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USER'S MANUAL FOR GENERALIZED ILSGLD-ILS GLIDE SLOPE PERFORMANCE PREDICTION: MULTIPATH SCATTERING

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16. Abstract

This manual presents the computer program package for the generalized ILSGLD scattering model. The text includes a complete description of the program itself as well as a brief description of the ILS system and antenna patterns. The program listings are included as appendixes, and contain both input-generation programs and output-plotting programs.

For a technical mathematical analysis of the system see the FAA report, "ILS Glide Slope Performance Prediction: Multipath Scattering."

The present report is a partial revision of part II of report FAA-RD-74-157B. The revisions include the treatment of scattering from randomly oriented rectangular surfaces.

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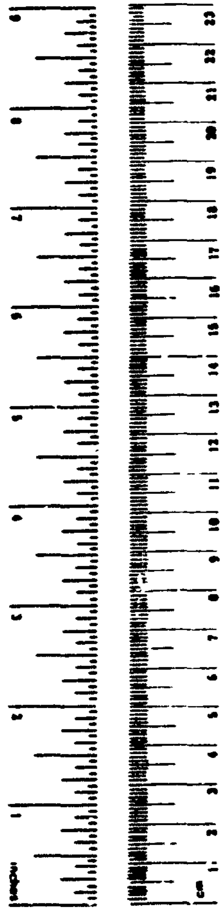
PREFACE

This document is a companion document to the Federal Aviation Administration report, "ILS Glide Slope Performance Prediction: Multipath Scattering," and contains the computer program for applying the model developed in the aforementioned report. The computational program may be used to predict the performance of new ILS glide slope systems, or modified existing systems. The manual contains a complete description of the glide slope system, the program listings, and step-by-step instructions for running the computer program.

METRIC CONVERSION FACTORS

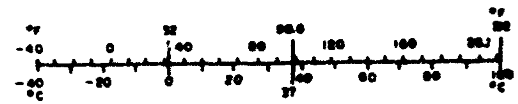
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

ILLUSTRATIONS

1. INTRODUCTION: DEFINITION OF INSTRUMENT LANDING SYSTEM

In a previous report,* a computer program (ILSGLD) was written to simulate certain terrain conditions which affect the glide slope portion of the Instrument Landing System (ILS). The ILSGLD model was developed to treat one-dimensional terrain variations. This report describes a generalized version of ILSGLD which treats two-dimensional ground plane variations, and which is able also to simulate the effects of scattering from planar, randomly oriented rectangular surfaces. A technical mathematical analysis of the system is described in a separate report.**

The ILS is used to provide signals for the safe navigation of landing aircraft during periods of low cloud cover and other conditions of restricted visual range. Separate systems are used to communicate vertical and horizontal information; the vertical system is called the "glide slope." This system operates by the transmission of an RF carrier, amplitude modulated by two audio frequencies, and beamed to approaching airborne receivers. In an instrumented aircraft, the glide slope receiver serves to demodulate the RF signal, amplify and isolate the corresponding audio signals and derive a signal to drive the ILS vertical display in the cockpit. The pilot, by reading the display, can determine if he is on course, above or below the glide path. These signals must be strong enough to cover a radius of 15 miles in front of the antenna.

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*"ILS Glide Slope Performance Prediction," FAA RD 74-157B, Part II. 9/74.

**FAA, ILS Glide Slope Performance Prediction: Multipath Scattering, In Preparation.

The directional information is determined by the relative strengths of the transmitted sideband signals. The audio frequency modulations, which are fixed at 90 and 150 Hz, are radiated in different angular patterns with respect to the intended glidepath. The "course" is defined as the locus of points where the amplitudes of the two modulations are equal. The display of a difference of the amplitudes (90 and 150 Hz) of the sidebands is referred to as the Course Deviation Indication. Thus, the CDI is the pilot's indication as to what his deviation is relative to the glidepath. The CDI is measured in microamperes. The actual course generated by any particular ILS installation will deviate from the ideal because of irregularities in the terrain. The deviation of the CDI caused by these irregularities, from the ideal receiver reading at that point in space (e.g., on the glidepath a CDI reading other than 0) is the derogation effect.

The glide slope system transmits an asymmetrical pattern by beaming a "carrier plus sideband" pattern and a "sideband only" pattern, the composite of which gives the desired effect.

2. ANTENNA PATTERNS

The proper angular variation of the transmitted 90 and 150 Hz modulation is achieved by the radiation of the two independent sideband patterns by the transmitting antenna. One pattern, the "carrier plus sideband" (C+S) signal, is radiated in a symmetrical pattern; the other pattern, the "sideband-only" (SO) signal, is radiated in an "anti-symmetrical" pattern relative to the prescribed glide angle (see Figure 1).

The C+S signal is composed of a carrier wave and paired sideband waves at 90 and 150 Hz. The sideband amplitudes are equal and represent a 40 percent modulation of the carrier wave (or a "depth of modulation" of 0.4) at both frequencies. The SO wave is a carrier wave that is equally modulated at 90 and 150 Hz to the extent that it retains no pure carrier component.

The spatial modulation pattern obtained by combining the symmetrical C+S pattern with the "anti-symmetrical" SO pattern is illustrated in Figure 1. At a given receiver point the total signal is the C+S carrier plus the combined sideband amplitudes of the C+S and SO patterns. The sideband amplitudes are phased so that above the glide path the 90 Hz amplitudes add and the 150 Hz amplitudes subtract, while below the glide path, the 90 Hz amplitudes subtract and the 150 Hz amplitudes add.

Any angular deviation of the airplane's receiver from the correct course results in a "Difference in Depth of Modulation" (DDM) between the 150 and 90 Hz signals. Since the trength of C+S and SO signals fall off at the same rate with distance from the transmitting antenna, the DDM is independent of range.

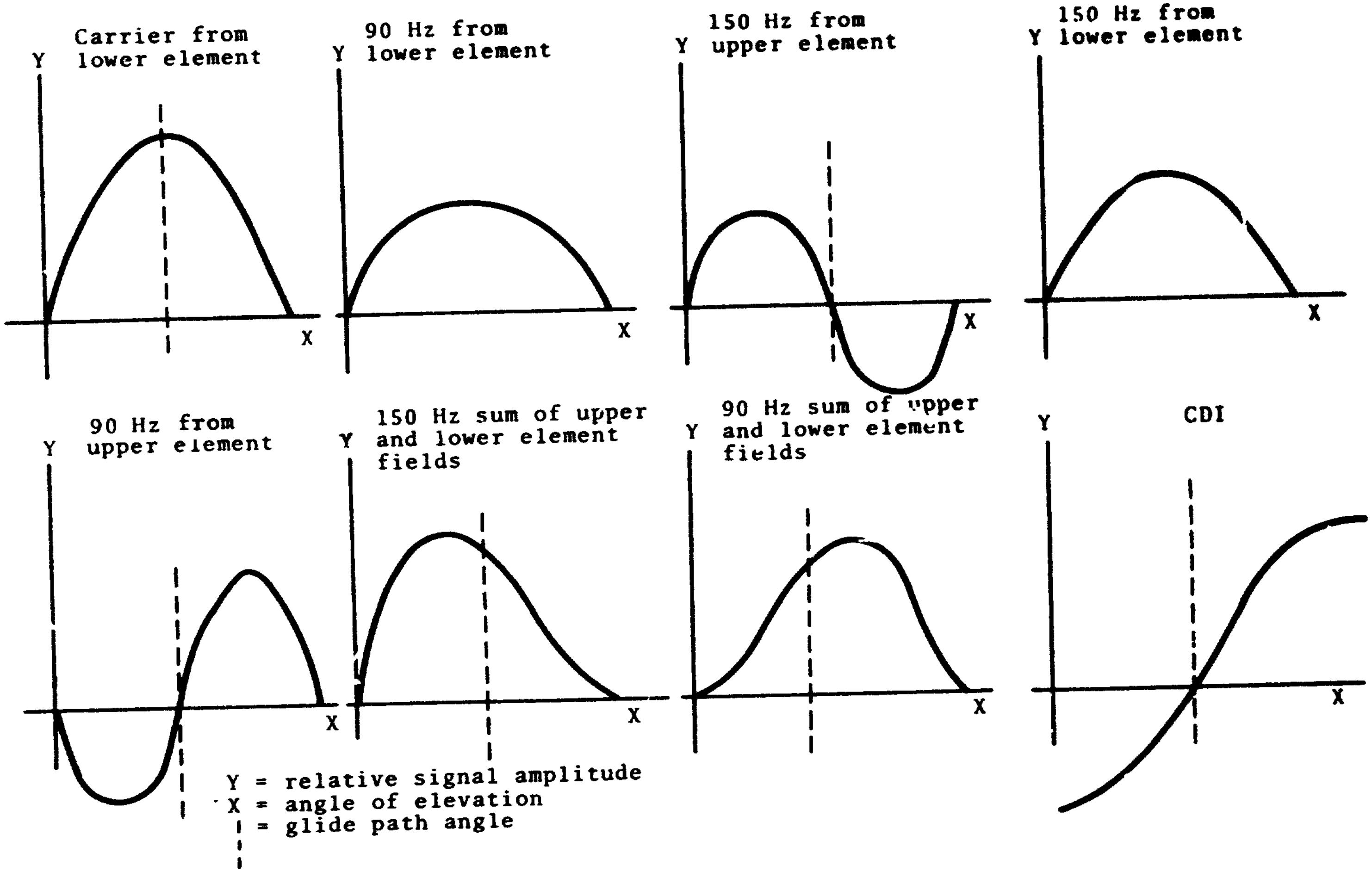


FIGURE 1. ANTENNA PATTERNS FOR NULL REFERENCE ANTENNA

The antenna patterns are generated by using arrays of one or more elements in combination with the ground as reflector. The effect of an ideal ground plane on a single element is as though there was an "image" element located below the ground and radiating equal power to the real element but with opposite phase. In a glide slope array there will be two or more elements radiating different signals to give the desired combined antenna pattern. (Note that this means that a glide slope array is defined by giving, for each element, its location and complex amplitude of the carrier and sidebands.) However, the real ground is not an ideal plane. This has the effect of distorting the element patterns and results in a derogation of the glide slope system performance.

The extended glideslope derogation simulation package consists of five programs. They are:

FMAKE.F4	Used to generate input files for the simulation.
ILSVEN.F4	Simulates the one-dimensional-variation ground. Takes input prepared by FMAKE. Outputs the complex field instensities at the various receiver locations.
MOLE.F4	Simulates the scattering from a rectangular planar surface with arbitrary orientation. Takes as input the data output from ILSVEN. Outputs a new set of fields.
GLDCDI.F4	Simulates the effects of the receiver, including CDI determination and dynamic smoothing from the instrumentation.
GLDPLT.F4	Produces graphical presentations of the CDI results from the simulation. Takes as input the data file

output from GLDCDI. Outputs graphs of various forms as determined by the user.

The inputs and operation of these programs will be given in the following sections.

The basic procedure is to prepare the input with FMAKE. The ground effects are determined by running ILSVEN. The output is a data file containing the antenna descriptors, the receiver locations and the complex field intensities for the carrier and sidebands. If desired GLDCDI may be run at this point to produce the CDI's that would be produced by this ground configuration, antenna system, and flight path. If additional scatterers are involved such as buildings or hills, they may be represented as rectangular surfaces and the derogation effects added with MOLE. MOLE may be used as often as needed to include any number of scattering surfaces. After all surfaces have been included GLDCDI is run to generate the CDI file for input to the graphing program. GLDPLT is then run to generate the graphs required.

3. GROUND EFFECT SIMULATION WITH ILSVEN

The ILSVEN program simulates the effects of a non-planar ground on the glide slope antenna system.

The program uses a ground description, an antenna description and a set of spatial coordinates for the receiver locations as input. The program calculates the outputs for each receiver location, the complex values of the fields for carrier and sidebands that would be received at that location. This represents the summation of the direct fields from each antenna element and the fields from each antenna element scattered from the parts of the ground "plane." Additionally the fields that would be produced by an ideal ground plane are included. This allows comparison with flights that do not have a simple ideal CDI along the flight path, for example, flights at right angles to the glide path such as are used to determine the course width.

