	WC
1.6500E 06	0.0200	22.50	17.50

OPT. ALT.	BT	DK	HASL
3984.6	180.0	3.14382	0.

AREA	RADIUS	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE AREA
9.70950E 07	5559.	0.0	4790.	-10.527	0.0	0.0
9.77370E 07	5578.	10.0	4685.	-10.286	9.74160E 08	9.74160E 07
9.82772E 07	5593.	20.0	4584.	-10.034	1.95423E 09	9.77115E 07
9.87234E 07	5506.	30.0	4484.	-9.779	2.93923E 09	9.79744E 07
9.90833E 07	5616.	40.0	4388.	-9.518	3.92827E 09	9.82067E 07
9.93618E 07	5624.	50.0	4294.	-9.252	4.92049E 09	9.84098E 07
9.95605E 07	5629.	60.0	4202.	-8.980	5.91510E 09	9.85850E 07
9.96863E 07	5633.	70.0	4114.	-8.702	6.91134E 09	9.87334E 07
9.97485E 07	5635.	80.0	4028.	-8.417	7.90851E 09	9.88563E 07
9.97491E 07	5635.	90.0	3945.	-8.124	8.90599E 09	9.89535E 07
9.96965E 07	5633.	100.0	3865.	-7.822	9.90322E 09	9.90322E 07
9.95955E 07	5630.	110.0	3789.	-7.509	1.08997E 10	9.90880E 07
9.94505E 07	5626.	120.0	3715.	-7.185	1.18949E 10	9.91242E 07
9.92697E 07	5621.	130.0	3645.	-6.848	1.28885E 10	9.91424E 07
9.90566E 07	5615.	140.0	3578.	-6.495	1.38801E 10	9.91438E 07
9.88195E 07	5608.	150.0	3515.	-6.124	1.48695E 10	9.91301E 07
9.85667E 07	5601.	160.0	3456.	-5.731	1.58564E 10	9.91027E 07
9.83028E 07	5594.	170.0	3401.	-5.311	1.68408E 10	9.90634E 07
9.80348E 07	5586.	180.0	3350.	-4.862	1.78225E 10	9.90137E 07

OPTIMUM IGNITION ALTITUDE= 4796. (WITHIN 6. FEET)

MK 45-8 VSF

CD	EMIN	TW	WC
1.6500E 06	0.0200	22.50	17.50

HC	BT	DK	HASL
5635.1	180.0	3.14382	0.

AREA	RADIUS2	RADIUS1	TIME	HEIGHT	VELOCITY	AREA-TIME INTEGRAL	AVERAGE ARE
1.30062E 08	1552.	6619.	0.0	4796.	-10.528	0.0	0.0
1.37437E 08	1430.	6767.	10.0	4691.	-10.287	1.33750E 09	1.33750E 08
1.44172E 08	1320.	6902.	20.0	4589.	-10.035	2.74554E 09	1.37277E 08
1.50355E 08	1221.	7025.	30.0	4490.	-9.780	4.21817E 09	1.40606E 08
1.56055E 08	1132.	7138.	40.0	4394.	-9.519	5.75022E 09	1.43756E 08
1.61326E 08	1051.	7243.	50.0	4299.	-9.253	7.33712E 09	1.46742E 08
1.66210E 08	977.	7339.	60.0	4208.	-8.981	8.97480E 09	1.49580E 08
1.70744E 08	910.	7428.	70.0	4119.	-8.703	1.06596E 10	1.52280E 08
1.74949E 08	849.	7511.	80.0	4034.	-8.418	1.23880E 10	1.54850E 08
1.78856E 08	793.	7587.	90.0	3951.	-8.125	1.41571E 10	1.57301E 08
1.82488E 08	742.	7658.	100.0	3871.	-7.822	1.59638E 10	1.59638E 08
1.85860E 08	696.	7723.	110.0	3795.	-7.510	1.78055E 10	1.61868E 08
1.88990E 08	654.	7784.	120.0	3721.	-7.186	1.96798E 10	1.63998E 08
1.91888E 08	615.	7840.	130.0	3651.	-6.849	2.15841E 10	1.66032E 08
1.94564E 08	580.	7891.	140.0	3584.	-6.496	2.35164E 10	1.67974E 08
1.97027E 08	549.	7938.	150.0	3521.	-6.125	2.54744E 10	1.69829E 08
1.99282E 08	520.	7981.	160.0	3462.	-5.731	2.74559E 10	1.71599E 08
2.01334E 08	494.	8021.	170.0	3406.	-5.311	2.94590E 10	1.73288E 08
2.03181E 08	472.	8056.	180.0	3356.	-4.862	3.14815E 10	1.74897E 08

EQJ TE7P40

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

NAD Crane, Indiana

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

AIRCRAFT PARACHUTE FLARE SIMULATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

RDTR No. 157, 1 October 1969

5. AUTHOR(S) (First name, middle initial, last name)

Angotti, Joseph J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1 Oct 1969	90	3

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	RDTR No. 157
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This report presents a computer program written in Fortran IV for the IBM 360 that is a simulation of the illumination on the ground during the descent of an aircraft parachute flare from ignition to burn out. The effect of air density on the velocity is taken into account by a numerical technique. The illumination on horizontal and vertical surfaces on the ground are considered. For the surface of interest the area consisting of those points having at least a certain value of illumination is computed. The program searches for the ignition altitude for which this area is maximized over the burn time, finds the ignition altitude for which the flare burns out at a chosen altitude, or simulates the descent with ignition at a chosen altitude. Atmospheric transmission is not considered in this report.

This study was supported by Naval Air Systems Command, AIRTASK NO. A35-532/323/69F17-546-502, Work Unit No. 2.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

UNCLASSIFIED

Security Classification

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Illumination Aircraft and Parachute Flares Optimum Ignition Altitude Air Drag Joseph J. Angotti computer simulation						

DD FORM 1 NOV 1473 (BACK)
(PAGE 2)

Security Classification