The ILSVEN simulation makes certain simplifying assumptions. They include:

a. Perfectly reflecting ground surface

b. Far-field scattering--all scattering from points on the ground surface is assumed independent of all other points; thus multiple reflections and near-field interactions are ignored

c. Noise-free environment

d. Relative field strengths--the absolute field strengtns involved are not calculated. Thus, while the CDI's can be calculated in microamperes, the absolute electric field intensities are not ascertained,

e. Geometric shadowing--the shadowing of one portion of the ground on another is done by straight ray approximations assuming a total cutoff with no diffraction, and

f. Antenna elements are assumed to be simple dipoles.

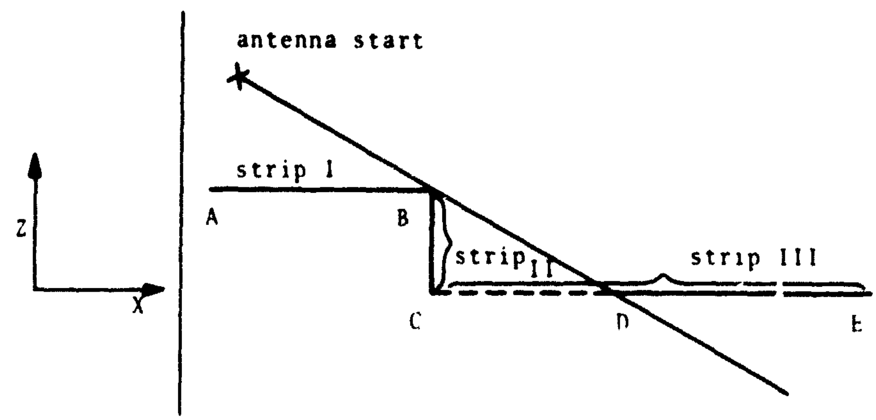
3.1 METHOD OF SIMULATION

An antenna element is described by giving its x , y- and z-coordinates and the complex amplitudes of its radiated amplitude at the three frequencies (carrier, 150 and 90 Hz sidebands). The ground is broken up into strips; these strips have an infinite width and a finite length. The infinite extent is parallel to the y-axis, that is at a right angle to the runway centerline. Thus, a ground strip is described by giving the x and z-coordinates of the leading and trailing edges of the strip. A receiver location is described by giving its time, x-, y- and z-coordinates.

The basic part of the simulation consists of calculating the field at a receiver location. This field is caused by the power radiated from an element and reflected from a strip. The receiver field can be expressed as a complex gain factor times the radiated antenna field. This gain factor is expressed as a double integral over the strip. The integration along the infinite extent (y axis direction) was approximated by using the stationary phase method. The resulting single integral is solved by a modified trapezoid rule. The trapezoid rule is used with the spacing between sample points adjusted for the derivative of the integrand.

Thus, for a given receiver location, the program takes an antenna element and calculates the "gain factor" for each ground strip, multiplies by the radiated power and sums the three complex field intensities for all ground strips. The direct field of the element at the receiver is then added. This process is repeated for all elements, giving the total field at the receiver. For comparison purposes the fields resulting from an ideal ground plane are calculated. The location of the receiver (x-, y-, z- and t coordinates) are output along with the six complex field intensit numbers. This is then repeated for each receiver location in the input file.

If the terrain is sufficiently irregular. part of the energy radiated toward a point on the ground may be intercepted by another piece of the ground closer to the antenna. This shadowing is complex including, as it does, diffraction as well as reflection. This is approximated in the simulation by using ray optics; that is, the shadow is assumed to have no diffraction at the edges and a zero field amplitude inside of the shadow. The program does this by assuming the ground is continuous; i.e, the far edge of one strip is the near edge of the next, and keeping track of the "furthest" (in angular sense) edge. If part (or all) of the next strip is "below" that edge, then that part (or all) will not be included in the trapezoid integration. For example in the sketch below:



all of strip I, none of strip II and that part of strip III between D and E will be included in the integration.

For the receiver antenna a "semi" directional antenna is assumed; that is, only the incident fields from the front half-sphere around the receiver are included. This is as though an omni-directional antenna was used but blocked by the fuselage from receiving signals from the direction of the tail. This is done in the program by stopping the summation of fields over the ground strips at a point directly below the receiver.

The back half-plane is assumed to be an ideal flat horizontal reflector of infinite extent. The field from this is included by adding the "gain factor" for this as an initial strip to that calculated by integrating over the "real" strips.

3.2 OPERATION

ILSVEN assumes the ground description is a file called GRND.DAT, and that the receiver locations are in a file called PATH.DAT. The user starts the program and then inputs the name of the file containing the antenna description. The simulation will be run, and the output will be found in file STRIP.DAT.

4. ADDITION OF SCATTERERS WITH MOLE

MOLE is used to include the derogation effects of finite scatterers. This would include sides of buildings and other man-made objects composed of flat rectangular surfaces. In addition portions of the ground surface such as hills can be simulated if they may be represented by rectangular pieces. The program takes as input a file generated by ILSVEN. This contains the antenna and flight path descriptions along with the complex fields scattered from the ground for both the non-planar ground simulated and for the ideal ground case. The program adds to these fields the fields resulting from scattering from the piece being simulated and outputs a new data file containing the input data with revised values for the complex fields. The output file being in the same format as the input file allows this output to be used as the input for another run of the MOLE program. This permits the user to continue to add in the effects of as many scatterers as desired.

The simulation makes certain simplifying assumptions. They include those explained for ILSVEN. In addition, the ground surface for the MOLE simulation is assumed to be the ideal flat horizontal ground plane. Thus the multiple reflections from the antenna element to ground to scatterer, and from scatterer to ground to receiver, are done using a simple ground plane.

To operate the program the user will have previously run ILSVEN to simulate the terrain involved When MOLE is run, the program will request:

INPUT FILE NAME:

The user types in the name of the file output from ILSVEN. This is initially named STRIP.DAT, but may have been renamed by the user if there is more than one simulation to be done.

The program will then request:

OUTPUT FILE NAME:

The user then types in the name to be given to the file to be output from MOLE. This file will contain the modified filed values in addition to the antenna and flight path data from the input.

The program will then read in the piece description data from unit 20. (Normally, it is a disk file FOR20.DAT.) These data are in free-field general FORTRAN format (3G). The data consist of the x-, y-, and z-coordinates for the four corners of the rectangle, one set of coordinates per line. The corners are described in the order that they would be scanned in traveling around the perimeter of the rectangle in a clockwise direction. In this sense, the rectangle is assumed to be facing the user. For example, the coordinates:

0.0.0,

1.0.0,

1.0.1, and

0.0.1,

describe a square, one foot on a side, situated on the centerline of the runway oriented with one side on the centerline on the ground, and one side vertical at the origin. The "front" of the square is facing in the positive y-direction. See figure example (Figure 2).

The program will then execute the simulation, output the new file, and terminate. Multiple runs, scatterers and input cases may be set up using the usual batch control features.

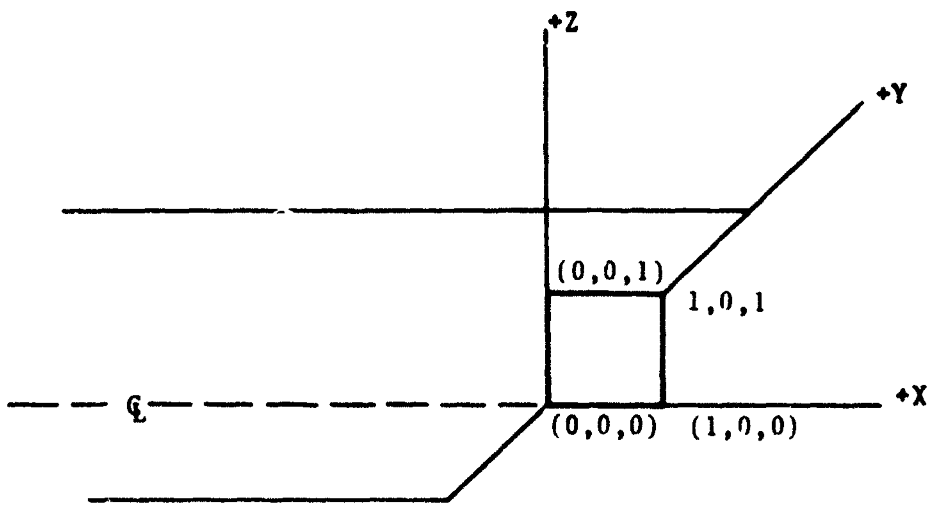


FIGURE 2. REPRESENTATION OF SQUARE SCATTERER

5. CDI DETERMINATION USING GLDCDI

The output files from ILSVEN and MOLE contain the complex field intensities for the carrier and sidebands for the cases simulated. For analysis purposes the user would usually wish to see the CDI's produced. The difference between these and the correct CDI's is the derogation that would affect the pilot in the case being studied. This CDI generation is done by GLDCDI. The program will calculate the CDI for both the static case and for a dynamic case using the smoothing time constant input in FMAKE.

To operate the program the user runs GLDCDI. The program will request:

INPUT FILE NAME:

The user then types in the name of the file (generated by ILSVEN or MOLE). The program will then request:

OUTPUT FILE NAME:

The user then types in the name of the file to be used for the output file. The program will then execute and terminate. The output file contains the CDI's static and dynamic for both the simulation and the ideal ground case. The various CDI's may be graphic using GLDPLT.

6. FMAKE PROGRAM DESCRIPTION

FMAKE is a file generation program used to create input files for ILSVEN. It is designed to be used interactively. The user starts by running the program. The program will respond by typing:

INPUT SWITCH:

The user then types in a single character switch, followed by a <CR>, for the file he wishes to generate. The program will then respond with a request for the input required for that file. If a blank is used as the input switch the program will terminate. If any character other than those explained below are used, an error message will be given. After each file is generated, the program will return to the switch input point thus allowing the user to generate the data files for many simulation runs in one sitting.

(N.B. All units are in feet unless otherwise stated)

6.1 SWITCH: Y

For this switch (Y), the program will type:

INPUT YO, LAMBDA:

The user then inputs in free field format the y-offset (i.e., the y-coordinate) of the antenna elements and the wavelength of the carrier, followed by a <CR>. The y-offset is the distance from the base of the antenna to the centerline of the runway. As this information is required for both the antenna description and the flight path, it is input with a separate switch to avoid repetition.

6.2 SWITCH: G

This switch (G) is used to input the ground description. The program will respond with:

INPUT GROUND FILE NAME:

The user then inputs a <five(5) character name for the ground description file, followed by a <CR>. ILSGLD requires the ground file to be called GRND.DAT. (The .DAT extension is a system default.) FMAKE allows the user to generate several ground files with different names at one sitting. Then by using system renaming commands, a single batch job may be set up that will run many simulations without further user interactions.

The program will then type:

INPUT GROUND LABEL.

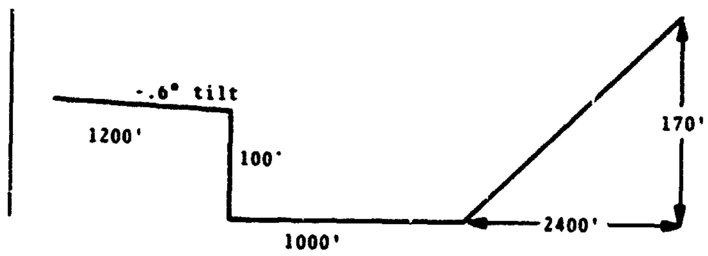
The user then inputs up to 40 characters to be used as a label for this ground description. The label is carried in the ground description file and will be placed in the output file by ILSGLD. It allows the GLDPLT program to label the plots with the ground description. This is necessary if a batch job generates plots from more than one simulation.

The program will then type:

INPUT GROUND SEGMENTS. STARTING FROM ANTENNA GIVE CONSECUTIVELY EITHER X AND Z INCREMENTS OR THE LENGTH AND ANGLE FROM HORIZONTAL IN DEGREES, SEPARATED BY A ZERO. HIT CARRIAGE RETURN FOR END OF DATA, OR IF THERE ARE NO MORE STRIPS.

The user inputs ground strip end points in either Cartesian or polar increments using two or three fields respectively. They are input in floating free field format followed by a <CR . The first point is taken relative to the origin and is the near edge of the closest strip to the antenna. The second point is the far edge of the first strip and the near edge of the second strip.

This second point is relative to the first. This will continue for additional strips until a <CR> is hit with no data, at which point the program will return to the switch input. For example to input this profile:



The input would be

0.,0.

1200., 0., -.6

0., -100.

2400., 170.

There is a maximum of 20 strips allowed in both FMAKE and ILSGLD. This is determined by array sizes and could be changed if desired.

6.3 SWITCH: P

This is used to generate a flight path file. The program will respond:

INPUT FLIGHT PATH FILE NAME:

The user then inputs a five (5) character file name (the name must be exactly 5 characters). ILSGLD requires the flight path to be in a file called PATH.DAT (for explanation of multiple files see SWITCH:G). The program will then type:

INPUT FLIGHT PATH TITLE:

The user then inputs a title, using up to 40 characters, for the flight path. This is used as a label on the plots ouput by GLDPLT. The program will then type:

INPUT FLIGHT PATH TYPE:

The user has a choice of two flight path types, linear or hyperbolic. For a linear flight path, typa a <CR>; for a hyperbolic path type a 'G' followed by a <CR>. When it is a linear flight the program will respond:

INPUT X0, Y0, Z0:

The user then inputs the x-, y-, and z-coordinates of the first receiver point in free field floating point format followed by a <CR>. The program will respond:

INPUT XF, YF, ZF:

The user then inputs the final receiver location in the same way. The program then types:

INPUT # OF POINTS, VELOCITY, TIME CONSTANT:

The user then inputs the total number of receiver locations desired in integer free field format, followed by the velocity of the aircraft in feet/sec. in floating point free field and the time constant in seconds (usually 0.4) used for the "inertia" of the receiver in dynamic simulation. The program will then generate the data file and return to the SWITCH POINT.

The actual ideal surface of zero CDI is a hyperboloid of two sheets whose axis of rotation is parallel to the z-axis and passes through the antenna. For comparison purposes it is convenient to have the aircraft travel along this surface and see how the real CDI deviated from 0. If the glide path is used for linear flight in the near field (between threshold and antenna) large CDI's will occur because of the hyperbolic shape. The program will allow the user to generate a hyperbola which is the intersection of the 0 CDI surface and the plane containing the runway centerline parallel to the z-axis. To do this the user types a 'G' for the flight path type. The program will respond:

INPUT XO, XF, H:

The user inputs these in floating point free field format followed by a <CR>. XO is the x-coordinate of the initial receiver point (YO is zero and ZO is specified by the hyperboloid), XF is the x-coordinate of the final receiver point. H is the height of the main carrier element in the antenna array. The program will then respond:

INPUT # OF POINTS, VELOCITY, TIME CONSTANT

These are input as above. The program will generate the file and return to the switch point.

6.4 SWITCH: A

This switch is used to generate the antenna description file. The program will respond:

INPUT ANTENNA FILE NAME:

The user inputs the 5 character file name. The program will type:

INPUT ANTENNA DESCRIPTION:

The user inputs a <40 character antenna description to be used as a plot label. The program will then type:

INPUT ELEMENT VALUES·

The user then types in, in free field floating format, a maximum of 8 fields followed by a <CR>. The fields have the following use:

field #	use
1	x-coordinate of element (usually 0)
2	z-coordinate of element (height)
3	real amplitude of carrier
4	imaginary amplitude of carrier
5	real amplitude of 150 Hz side band
6	imaginary amplitude of 150 Hz side band
7	real amplitude of 90 Hz side band
8	imaginary amplitude of 90 Hz side band

This element inputting is repeated for each element. After the last element is input an extra carriage return is typed. No y-coordinate is input for the elements. This is because nominally all the elements have the same y offset (the value input as YO under switch:Y). However, a small offset correction is applied for near field correction. An explanation of this correction may be found in part I (see discussion preceeding Eq. (33)). This is automatically done by the program. As the first element input is assumed to have the correct offset, it will always have a value of YO. Thus the main carrier element should be input first, for example, a null reference antenna was input as follows:

INPUT SWITCH: Y

INPUT YO, LAMBDA: 300., 3.

7. GLDPLT PROGRAM DESCRIPTION

GLDPLT is a plotting output program to graph the CDI information from GLDCDI. The user runs GLDPLT which then types:

INPUT FILE NAME AND AXIS TYPE:

The user then types in a 5 character (left-justified and blank filled to 5 characters) and two integer fields in free field format. The first integer is the switch for x-axis type and the second integer is the switch for the y-axis. The y-switch has two values, 1 and 2, the x-switch has three 1, 2, and 3; any other values will terminate the program.

The switches have the following use:

y-switch=1 this plots the static CDI values

y-switch=2 this plots the dynamic CDI values

x switch=1 this uses the altitude angle, in degrees measured from the origin of the receiver point as x-coordinate

x-switch=2 this uses the x-coordinate of the receiver as the x-axis

x-switch=3 uses the time in seconds, at the receiver point, as the x-coordinate.

After the input, a plot is generated and the program returns to the input and asks for the data for the next plot. The user can give the same file name to plot the data differently, or a new file name can be given. This would be done when multiple runs were done before plotting, the output file from each simulation run carrying its own name.

INPUT SWITCH: A

INPUT ANTENNA FILE NAME: NULL

INPUT ANTENNA DESCRIPTION

NULL REFERENCE ANTENNA

INPUT ELEMENT VALUES

0., 15., 1., 0., .4, 0., .4, 0.

0., 30., 0., 0., -.12. 0., .12, 0.

APPENDIX A ILSVEN

```
      DIMENSION ILABL(8)
      DIMENSION IPTDAT(33)
      COMMON /PLKT/ NRP,RXMN,RXMX,RXFT,RXLT,RYMN,RYMX,RYFT,RYLT,
     1RZMN,RZMX,RZFT,RZLT,RTMN,RTMX,RTFT,RTLT,
     2AIMN,AIMX,AIFT,AILT,ARMN,ARMX,ARFT,ARLT,
     3ADIN,ADIX,ADIF,ADIL,
     4ADRN,ADRX,ADRF,ADRL
      EQUIVALENCE (IPTDAT(1),NRP)
      IMPLICIT COMPLEX (C)
      DIMENSION X(20),Y(20),Z(20)
      DIMENSION CF1(20),CF2(20),CF3(20)
      IMPLICIT DOUBLE PRECISION (D)
      COMMON /REC/RX,RY,RZ,RT,NSIZF
      REAL LAMBDA
      COMMON /GROUND/ K,X1(20),Z1(20),X2(0/20),Z2(0/20),IEL
      COMMON /ANT/AX,AY,AZ,LAMBDA,DAK,DPI
      COMMON /VAL/ HR,HI
C
C        THIS VALUE OF TWO PI IS INITIALIZED THIS WAY TO AVOID USING
C BLOCK DATA
      DPI=6.2831853071795864769
C
C        THIS OPENS THE OUTPUT FILE
      CALL OFILE(1,'STRIP')
C
C        THIS SUBROUTINE OPENS THE FLIGHT PATH FILE AND RETURNS WITH
C THE FLIGHT PATH PLOT LABEL (ILABL) AND TIME CONSTANT (TAU)
C THE FILE WAS SET UP WITH JOVRAX SO THIS SUBROUTINE AND INPUT ARE
C USED TO FACILITATE MODIFACTIONS
      CALL IF(ILABL,TAU)
1000  FORMAT(8A5,F)
      WRITE(1,1000) ILABL,TAU
C
C        THIS SECTION INITIALIZES SOME CONSTANTS
      NRP=0
C
C        THIS SECTION INPUTS THE GROUND STRIPS DECSRIPTIONS
      CALL IFILE(20,'GRND')
      READ(20,1000) ILABL
      WRITE(1,1000) ILABL
      READ(20) K,X1,Z1,X2,Z2
      CALL RELEAS (20)
C
C        THIS SECTION INPUTS THE ANTENNA FILE NAME TO BEUSED
C AND THEN INPUTS THE ANTENNA ELEMENT DESCRIPTIONS
      WRITE(5,2001)
2001  FORMAT(' INPUT ANTENNA FILE NAME:',$)
      READ(5,2000) ILBL
2000  FORMAT(A5)
      CALL IFILE(20,ILBL)
      READ(20,1000) ILABL
      WRITE(1,1000) ILABL
      READ(20) LAMBDA,NEL,(X(I),Y(I),Z(I),CF1(I),CF2(I),CF3(I),I=1,NEL)
```

```
      WRITE(1) LAMBDA,NEL,(X(I),Y(I),Z(I),CF1(I),CF2(I),CF3(I),I=1,NEL)
      CALL RELEAS (20)
      SQRT2L=1./SQRT(2.*LAMBDA)
      TEMP2=LAMBDA
      DAK=DPI/DBLE(LAMBDA)
      SAK=SNGL(DAK)
C
C     THIS IS THE MAIN LOOP FOR THE SIMULATION.  THE RECEIVER
C LOCATION IS READ IN BY INPUT.  THE DATA IS IN COMMON 'REC'
C THE INPUT BEING DONE BY JOVRAX.  IF THERE ARE NO MORE RECEIVER
C POINTS THE SUBROUTINE RETURNS TO 200.
201   CALL INPUT($200)
C
C     THIS SECTION INITIALIZES THE COMPLEX AMPLITUDES FOR
C THE RECEIVED FIELD AS FOLLOWS:
C     CFR1    CARRIER WITH 'REAL' GROUND
C     CFR2    150 HZ SIDEBAND WITH 'REAL' GROUND
C     CFR3    90HZ SIDEBAND WITH 'REAL' GROUND
C     CFS1    CARRIER WITH 'IDEAL' FLAT GOUND PLANE
C     CFS2    150HZ WITH 'IDEAL' GROUND
C     CFS3    90 HZWITH 'IDEAL' GROUND
      CFR1=(0.,0.)
      CFR2=(0.,0.)
      CFR3=(0.,0.)
      CFS1=(0.,0.)
      CFS2=(0.,0.)
      CFS3=(0.,0.)
      R2=SQRT(RX*RX+RZ*RZ)
C
C     THIS LOOP IS OVER THE ELEMENTS OF THE ANTENNA
C THE COMPLEX FIELDS ARE SUMMED IN CFR1,CFR2 ETC.
      DO 3 IEL=1,NEL
C
C     THESE ARE THE LOCATION COORDINATES OF THE ANTENNA ELEMENTS
C AND CONSTANTS USED IN THE STRIP INTEGRATION
      AX=X(IEL)
      AY=Y(IEL)
      AZ=Z(IEL)
      DELX=RX-AX
      DELY=RY-AY
      DELZ=RZ-AZ
      DR=DSQRT(DELX*DELX+DELY*DELY+DELZ*DELZ)
      R=SNGL(DR)
      DR=DR*DAK
      IL=DR/DPI
C
C     THIS SECTION INITIALIZES  HR AND HI TO INCLUDE THE
C SEMI-INFINITE REAR GROUND PLANE
      TEMP2=DR-DBLE(FLOAT(IL))*DPI
      TEMP=RZ+AZ
      F1=SQRT(TEMP*TEMP+AY*AY)
      F2=-RX*TEMP/(R2*F1)
      TC=SQRT(1.+AY*AY/(TEMP*TEMP))
```

```
        TD=TP*A2
        R1=R2*TC
        S=SQRT((1./R2+1./A2)/(TC*TC*TC)).
        G=RX/(TD*TD*R1*R1*S)
        TEMP=SAK*F1
        SF=SIN(TEMP)
        FC=COS(TEMP)
        TEMP=A2*G/DAK/F2
C
C          HR AND HI ARE THE REAL AND IMAGINARY PARTS OF THE COMPLEX
C 'GAIN' FACTOR OF THE GROUND SURFACE SCATTERING TO THE RECIEVER
C LOCATION
        HR=-TEMP*(SF+FC/(DAK*TD))
        HI=TEMP*(FC-SF/(DAK*TD))
C
C          THIS SUBROUTINE SUMS THE 'GAIN' FACTOR FOR EACH STRIP OF
C THE GROUND SURFACE
        CALL SCAT
C
C          THIS SECTION INCLUDES THE EFFECT OF THE DIRECT RADIATION FROM
C THE ANTENNA ELEMENT AT THE RECEIVER
        HR=HR*SQRT2L
        HI=HI*SQRT2L
        TEMP=DELX/(R*R)
        SF=SIN(TEMP2)
        FC=COS(TEMP2)
C
C          CTEMP IS THE COMPLEX GAIN FACTOR INCLUDING ALL RADIATION FROM
C THIS ELEMENT
        CTEMP=CMPLX(-TEMP*SF+HR-HI,TEMP*FC+HR+HI)*.5/LAMBDA
C
C          THIS SECTION ACCUMULATES THE FIELDS OF THE VARIOUS FREQUENCIES
        CFS1=CFS1+CTEMP*CF1(IFL)
        CFS2=CFS2+CTEMP*CF2(IFL)
        CFS3=CFS3+CTEMP*CF3(IEL)
        ALPH=SAK*2.*A2*R2/R
        CTEMP=TEMP*.5/LAMBDA*CMPLX(-SF,FC)*
       1CMPLX((1.-COS(ALPH)),-SIN(ALPH))
        CFR1=CFR1+CTEMP*CF1(IEL)
        CFR2=CFR2+CTEMP*CF2(IEL)
        CFR3=CFR3+CTEMP*CF3(IFL)
3       CONTINUE
        WRITE(1,2003) RX,RY,RZ,RT,CFR1,CFR2,CFR3,CFS1,CFS2,CFS3
2003    FORMAT(4F,/,6E13.6,/,6E13.6)
        GO TO 201
C
C          THIS IS THE TERMINATION SECTION.  THE INITIAL RECORD ON
C THE OUTPUT FILE IS WRITTEN AND THE PROGRAM TERMINATES.
200     CALL RELEAS (1)
        CALL EXIT
        STOP
        END
```

```
ILOVEN.F4        F40     V27(360)        22-APR-76       11:09

        CONSTANTS

        P       203622077325    1       150442799001    2       000000000001    3       510012044640    4       000000000000
        5       000000000024    6       434451042100    7       000000000000    10      000000000000

        COMMON

        NRP     /PLXT  /+0      RXMN    /PLXT  /+1      RXMX    /PLXT  /+2      RXFT    /PLXT  /+3      RXLT    /PLXT  /+4
        RYMN    /PLXT  /+5      RYMX    /PLXT  /+6      RYFT    /PLXT  /+7      RYLT    /PLXT  /+10     RZMN    /PLXT  /+11
        RZMX    /PLXT  /+12     RZFT    /PLXT  /+13     RZLT    /PLXT  /+14     RTMN    /PLXT  /+15     RTMX    /PLXT  /+16
        RTFT    /PLXT  /+17     RTLT    /PLXT  /+20     AIMN    /PLXT  /+21     AIMX    /PLXT  /+22     AIFT    /PLXT  /+23
        AILT    /PLXT  /+24     ARMN    /PLXT  /+25     ARMX    /PLXT  /+26     ARFT    /PLXT  /+27     ARLT    /PLXT  /+30
        ADIN    /PLXT  /+31     ADIX    /PLXT  /+32     ADIF    /PLXT  /+33     ADIL    /PLXT  /+34     ADRN    /PLXT  /+35
        ADRX    /PLXT  /+36     ADRF    /PLXT  /+37     ADRL    /PLXT  /+40     RX      /REC   /+0      RY      /REC   /+1
        RZ      /REC   /+2      RT      /REC   /+3      NSIZE   /REC   /+4      K       /GROUND/+0      X1      /GROUND/+1
        Z1      /GROUND/+25     X2      /GROUND/+51     Z2      /GROUND/+76     IEL     /GROUND/+123    AX      /ANT   /+0
        AY      /ANT   /+1      AZ      /ANT   /+2      LAMBDA  /ANT   /+3      DAK     /ANT   /+4      DPI     /ANT   /+6
        NP      /VAL   /+0      NI      /VAL   /+1      IPTDAT  /PLXT  /+0

        SUBPROGRAMS

        FORSE.  .JOFF   DFILE   IF      ALPHC.  ALPHI.  FLOUT.  FLIRT.  IFILE   BINWR.  RELEAS  SQRT    DBLE    DFD.2   SNGL
        INPUT   DSQRT   DFM.2   DFM.4   DFA.2   DFM.4   DFMM.2  IDINT   FLOAT   DFM.0   DFS.0   SIN     COS     DFD.4   DFA.4
        DFS.4   SCAT    CMPLX   CFD.2   CFM.2   CFM.0   EXIT

        SCALARS

        DPI     6               TAU     1017            NRP     0               K       0               ILBL    1020
        LAMBDA  3               NEL     1021            T       1022            SQRT2L  1023            TEMP2   1024
        DAK     4               SAK     1025            CFR1    1026            CFR2    1030            CFR3    1032
        CFS1    1034            CFS2    1036            CFS3    1040            R2      1042            RX      0
        RZ      2               IEL     123             AX      0               AY      1               AZ      2
        DELX    1043            DELY    1045            RY      1               DELZ    1047            DR      1051
        R       1053            IL      1054            TEMP    1055            F1      1056            F2      1057
        TC      1060            TD      1061            R1      1062            S       1063            C       1064
        SF      1065            FC      1066            NP      0               NI      1               CTEMP   1067
        ALPH    1071            RT      3               RXMN    1               RXMX    2               RXFT    3
        RXLT    4               RYMN    5               RYMX    6               RYFT    7               RYLT    10
        RZMN    11              RZMX    12              RZFT    13              RZLT    14              RTMN    15
        RTMX    16              RTFT    17              RTLT    20              AIMN    21              AIMX    22
        AIFT    23              AILT    24              ARMN    25              ARMX    26              ARFT    27
        ARLT    30              ADIN    31              ADIX    32              ADIF    33              ADIL    34
        ADRN    35              ADRX    36              ADRF    37              ADRL    40              NSIZE   4

        ARRAYS

        ILABL   1072            IPTDAT  0               X       1102            Y       1126            Z       1152
        CF1     1176            CF2     1246            CF3     1316            X1      1               Z1      25
        X2      51              Z2      76
```

ADIF	3										
ADIL	3										
ADIM	3										
ADIX	3										
ADRF	3										
ADRL	3										
ADRM	3										
ADRX	3										
AIFT	3										
AILT	3										
AIMN	3										
AIMX	3										
ALPH	142	143									
ANT	16										
ARFT	3										
ARLT	3										
ARMN	3										
ARMX	3										
AX	16	89	92								
AY	16	90	93	104	106						
AZ	16	91	94	103	107	109	114	142			
CF1	11	53	54	139	145						
CF2	11	53	54	140	146						
CF3	11	53	54	141	147						
CFR1	75	145	149								
CFR2	76	146	149								
CFR3	77	147	149								
CFS1	78	139	149								
CFS2	79	140	149								
CFS3	80	141	149								
CMPLX	136	143									
COS	113	132	143								
CTEMP	136	139	140	141	143	145	146	147			
DAK	16	58	59	97	114	1'9	170				
DBLE	90	102									
DELX	92	95	130								
DELY	93	95									
DELZ	94	95									
DPI	16	21	58	98	102						
DR	95	96	97	98	102						
DSQRT	95										
EXIT	15'										
F1	104	105	111								
F2	109	114									
FC	113	119	120	132	136	143					
FLOAT	102										
G	110	114									
GROUND	15										
HI	17	120	129	136							
HR	17	119	120	136							
I	53	54									
IEL	15	85	89	90	91	139	140	141	145	146	147
IF	30										

IFILE	30	50											
IL	90	102											
ILAM	1	31	32	39	40	51	52						
ILBL	40	50											
INPUT	60												
IPTDAT	2	8											
K	15	41											
LAMBDA	14	18	93	94	96	97	98	130	143				
NEL	33	94	85										
NMP	3	8	55										
NSIRK	13												
OFILE	34												
PLOT	3												
Q	96	130	142										
Q1	100	119											
Q2	81	103	105	108	120								
REC	13												
RELEAS	42	95	155										
RT	13	149											
RTFT	3												
RTLT	3												
RTMN	3												
RTMX	3												
RX	13	81	92	105	120	149							
RXFT	3												
RXLT	3												
RXMN	3												
RXMX	3												
RY	13	83	149										
RYFT	3												
RYLT	3												
RYMN	3												
RYMX	3												
RZ	13	81	84	142	149								
RZFT	3												
RZLT	3												
RZMN	3												
RZMX	3												
S	109	110											
SAN	99	111	142										
SCAT	124												
SF	112	119	120	131	136	143							
SIN	112	131	143										
SNBL	99	96											
SORT	56	81	124	126	129								
SORTBL	96	128	129										
TAU	30	37											
TC	106	107	110	120									
TD	107	117	119	120									
TEMP	103	104	105	106	111	112	113	114	119	120	130	134	143
TEMP2	97	102	131	132									
VAL	17												
X	10	53	54	89									
X1	15	41											
X2	15	41											
Y	10	53	54	90									
Z	10	53	54	91									
Z1	15	41											
Z2	15	41											
3P	85	148											
200P	[illegible]	155											
201P	65	151											
1000P	31	32	39	40	51	52							
2000P	48	49											
2001P	46	47											
2003P	149	150											

```
ILSVEN.F4      F40      (27)307)      22-APR-78      13:09

1        C
2        C        THIS SUBROUTINE OPENS THE FLIGHT PATH FILE AND INPUTS THE
3        C FLIGHT PATH PLOT LABEL AND THE VERTICAL TIME CONSTANT
4        C
5        C        THIS SUBROUTINE INPUTS THE RECEIVER LOCATION
6        C COORDINATES OF THE NEXT POINT ON THE FLIGHT PATH.  IF THERE
7        C ARE NO MORE POINTS THE SUBRO TINE EXITS TO THE
8        C END RETURN POINT
9              SUBROUTINE IF(ILAB,TAU)
10             DIMENSION ILABL(8)
11             COMMON/REC/ DUM(4),NSIZE
12             CALL JOVSET(1,'PATH.DAT',NS)
13             WRITE(5,1000) NS
14       1000  FORMAT(I5,' RECORDS IN PATH.DAT'/)
15             NSIZE=(NS-8)/4
16             CALL JOVMI(1,ILABL,0,8)
17             CALL JOVMI(1,TAU,1,8)
18             RETURN
19             END

CONSTANTS

0      200000000001     1      577777444134     2      422022420100     3      000000000000     4      000000000010

GLOBAL COMMONS

ILABL   60              TAU     67

COMMON

DUM     /REC   /+0       NSIZE   /REC   /+4

SUBPROGRAMS

JOVSET  INTO    INTL    JOVMI

SCALARS

IF      70              NS      71               NSIZE   4              TAU     67

ARRAYS

ILABL   66              DUM     0


DUM         11
IF           9
ILABL        9      12      16
JOVSET      12
JOVMI       16      17
NS          12      13      15
NSIZE       11      15
REC         11
TAU          9      17

 1000P      13      14
```

```
1          SUBROUTINE INPUT(S)
2          COMMON /REC/ RX(4),NSIZE
3          IF(NSIZE .LE. 0) RETURN 1
4          CALL JOVMI(1,RX,4,0)
5          NSIZE=NSIZE-1
6          RETURN
7          END

CONSTANTS

0       000000000001    1       000000000004    2       000000000000

COMMON

RX      /REC    /+0     NSIZE   /REC    /+4

SUBPROGRAMS

JOVMI

SCALARS

INPUT   36              NSIZE   4

ARRAYS

RX      0


INPUT       1
JOVMI       4
NSIZE       2       3       5
REC         2
RX          2       4
```

```
C
C      THIS SUBROUTINE SUMS THE EFFECTS OF THE STRIPS THAT MAKE
C UP HE GROUNDSURFACE.  THERE ARE 'K' STRIPS DESCRIBED IN COMMON
C GROUND AS FOLLOWS:
C      X1(I)   THE X-COORDINATE OF THE LEADING EDGE OF THE I'TH STRIP
C      Z1(I)   THE Z-COORDINATE OF THE LEADING EDGE OF THE I'TH STRIP
C      X2(I)   THE X-COORDINATE OF THE ENDING EDGE OF THE I'TH STRIP
C      Z2(I)   THE Z-COORDINATE OF THE ENDING EDGE OF THE I'TH STRIP
      SUBROUTINE SCAT
      COMMON /REC/ RX,RY,RZ
      COMMON /ANT/AX,AY,AZ
      COMMON /GROUND/ K,X1(20),Z1(20),X2(0/20),Z2(0/20),IEL
      COMMON /SEG/ XX1,ZZ1,XX2,ZZ2,N
C
C      THESE ARE INITIAL VALUES FOR THE PARAMETERS USED IN SHADOWING
      SLOPE=-1.
      PHIE=-1.
C
C      THIS IS THE LOOP OVER THE STRIPS
      DO 1 I=1,K
C
C      THESE ARE THE VALUES TO BE USED IN THE STRIP
C INTEGRATION SUBROUTINE
C      XX1    LEADING X-COORDINATE
C      ZZ1    LEADING Z-COORDINATE
C      XX2    TRAILING X-COORDINATE
C      ZZ2    TRAILING Z-COORDINATE
      XX1=X1(I)
      ZZ1=Z1(I)
      XX2=X2(I)
      ZZ2=Z2(I)
C
C      THIS IS A TEST TO SEE IF THE SUMMATION OVER THE GROUND
C STRIPS HAS REACHED THE RECEIVER LOCATION.  IF IT HAS THE SUMMATION
C IS STOPPED.  THIS IS TO GIVE THE EFFECT OF FOWARD LOCKING RECEIVER
C ANTENNA PATTERN.
      IF( XX1 .GE. RX) GO TO 6
C
C      IF THE RECIEVER IS LOCATED OVER THE MIDDLE PORTION OF A STRIP
C THE STRIP WILL BE INTEGRATE ONLY UP TO THE VALUE OF THE
C RECEIVER X-COORDINATE
      IF(XX2 .LE. RX) GO TO 5
      ZZ2=ZZ1+(RX-XX1)*(ZZ2-ZZ1)/(XX2-XX1)
      XX2=RX
    5 CONTINUE
C
C      THIS SECTION DOES THE SHADOWING.  IF PART OR ALL OF THE STRIP
C IS IN THE SHADOW OF A PREVIOUS STRIP, THIS STRIP WILL BE ELIMINATED
C OR MASKED TO GIVE THE EFFECT OF SHADOWING.
      DELX=XX2-AX
      IF(DELX .LE. 0.) GO TO 3
      PHIE=(AZ-ZZ2)/DELX
      IF(SLOPE .LT. 0.) GO TO 3
```

```
ILLVEN.F4        F40      V27(360)        22-APR-76        15:09

                      IF(PHIE .GE. SLOPE) GO TO 1
                      PHID=(A2-ZZ1)/(XX1-AX)
                      IF( PHID .LE. SLOPE) GO TO 3
                      IF( XX1 .EQ. XX2) GO TO 4
                      A=(ZZ2-ZZ1)/(XX2-XX1)
                      B=ZZ1-A*(XX1-AX)
                      XX1=(A2-B)/(A-SLOPE)+AX
                4     ZZ1=SLOPE*(XX1-AX)+A2
                C
                C        THIS SUBROUTINE WILL INTEGRATE OVER THE STRIP THE
                C COMPLEX 'GAIN' EFFECT OF THIS STRIP WILL BE ADDED TO HR AND HI
                C IN COMMON 'VALL'
                3     CALL SUM
                      SLOPE=PHIE
                1     CONTINUE
                6     RETURN
                      END

CONSTANTS

P       201400000000

COMMON

RX      /REC    /+0       RY      /REC    /+1       RZ      /REC    /+2       AX      /ANT    /+0       AY      /ANT    /+1
AZ      /ANT    /+2       K       /GROUND/+0        Y1      /GROUND/+1        Z1      /GROUND/+29       X2      /GROUND/+91
Z2      /GROUND/+74       IEL     /GROUND/+123      XX1     /SEG    /+0       ZZ1     /SEG    /+1       XX2     /SEG    /+2
ZZ2     /SEG    /+3       N       /SEG    /+4

SUBPROGRAMS

SUM

SCALARS

SCAT    143               SLOPE   144               PHIE    145               I       146               K       0
XX1     0                 ZZ1     1                 XX2     2                 ZZ2     3                 RX      0
DELX    147               AX      0                 AZ      2                 PHID    150               A       151
B       152               RY      1                 RZ      2                 AY      1                 IEL     123
N       4

ARRAYS

X1      1                 Z1      29                Y2      91                Z2      76
```

A	50	59	60								
ANT	11										
AX	11	53	55	59	60	61					
AY	11										
AZ	11	52	55	60	61						
B	59	60									
DELX	50	51	52								
GROUND	12										
I	20	28	29	30	31						
IEL	12										
K	12	20									
N	13										
PHI0	55	56									
PHIE	17	52	54	67							
REC	10										
RX	10	37	42	43	44						
RY	10										
RZ	10										
SCAT	9										
SEG	13										
SLOPE	16	53	54	56	60	61	67				
SUM	66										
X1	12	28									
X2	12	30									
XX1	13	28	37	43	55	57	58	59	60	61	
XX2	13	30	42	43	44	50	57	58			
Z1	12	29									
Z2	12	31									
ZZ1	13	29	43	55	58	59	61				
ZZ2	13	31	43	52	58						

1P	20	54	60	
3P	51	53	56	66
4P	57	61		
5P	42	45		
6P	37	69		

```
C
C       THIS SUBROUTINE INTEGRATES OVER THE SURFACE STRIP DEFINED
C BY X1,Z1,X2,Z2 IN COMMON 'SEG', TO GIVE THE FIELD EFFECT
C OF THEANTENNA ELEMENT IN COMMON 'ANT' AT RECIEVER DEFINED
C IN COMMON 'REC'.  THE VARIABLES ARE AS FOLLOWS:
C       AX      ANTENNA X-COORDINATE
C       AY      ANTENNA Y-COORDINATE
C       AZ      ANTENNA Z-COORDINATE
C       LAMBDA  WAVELENGTH OF CARRIER
C       AK      TWO*PI/LAMBDA
C       DPI     TWO*PI (DOUBLE PRECISION)
C       RX      RECEIVER X-COORDINATE
C       RY      RECEIVER Y-COORDINATE
C       RZ      RECEIVER Z-COORDINATE
C       HR      REL PART OF 'GAIN' FACTOR
C       HI      IMAGINARY PART OF 'GAIN' FACTOR
C       X1      LEADING EDGE OF STRIP'S X-COORDINATE
C       Z1      LEADING Z-COORDINATE
C       X2      TRAILING EDGE X-COORDINATE
C       Z2      TRAILING Z-COORDINATE
C THE INTEGRATION IS PERFORMED BY A MODIFIED TRAPIZOID RULE.
C THE SPACING BETWEEN POINTS ALONG THE VARIABLE OF INTEGRATION
C IS VARIED BY THE RATE OF CHANGE OF THE INTEGRAND.
        SUBROUTINE SUM
      COMMON /SEG/ X1,Z1,X2,Z2,N
      DOUBLE PRECISION A1,A2,B1,B2,XL,AY2
      REAL  JR,JI,J0R,J0I,JNR,JNI
      REAL LAMBDA
       DOUBLE PRECISION AK,DPI,DR
      COMMON /ANT/AX,AY,AZ,LAMBDA,AK,DPI
      COMMON /REC/RX,RY,RZ
      COMMON /VAL/HR,HI
      REAL L3,L10
C
C       THIS IS THE INITIALIZATION SECTION
      AY2=DBLE(AY)*DBLE(AY)
      AKK=SNGL(AK)
      SE=Z2-Z1
      CE=X2-X1
C
C       XMAX IS THE LENGTH ALONG THE SURFACE OF THE STRIP
      XMAX=SQRT(SE*SE+CE*CE)
C
C       THESE ARE THE SIN AND COS OF THE ANGLE THE STRIP MAKES WITH
C A HORIZONTAL PLANE
      SE=SE/XMAX
      CE=CE/XMAX
      JR=0.
      JI=0.
C
C       XL IS THE VARIABLE OF INTEGRATION.  IT IS THE DISTANCE
C LONG THE SURFACE OF THE STRIP STARTING FROM THE LEADING EDGE
      XL=0.
```

```
      NX=1
      IT=0
C
C        THESE ARE THE LOWER AND UPPER BOUNDS FOR THE SPACING BETWEEN
C POINTS ALONG THE VARIABLE OF INTEGRATION
      L3= LAMBDA/24.
      L10=20.*LAMBDA
      A1=RX-X1
      A2=RZ-Z1
      B1=X1
      B2=Z1-AZ
      A=A1
      TEMP=A2
       A= SQRT(A*A+TEMP*TEMP)
      B=B1
      TEMP=B2
      B= SQRT(B*B+TEMP*TEMP)
      TEMP=A*B
      DR=DSQRT(DBLE(TEMP)*DBLE(TEMP)+DBLE(AY*AY))
      C=DR
      DR=DR*AK
      I=DR/DPI
      F=DR-DBLE(FLOAT(I))*DPI
      C=C/TEMP
      D=C*B
      R=C*A
       S=SQRT((1./A+1./B)/C/C/C)
      G=A1/D/D/R/R/S
      TEMP=G/(AKK*D)
      CF=COS(F)
      SF=SIN(F)
      JOR=G*CF-TEMP*SF
      JOI=G*SF+TEMP*CF
      AP=(-A1*CE-A2*SE)/A
      BP=(B1*CE+B2*SE)/B
C
C        FP IS THE DERIVATIVE OF THE PHASE FUNCTION
C OF THE INTEGRAND
      FP=ABS((AP+BP)/C)
C
C        DL IS DELTA XL
      DL=L3/FP
      IF(DL .GT. L10) DL=L10
      IF(DL .LT. L3) DL=L3
      XL=XL+DL
C
C        THIS IS THE LOOP OVER THE SURFACE OF THE STRIP.  XL IS
C INCREMENTED BY DL (OF VARIABLE SIZE  UNTIL THE END OF THE STRIP
C IS REACHED (XMAX)
1     CONTINUE
C
C        THIS SECTION CALCULATE VARIOUS TERMS USED IN EVALUATING THE
C INTEGRAND,  THE AMPLITUDE AND PHASE FUNCTION
```

```
C ARE EVALUTATED SEPARATELLY.  THE DERIVATIVE OF THE PHASE FUNCTION
C IS EVALUATED TO DETERMUINE THE SIZE FOR DELTA X
      DLSE=DL*SE
      DLCE=DL*CE
      A1=A1-DLCE
      A2=A2-DLSE
      B1=B1+DLCE
      B2=B2+DLSE
      A=A1
       TEMP=A2
      A= SQRT(A*A+TEMP*TEMP)
      B=B1
      TEMP=B2
      B= SQRT(B*B+TEMP*TEMP)
      TEMP=A+B
      DR=DSQRT(DBLE(TEMP)*DBLE(TEMP)+DBLE(AY*AY))
      C=SNGL(DR)/TEMP
      DR=DR*AK
      I=DR/DPI
C
C        THIS IS THE PHASEE ANGLE *MODULO TWO P'*
      F=DR-DBLE(FLOAT(I))*DPI
      D=C*B
      R=C*A
      S=SQRT((1./A+1./B)/C)/C
      G=A1/(D*D*R*R*S)
C
C        THIS IS THE AMPLITUDE FUNCTION
      TEMP=G/(AKK*D)
      CF=COS(F)
      SF=SIN(F)
C
C        THIS IS THE REAL PART OF THE INTEGRAND FOR THE
C INTEGRATION VARIABLE VALUE OF XL
      JNR=G*CF-TEMP*SF
C
C        THIS IS THE IMAGINARY PART
      JNI=G*SF+TEMP*CF
      TEMP=DL
C
C        THESE ARE THE REAL AN IMAGINARY PARTS OF THE THE SUMMATION
C OF THE TRAPIZOIDS MAKING UP THE APPROXIMATION TO THE INTEGRAL
      JR=JR+(JOR+JNR)*TEMP
      JI=JI+(JOI+JNI)*TEMP
       IF(IT .NE. 0) GO TO 2
      JOR=JNR
      JOI=JNI
      AP=(-A1*CE-A2*SE)/A
       BP=(B1*CE+B2*SE)/B
C
C        FP IS THE DERIVATIVE OF THE PHASE FUNCTION
      FP=ABS((AP-BP)/C)
C
```

```
C        DL IS DELTA X AND IS LIMITED BY THE BOUNDS L3,L10
         DL=L3/FP
         IF(DL .GT. L10) DL=L10
         IF(DL .LT. L3) DL=L3
         NX=NX+1
C
C        THE VARIABLE OF INTGRATION IS INCREMENTED AND IF THE END OF THE
C STRIP IS REACHED THE LAST TRAPIZOID IS ADDED
         XL=XL+DL
         IF( XL .LT. XMAX) GO TO 1
         DL=XMAX+DL-XL
         XL=XMAX
         IT=2
         GO TO 1
C
C        THIS SECTION ADDS THE FIELD EFFECT FROM THE STRIP TO THE
C  TOTAL FIELD SUM AND TEH SUBROUTINE TERMINATES
2        CONTINUE
         N=NX
         TEMP=((Z1-A2)*CE-X1*SF)/2.
         HR=HR+JR*TEMP
         HI=HI+JI*TEMP
         RETURN
         END
```

CONSTANTS

```
F        205602200770
```

COMMON

```
X1       /SEG    /+0      Z1       /SEG    /+1      X2       /SEG    /+2      Z2       /SEG    /+3      N        /SEG    /+4
AX       /ANT    /+0      AY       /ANT    /+1      AZ       /ANT    /+2      LAMBDA   /ANT    /+3      AK       /ANT    /+4
DPI      /ANT    /+6      RX       /REC    /+0      RY       /REC    /+1      R0       /REC    /+2      HR       /VAL    /+0
HI       /VAL    /+1
```

SUBPROGRAMS

```
DBLE     DFM.3    SNGL     SQRT     DSQRT    DFA.2    DFMN.2   DFD.2    IDINT    FLOAT    DFS.0    DFD.6    COS      SIN      DFM.4
DFM.6    DFA.4    DFD.4    ABS      DFAM.2   DFS.2
```

SCALARS

```
SUM      1064          AX2      1065          AY       1             AKK      1067          AK       4
SE       1070          Z2       3             Z1       1             CE       1071          X2       2
X1       0             XMAX     1072          JR       1073          JI       1074          XL       1075
NX       1077          IT       1100          L3       1101          LAMBDA   3             L10      1102
A1       1103          RX       0             A2       1105          R2       2             B1       1107
B2       1111          AZ       2             A        1113          TEMP     1114          B        1115
DR       1116          C        1122          I        1121          DPI      6             F        1122
D        1123          R        1124          S        1125          G        1126          CF       1127
SF       1130          JOR      1131          JOI      1132          AP       1133          BP       1134
FP       1135          DL       1136          DLSE     1137          DLCE     1140          JNR      1141
```



```
JNI      1142          N        4             HR       0             HI       1             AX       0
RY       1
```

A	65	67	71	79	80	87	119	117	121	130	131	194		
A1	26	61	65	81	87	111	115	132	154					
A2	26	62	66	87	112	116	154							
ABS	92	150												
AK	29	38	37	74	124									
AKK	37	82	135											
ANT	30													
AP	87	92	154	150										
AX	30													
AY	38	36	72	122										
AY2	26	36												
AZ	30	64	179											
B	68	70	71	78	80	88	118	120	121	129	131	195		
B1	26	63	68	88	113	118	155							
B2	26	64	69	88	114	119	155							
BP	88	92	155	158										
C	73	77	78	79	80	92	123	129	130	131	150			
CE	39	42	47	87	88	118	154	155	179					
CF	83	85	86	136	141	144								
COS	83	136												
D	28	81	82	129	132	135								
DBLE	36	72	76	122	128									
DL	95	96	97	98	109	118	145	161	162	163	168	178		
DLCE	110	111	113											
DLSE	109	112	114											
DPI	29	38	75	76	125	128								
DR	29	72	73	74	75	76	122	123	124	125	128			
DSQRT	72	122												
F	76	83	84	128	136	137								
FLOAT	76	128												
FP	92	95	158	161										
G	81	82	85	86	132	135	141	144						
HI	32	181												
HR	32	180												
I	75	76	125	128										
IT	55	151	172											
JI	27	49	158	181										
JNI	27	144	158	193										
JNR	27	141	149	152										
JOI	27	86	150	153										
JOR	27	85	149	152										
JR	27	48	149	180										
L10	33	60	96	162										
L3	33	59	95	97	161	163								
LAMBDA	28	38	59	60										
N	25	178												
NX	54	164	178											
R	79	81	130	132										
REC	31													
RX	31	61												
RY	31													
RZ	31	62												
S	80	81	131	132										
SE	38	42	46	87	88	109	154	155	179					
SEG	25													
[illegible]	84	85	86	137	141	144								
SIN	84	137												
SMAL	37	123												
SQRT	42	67	78	88	117	128	131							
SUM	24													
TEMP	66	67	69	78	71	72	77	82	85	86	116	117	119	120
	121	122	123	135	141	144	145	149	150	179	180	181		
VAL	32													
X1	25	39	61	63	179									
X2	25	39												
XL	26	53	98	168	169	170	171							
XMAX	42	46	47	169	170	171								
Z1	25	38	62	64	178									
Z2	25	38												
1P	183	169	173											
2P	151	177												

APPENDIX B MOLE

```
      DIMENSION ILABL(8)
      DIMENSION IPTDAT(33)
      COMMON /PLXT/ NRP,RXMN,RXMX,RXFT,RXLT,RYMN,RYMX,RYFT,RYLT,
     1RZMN,RZMX,RZFT,RZLT,RTMN,RTMX,RTFT,RTLT,
     2AIMN,AIMX,AIFT,AILT,ARMN,ARMX,ARFT,ARLT,
     3ADIN,ADIX,ADIF,ADIL,
     4ADRN,ADRX,ADRF,ADRL
      EQUIVALENCE (IPTDAT(1),NRP)
      IMPLICIT COMPLEX (C)
      DIMENSION X(20),Y(20),Z(20)
      DIMENSION CF1(20),CF2(20),CF3(20)
      IMPLICIT DOUBLE PRECISION (D)
      COMMON /REC/RX,RY,RZ,RT,NSIZE
      REAL LAMBDA
      COMMON /ANT/AX,AY,AZ,LAMBDA,DAK,DPI
      COMMON /VAL/ WR,WI
      COMMON /GRND/ P(3,4),N(3)
C
C        THIS VALUE OF TWO PI IS INITIALIZED THIS WAY TO AVOID USING
C BLOCK DATA
      DPI=6.2831853071795864769
      WRITE(5,2001)
2001  FORMAT(' INPUT FILE NAME:',$)
      READ(5,2000) ILBL
2000  FORMAT(A5)
      CALL IFILE(21,ILBL)
      WRITE(5,2002)
2002  FORMAT(' OUTPUT FILE NAME:',$)
      READ(5,2000) ILBL
      CALL OFILE(1,ILBL)
      READ(20,4000) ((P(I,J),I=1,3),J=1,4)
4000  FORMAT(4(3G,/))
      READ(21,1000) ILABL,TAU
      WRITE(1,1000) ILABL
      DO 3 I=1,2
      READ(21,1000) ILABL
3     WRITE(1,1000) ILABL
1000  FORMAT(8A5,F)
      READ(21) LAMBDA,NEL,(X(I),Y(I),Z(I),CF1(I),CF2(I),CF3(I),I=1,NEL)
      WRITE(1) LAMBDA,NEL,(X(I),Y(I),Z(I),CF1(I),CF2(I),CF3(I),I=1,NEL)
      DAK=DPI/DBLE(LAMBDA)
201   READ(21,2005,END=200) RX,RY,RZ,RT,
     1CFR1,CFR2,CFR3,CFS1,CFS2,CFS3
2005  FORMAT(4F,/,6E13.6,/,6E13.6)
      READ(5,3000) P
3000  FORMAT(3G)
      DO 5 I=1,NEL
      AX=X(I)
      AY=Y(I)
      AZ=Z(I)
      CTEMP=(0.,0.)
      CALL INTR2(CTEMP)
      CT=CTEMP*CF1(I)
```

```
              CFR1=CFR1+CT
              CFS1=CFS1+CT
              CT=CTEMP*CF2(I)
              CFR2=CFR2+CT
              CFS2=CFS2+CT
              CT=CTEMP*CF3(I)
              CFS3=CFS3+CT
              CFR3=CFR3+CT
        5     CONTINUE
              WRITE(1,2005) RX,RY,RZ,RT,CFR1,CFR2,CFR3,CFS1,CFS2,CFS3
              GO TO 201
        C
        C        THIS IS THE TERMINATION SECTION.  THE INITIAL RECORD ON
        C THE OUTPUT FILE IS WRITTEN AND THE PROGRAM TERMINATES.
        200   CALL RELEAS (1)
              CALL EXIT
              STOP
              END

CONSTANTS

0     203622077325    1     150042055061    2     000020000025    3     000000000001    4     000000000000
5     000000000000

COMMON

                                           RXMX    /PLXT  /+2      RXFT    /PLXT  /+3      RXLT    /PLXT  /+4
NRP     /PLXT  /+0      RXMN    /PLXT  /+1      RYFT    /PLXT  /+7      RYLT    /PLXT  /+10     RZMN    /PLXT  /+11
RYMN    /PLXT  /+5      RYMX    /PLXT  /+6      RZLT    /PLXT  /+14     RTMN    /PLXT  /+15     RTMX    /PLXT  /+16
RZMX    /PLXT  /+12     RZFT    /PLXT  /+13     AIMN    /PLXT  /+21     AIMX    /PLXT  /+22     AIFT    /PLXT  /+23
RTFT    /PLXT  /+17     RTLT    /PLXT  /+20     ARMX    /PLXT  /+26     ARFT    /PLXT  /+27     ARLT    /PLXT  /+30
AILT    /PLXT  /+24     ARMN    /PLXT  /+25     ADIF    /PLXT  /+33     ADIL    /PLXT  /+34     ADRN    /PLXT  /+35
ADIN    /PLXT  /+31     ADIX    /PLXT  /+32     ADRL    /PLXT  /+40     RX      /REC   /+0      RY      /REC   /+1
ADRX    /PLXT  /+36     ADRF    /PLXT  /+37     NSIZE   /REC   /+4      AX      /ANT   /+0      AY      /ANT   /+1
RZ      /REC   /+2      RT      /REC   /+3      DAK     /ANT   /+4      DPI     /ANT   /+6      WR      /VAL   /+0
AZ      /ANT   /+2      LAMBDA  /ANT   /+3      .       /GRNC  /+14     IPTDAT  /PLXT  /+0
WI      /VAL   /+1      P       /GRND  /+0

SUBPROGRAMS

FORSE.  .JBFF   ALPHO.  ALPHI.  IFILE   OFILE   ALLIO.  FLOUT.  FLIRT.  BINWR.  DBLE    DFD.2   END.    INTR2   CFM.2
RELEAS  EXIT

SCALARS

                                                                    J       410     TAU     411
                        ILBL    406             I       407         RX      0       RY      1
DPI     6               NEL     412             DAK     4           CFR2    415     CFR3    417
LAMBDA  3               RT      3               CFR1    413         AX      0       AY      1
RZ      2               CFS2    423             CFS3    425         NRP     0       RXMN    1
CFS1    421             CTEMP   427             CT      431         RYMN    5       RYMX    6
AZ      2               RXFT    3               RXLT    4           RZMX    12      RZFT    13
RXMX    2               RYLT    10              RZMN    11          RTFT    17      RTLT    20
RYFT    7               RTMN    15              RTMX    16          AILT    24      ARMN    25
RZLT    14              AIMX    22              AIFT    23
AIMN    21
```

```
MOLE.F4 F40      V27(360)      23-APR-76      13:53

        ARMX   26        ARFT    27        ARLT   30        ADIN   31        ADIX   32
        ADIF   33        ADIL    34        ADRN   35        ADRX   36        ADRF   37
        ADRL   40        NSIZE   4         NR     P         NI     1

        ARRAYS

        ILABL  433       IPTDAT  P         X      443       Y      467       Z      513
        CF1    537       CF2     607       CF3    657       P      0         Q      14


  ADIF      3
  ADIL      3
  ADIN      3
  ADIX      3
  ADRF      3
  ADRL      3
  ADRN      3
  ADRX      3
  AIFT      3
  AILT      3
  AIMN      3
  AIMX      3
  AMT      15
  ARFT      3
  ARLT      3
  ARMN      3
  ARMX      3
  AX       15    48
  AY       15    49
  AZ       15    50
  CF1      11    39    40    53
  CF2      11    39    40    56
  CF3      11    39    40    59
  CFR1     42    54    63
  CFR2     42    57    63
  CFR3     42    61    63
  CFS1     42    55    63
  CFS2     42    58    63
  CFS3     42    60    63
  CT       53    54    55    56    57    58    59    60    61
  CTEMP    51    52    53    56    59
  DAK      15    41
  DBLE     41
  DPI      15    21    41
  EXIT     69
  GRND     17
  NI       16
  NR       16
  I        31    35    39    40    47    48    49    50    53    56    59
  ??LE     26
  IL JL     1    33    34    36    37
  ILLL     24    26    29    30
  INTRZ    52
  IPTDAT    2     0
  J        31
  LAMBDA   14    15    39    40    41
  N        17
  NEL      39    40    47
  NRP       3     0
  NSIZE    13
  OFILE    30
  P        17    31    45
  PLXT      3
```

REC	13			
RELEAS	60			
RT	13	42	63	
RTFT	3			
RTLT	3			
RTMN	3			
RTMX	3			
RX	13	42	63	
RXFT	3			
RXLT	3			
RXMN	3			
RXMX	3			
RY	13	42	63	
RYFT	3			
RYLT	3			
RYMN	3			
RYMX	3			
RZ	13	42	63	
RZFT	3			
RZLT	3			
RZMN	3			
RZMX	3			
TAU	33			
VAL	16			
X	10	39	40	48
Y	10	39	40	49
Z	10	39	40	50

3P	35	37			
5P	47	62			
200P	42	60			
201P	42	64			
1000P	33	34	36	37	38
2000P	24	25	29		
2001P	22	23			
2002P	27	28			
2003P	42	44	63		
3002P	45	46			
4000P	31	32			

```
HOLE.F4 F40     V27(360)        23-APR-76       13:53

                SUBROUTINE NORMAL(V1,V2,V3,V4,R)
                DIMENSION V1(1),V2(1),V3(1),V4(1)
                X1=V2(1)-V1(1)
                X2=V3(1)-V1(1)
                Y1=V2(2)-V1(2)
                Y2=V3(2)-V1(2)
                Z1=V2(3)-V1(3)
                Z2=V3(3)-V1(3)
                X=Y1*Z2-Y2*Z1
                Y=Z1*X2-Z2*X1
                Z=X1*Y2-Y1*X2
                R=SQRT(X*X+Y*Y+Z*Z)
                V4(1)=X/R
                V4(2)=Y/R
                V4(3)=Z/R
                RETURN
                END

GLOBAL DUMMIES

V1      133         V2      134         V3      135         V4      136         R       137

SUBPROGRAMS

SQRT

SCALARS

NORMAL  141         X1      142         X2      143         Y1      144         Y2      145
Z1      146         Z2      147         X       150         Y       151         Z       152
R       137

ARRAYS

V1      133         V2      134         V3      135         V4      136
```

NORMAL	1							
R	1	12	13	14	15			
SQRT	12							
V1	1	2	3	4	5	6	7	8
V2	1	2	3	5	7			
V3	1	2	4	6	8			
V4	1	2	13	14	15			
X	9	12	13					
X1	3	10	11					
X2	4	10	11					
Y	10	12	14					
Y1	5	9	11					
Y2	6	9	11					
Z	11	12	15					
Z1	7	9	10					
Z2	8	9	10					

```
HOLE.F4 F40     V27(360)          23-APR-76        13:53

                        DOUBLE PRECISION FUNCTION DIST(X,Y)
                        DIMENSION X(1),Y(1)
                        DOUBLE PRECISION R,TEMP
                        R=0.
                        DO 1 I=1,3
                        TEMP=X(I)-Y(I)
                  1     R=R+TEMP*TEMP
                        DIST=DSQRT(R)
                        RETURN
                        END

        GLOBAL DUMMIES

        X       56                Y       57

        SUBPROGRAMS

        DFM.2   DFAM.2  DSQRT

        SCALARS

        DIST    60                R       62                I       64                TEMP    65

        ARRAYS

        X       56                Y       57


DIST          1       8
DSQRT         8
I             5       6
R             3       4       7       8
TEMP          3       6       7
X             1       2       6
Y             1       2       6


   1P         5       7
```

```
      SUBROUTINE INTR2(CTEMP)
      DATA DX,DY/23.,40./
      DIMENSION XTA(3),ZTA(3)
      DOUBLE PRECISION D10,D20,R10,R20
      COMPLEX A,B
      DOUBLE PRECISION DR1,DR2
      COMPLEX CTEMP,CCT,CCX,CCY,CCX0
      REAL N,LAMBDA,N1,N2,N3
      COMMON /GRND/ P(3,4),N(3)
      EQUIVALENCE (N(1),N1),(N(2),N2),(N(3),N3)
      DOUBLE PRECISION DAK,DPI
      COMMON /REC/ XR,YR,ZR
      COMMON /ANT/XA,YA,ZA,LAMBDA,DAK,DPI
      EQUIVALENCE (P11,P(1,1)),(P12,P(1,2)),(P21,P(2,1))
      EQUIVALENCE (P24,P(2,4)),(P31,P(3,1)),(P34,P(3,4))
      LOGICAL TEST
      DATA TEST/.TRUE./
      IF(TEST) CALL NORMAL(P11,P12,P(1,4),N(1),TEMP)
      TEST=.FALSE.
      ZA2=2.*ZA
      TPI=SNGL(DPI)
      AK=SNGL(DAK)
      CTEMP=(0.,0.)
      DELX=DX
      DG0=DIST(D(1,1),D(1,2))
      IX=DG0/DELX
      IF(IX .LT. 0) IX=-IX
      IF(IX .LT. 1) IX=1
      IX=((IX+1)/2)*2
      DELX=DG0/FLOAT(IX)
      XTA(1)=(P(1,2)-P(1,1))/DG0
      XTA(2)=(P(2,2)-P(2,1))/DG0
      XTA(3)=(P(3,2)-P(3,1))/DG0
      DG0X=XTA(1)*DELX
      DG0Y=XTA(2)*DELX
      DG0Z=XTA(3)*DELX
      DG1=DIST(P(1,1),P(1,4))
      DELZ=DY
      IZ=DG1/DELZ
      IF(IZ .LT. 0) IZ=-IZ
      IF(IZ .LT. 1) IZ=1
      IZ=((IZ+1)/2)*2
      DELZ=DG1/FLOAT(IZ)
      ZTA(1)=(P(1,4)-P(1,1))/DG1
      ZTA(2)=(P(2,4)-P(2,1))/DG1
      ZTA(3)=(P(3,4)-P(3,1))/DG1
      DG1X=ZTA(1)*DELZ
      DG1Y=ZTA(2)*DELZ
      DG1Z=ZTA(3)*DELZ
      DO 1 IXX=1,IX
      FX=FLOAT(IXX)-.5
      XS=P(1,1)+FX*DG0X
      YS=P(2,1)+FX*DG0Y
```

```
ZS=P(3,1)+FX*DG0Z
DO 2 IZZ=1,IZ
FZ=FLOAT(IZZ)-.5
XS=XS+FZ*DG1X
YS=YS+FZ*DG1Y
ZS=ZS+FZ*DG1Z
CC6=XR-XS
CC7=XS-XA
TEMP=YR-YS
TEMP2=ZR-ZS
TEMP3=ZR+ZS
DR1=DBLE(CC6*CC6)+DBLE(TEMP*TEMP)
DR2=DR1+DBLE(TEMP3*TEMP3)
DR1=DR1+DBLE(TEMP2*TEMP2)
R12=DR1
R22=DR2
R10=DSQRT(DR1)
R20=DSQRT(DR2)
R1=R10
R2=R20
TEMP=YS-YA
TEMP2=ZS-ZA
TEMP3=ZS+ZA
DR1=DBLE(CC7*CC7)+DBLE(TEMP*TEMP)
DR2=DR1+DBLE(TEMP3*TEMP3)
DR1=DR1+DBLE(TEMP2*TEMP2)
D12=DR1
D22=DR2
D10=DSQRT(DR1)
D20=DSQRT(DR2)
D1=D10
D2=D20
F10=N2*XS*(YR-YS)+(N1*YS+N3*(ZS-ZA))*(XR-XS)
F20=F10+N3*(XR-XS)*ZA2
COSA=(XTA(1)*CC7+XTA(2)*(YS-YA)+XTA(3)*(ZS-ZA))/D1
COSA1=(XTA(1)*CC7+XTA(2)*(YS-YA)+XTA(3)*(ZS+ZA))/D2
COSG=(XTA(1)*CC6+XTA(2)*(YR-YS)+XTA(3)*(ZR-ZS))/R1
COSG1=(XTA(1)*CC6+XTA(2)*(YR-YS)+XTA(3)*(ZR+ZS))/R2
COSB=(ZTA(1)*CC7+ZTA(2)*(YS-YA)+ZTA(3)*(ZS-ZA))/D1
COSB1=(ZTA(1)*CC7+ZTA(2)*(YS-YA)+ZTA(3)*(ZS+ZA))/D2
COSD=(ZTA(1)*CC6+ZTA(2)*(YR-YS)+ZTA(3)*(ZR-ZS))/R1
COSD1=(ZTA(1)*CC6+ZTA(2)*(YR-YS)+ZTA(3)*(ZR+ZS))/R2
CM=COSA-COSG
CM1=COSA-COSG1
CM2=COSA1-COSG
CM3=COSA1-COSG1
C=COSB-COSD
C1=COSB-COSD1
C2=COSB1-COSD
C3=COSB1-COSD1
D10=D10*DAK
D20=D20*DAK
R10=R10*DAK
```

```
          R20=R20*DAK
          ID=D10/DPI
          D1=D10-DBLE(FLOAT(ID))*DPI
          ID=D20/DPI
          D2=D20-DBLE(FLOAT(ID))*DPI
          ID=R10/DPI
          R1=R10-DBLE(FLOAT(ID))*DPI
          ID=R20/DPI
          R2=R20-DBLE(FLOAT(ID))*DPI
          TEMP=F10*SIN(AK*CH*DELX*.5)*SIN(AK*C*DELZ*.5)/(CH*C*D12*R12)
          CTEMP=CTEMP+TEMP*CEXP(CMPLX(0.,D1+R1))
          TEMP=F10*SIN(AK*CH1*DELX*.5)*SIN(AK*C1*DELZ*.5)/(CH1*C1*D12*R22)
          CTEMP=CTEMP-TEMP*CEXP(CMPLX(0.,D1+R2))
          TEMP=F20*SIN(AK*CH2*DELX*.5)*SIN(AK*C2*DELZ*.5)/(CH2*C2*D22*R12)
          CTEMP=CTEMP-TEMP*CEXP(CMPLX(0.,D2+R1))
          TEMP=F20*SIN(AK*CH3*DELX*.5)*SIN(AK*C3*DELZ*.5)/(CH3*C3*D22*R22)
          CTEMP=CTEMP+TEMP*CEXP(CMPLX(0.,D2+R2))
        2 CONTINUE
        1 CONTINUE
          CTEMP=CTEMP*2./(TPI*TPI)
          ICC=IX*I2
          RETURN
          END

CONSTANTS

0      000000000000     1      202000000000     2      000000000001     3      000000000002

GLOBAL DUMMIES

CTEMP   1341

COMMON

P       /GRND  /+0     N      /GRND  /+14    XR     /REC   /+0    YR      /REC   /+1    ZR     /REC   /+2
XA      /ANT   /+0     YA     /ANT   /+1     ZA     /ANT   /+2    LAMBDA  /ANT   /+3    DAK    /ANT   /+4
DPI     /ANT   /+6     N1     /GRND  /+14    N2     /GRND  /+15   N3      /GRND  /+16   P11    /GRND  /+0
P12     /GRND  /+3     P21    /GRND  /+1     P24    /GRND  /+12   P31     /GRND  /+2    P34    /GRND  /+13

SUBPROGRAMS

NORMAL  SNGL   DIST    D      IFIX   FLOAT  DBLE   DFA.0  DFAM.0 DSQRT  DFMM.2 DFD.2  IDINT  DFM.0  DFS.0
S N     CEXP   CMPLX   CFM.0  CFD.4

SCALARS

INTR2   1347     DX     1352     DY     1351     TEST   1392     P11    0
P12     3        TEMP   1353     ZA2    1354     ZA     2        TPI    1355
DPI     6        AK     1356     DAK    4        CTEMP  1341     DELX   1357
DG0     1360     IX     1361     DGPX   1362     DGPY   1363     DG02   1364
DG1     1365     DELZ   1366     I2     1367     DG1X   1370     DG1Y   1371
DG12    1372     IXX    1373     FX     1374     XS     1375     YS     1376
ZS      1377     I22    1400     F2     1401     CC6    1402     XR     0
```

```
HOLE.F4 F40     V27(360)        23-APR-76       14:0P

        CC7     1403          XA      0             YR      1             TEMP2   1404          ZR      2
        TEMP3   1405          DR1     1406          DR2     1410          R12     1412          R22     1413
        R10     1414          R20     1416          R1      1420          R2      1421          YA      1
        D12     1422          D22     1423          D10     1424          D20     1426          D1      1430
        R2      1431          F10     1432          N2      15            N1      14            N3      16
        F20     1433          COSA    1434          COSA1   1435          COSG    1436          COSG1   1437
        COSB    1440          COSB1   1441          COSD    1442          COSD1   1443          CH      1444
        CH1     1445          CH2     1446          CH3     1447          C       1450          C1      1451
        C2      1452          C3      1453          I?      1454          ICC     1455          LAMBDA  3
        P21     1           P24     12            P31     2             P34     13

        ARRAYS

        XTA     1456          ZTA     1461          P       0             N       14


A            5
AK          22     116     118     120     122
ANT         13
B            5
C          100     116
C1         101     118
C2         102     120
C3         103     122
CC6         60      65      90      91      94      95
CC7         61      77      80      89      92      93
CCT          7
CCX          7
CCX0         7
CCY          7
CEXP       117     119     121     123
CH          96     116
CH1         97     118
CH2         98     120
CH3         99     122
CMPLX      117     119     121     123
COSA        88      96      97
COSA1       89      98      99
COSB        92     100     121
COSB1       93     102     123
COSD        94     100     122
COSD1       95     101     123
COSG        90      96      98
COSG1       91      97      99
CTEMP        1       7      23     117     119     121     123     126
D           25
D1          84      88      92     109     117     119
D10          4      82      84     104     108     109
D12         80     116     118
D2          85      89      93     111     121     123
D20          4      83      85     105     110     111
D22         81     120     122
DAK         11      13      72     104     105     106     107
DELE        65      66      67      77      78      79     109     111     113     115
DELX        24      26      30      34      35      36     116     118     120     122
DELZ        38      39      43      47      48      49     116     118     120     122
DG0         25      26      30      31      32      33
DG[illegible]       34      52
D[illegible]        35      53
[illegible]         36      54
DG1         37      39      43      44      45      46
DG1X        47      57
DG1Y        48      58
DG1Z        49      59
DIST        25      37
DPI         11      13      21     108     109     112     111     112     113     114     115
DR1          6      65      66      67      68      76      77      78      79      80      82
DR2          6      66      69      71      78      81      83
DSQRT       70      71      82      83
```

DX	2	24												
DY	2	30												
F10	86	87	116	118										
F20	87	120	122											
FLOAT	30	43	51	56	100	111	113	115						
FX	51	52	53	54										
FZ	56	57	58	59										
GRND	9													
ICC	127													
ID	108	109	110	111	112	113	114	115						
INTR2	1													
IX	26	27	28	29	30	50	127							
IXX	50	51												
IZ	39	40	41	42	43	55	127							
IZZ	55	56												
LAMBDA	8	13												
N	8	9	10	18										
N1	8	10	86											
N2	8	10	86											
N3	8	10	86	87										
NORMAL	10													
P	9	14	15	18	31	32	33	37	44	45	46	52	53	54
P11	14	18												
P12	14	18												
P21	14													
P24	15													
P31	15													
P34	15													
R1	72	90	94	113	117	121								
R10	4	70	72	106	112	113								
R12	68	116	120											
R2	73	91	95	115	119	123								
R20	4	71	73	107	114	115								
R22	69	118	122											
REC	12													
SIN	116	118	120	122										
SNGL	21	22												
TEMP	18	62	65	74	77	116	117	118	119	120	121	122	123	
TEMP2	63	67	75	79										
TEMP3	64	66	76	78										
TEST	16	17	18	19										
TP1	21	126												
XA	13	61												
XR	12	60	86	87										
XS	52	57	60	61	86	87								
XTA	3	31	32	33	34	35	6	88	89	90	91			
YA	13	74	80	89	92	93	95							
YR	12	62	86	90	91	94	89	90	91	92	93	94	95	
YS	93	58	62	74	86	88	89	92	93					
ZA	13	28	75	76	86	88	89							
ZA2	28	87												
ZR	12	63	64	90	91	94	95	88	89	90	91	92	93	94
ZS	54	59	63	64	75	76	86							
ZTA	95	3	44	45	46	47	48	49	92	93	94	95		
1P	50	125												
2P	55	124												

APPENDIX C GLDCDI

```
      DIMENSION ILABL(8)
      DIMENSION IPTDAT(33)
      COMMON /PLXT/ NRP,RXMN,RXMX,RXFT,RXLT,RYMN,RYMX,RYFT,RYLT,
     1RZMN,RZMX,RZFT,RZLT,RTMN,RTMX,RTFT,RTLT,
     2AIMN,AIMX,AIFT,AILT,ARMN,ARMX,ARFT,ARLT,
     3ADIN,ADIX,ADIF,ADIL,
     4ADRN,ADRX,ADRF,ADRL
      EQUIVALENCE (IPTDAT(1),NRP)
      IMPLICIT COMPLEX (C)
      DIMENSION X(20),Y(20),Z(20)
      DIMENSION CF1(20),CF2(20),CF3(20)
      IMPLICIT DOUBLE PRECISION (D)
      COMMON /REC/RX,RY,RZ,RT,NSIZE
      REAL LAMBDA
      COMMON /GROUND/ K,X1(20),Z1(20),X2(0/20),Z2(0/20),IEL
      COMMON /ANT/AX,AY,AZ,LAMBDA,DAK,DPI
      COMMON /VAL/ WR,WI
C
C        THIS VALUE OF TWO PI IS INITIALIZED THIS WAY TO AVOID USING
C BLOCK DATA
      DPI=6.2031853071795864769
      WRITE(5,2001)
2001  FORMAT(' INPUT FILE NAME:',$)
      READ(5,2000) ILBL
2000  FORMAT(A9)
      CALL IFILE(20,ILBL)
      WRITE(5,2002)
2002  FORMAT(' OUTPUT FILE NAME:',$)
      READ(5,2000) ILBL
      CALL OFILE(1,ILBL)
      WRITE(1) IPTDAT
      READ(20,1000) ILABL,TAU
      WRITE(1,1000) ILABL
      DO 3 I=1,2
      READ(20,1000) ILABL
3     WRITE(1,1000) ILABL
1000  FORMAT(8A5,F)
      READ(20) LAMBDA,NEL,(X(I),Y(I),Z(I),CF1(I),CF2(I),CF3(I),I=1,NEL)
201   READ(20,2005,END=200) RX,RY,RZ,RT,
     1CFR1,CFR2,CFR3,CFS1,CFS2,CFS3
2005  FORMAT(4F,/,6E13.6,/,6E13.6)
C
C        AFTER THE FIELDS HAVE BEEN ACCUMULATED FOR ALL THE ELEMENTS
C THE CDI'S ARE CALCUATED
C        ACDR    CDI FOR THE GROUND SUFACE
C        ACDI    CDI FOR 'IDEAL' GROUND PLANE
      ACDR=057.14*REAL((CFR2-CFR3)/CFR1)
      ACDI=057.14*REAL((CFS2-CFS3)/CFS1)
C
C        NCRP IS THE COUNT OF THE RECEIVERPOINTS
      NRP=NRP+1
      IF(NRP .NE. 1) GO TO 4
C
```

```
C      THIS SECTION INITIALIZES THE MAXIMUM AND MINIMUM VALUES
C OF THE VARIOUS RANGE AND DOMAIN VARIABLES.  THESE ARE
C USED IN THE PLOTTING PROGRAM TO SCALE THE PLOTS.  AFTER THE
C RUN IS FINISHED THEY WILL BE OUTPUT IN PLACE OF THE
C INITIAL DUMMY RECORD
      ADDI=ACDI
      ADDR=ACDR
      T0=RT
      ADIX=ACDI
      ADIN=ACDI
      ADIF=ACDI
      ADRX=ACDR
      ADRN=ACDR
      ADRF=ACDR
      RXFT=RX
      RYFT=RY
      RZFT=RZ
      RTFT=RT
      AIFT=ACDI
      ARFT=ACDR
      RXMN=RX
      RXMX=RX
      RYMN=RY
      RYMX=RY
      RZMN=RZ
      RZMX=RZ
      RTMN=RT
      RTMX=RT
      AIMX=ACDI
      AIMN=ACDI
      ARMX=ACDR
      ARMN=ACDR
C
C      THIS SECTION UPDATES THE MAXIMUM AND MINIMUM VALUES
4     CONTINUE
      RXLT=RX
      RYLT=RY
      RZLT=RZ
      RTLT=RT
      AILT=ACDI
      ARLT=ACDR
      IF(RX .LT. RXMN) RXMN=RX
      IF(RX .GT. RXMX) RXMX=RX
      IF(RY .LT. RYMN) RYMN=RY
      IF(RY .GT. RYMX) RYMX=RY
      IF(RZ .GT. RZMX) RZMX=RZ
      IF(RZ .LT. RZMN) RZMN=RZ
      IF(RT .GT. RTMX) RTMX=RT
      IF(RT .LT. RTMN) RTMN=RT
      IF(ACDI .GT. AIMX) AIMX=ACDI
      IF(ACDI .LT. AIMN) AIMN=ACDI
      IF(ACDR .GT. ARMX) ARMX=ACDR
      IF(ACDR .LT. ARMN) ARMN=ACDR
```

```
              CON=EXP((T0-RT)/TAU)
        C
        C          THIS  SECTION SIMULATE THE EFFECT OF THE ELECTICAL AND
        C MECHANICAL 'INERTIA' OF THE ILS
        C RECEIVER SYSTEM FOR DYNAMIC SIMULATION
              T0=RT
              ADCI=CON*(ADDI-ACDI)+ACDI
              ADDR=CON*(ADDR-ACDR)+ACDR
              IF(ADDI .LT. ADIN) ADIN=ADDI
              IF(ADDI .GT. ADIX) ADIX=ADDI
              ADIL=ADDI
              IF(ADDR .LT. ADRN) ADRN=ADDR
              IF(ADDR .GT. ADRX) ADRX=ADDR
              ADRL=ADDR
        C
        C          THIS IS THE OUTPUT OF THE REAL AND 'IDEAL' , STATIC
        C AND DYNAMIC CDI'S WHITH THE RECEIVER COORDINATES
              WRITE(1,2003) R ,RY,R2,RT,ACDI,ACDR,ADDI,ACDR
        2003  FORMAT(8F)
              GO TO 201
        C
        C          THIS IS THE TERMINATION SECTION.  THE INITIAL RECORD ON
        C THE OUTPUT FILE IS WRITTEN AND THE PROGRAM TERMINATES.
        200   CALL RELEAS (1)
              ENCODE (9,2006,ILABL(1)) ILBL
        2006  FORMAT(A5,'.DAT')
              CALL DEFINE FILE(1,25,I,ILABL(1))
              WRITE(1#1) IPTDAT
              CALL RELEAS (1)
              CALL EXIT
              STOP
              END

CONSTANTS

0       203622077325    1       150042055061    2       000000000024    3       000000000001    4       212054443056
5       000000007031

COMMON

NRP     /PLXT  /+0      RXMN    /PLXT  /+1      RXMX    /PLXT  /+2      RXFT    /PLXT  /+3      RXLT    /PLXT  /+4
RYMN    /PLXT  /+5      RYMX    /PLXT  /+6      RYFT    /PLXT  /+7      RYLT    /PLXT  /+10     RZMN    /PLXT  /+11
RZMX    /PLXT  /+12     RZFT    /PLXT  /+13     RZLT    /PLXT  /+14     RTMN    /PLXT  /+15     RTMX    /PLXT  /+16
RTFT    /PLXT  /+17     RTLT    /PLXT  /+20     AIMN    /PLXT  /+21     AIMX    /PLXT  /+22     AIFT    /PLXT  /+23
AILT    /PLXT  /+24     ARMN    /PLXT  /+25     ARMX    /PLXT  /+26     ARFT    /PLXT  /+27     ARLT    /PLXT  /+30
ADIN    /PLXT  /+31     ADIX    /PLXT  /+32     ADIF    /PLXT  /+33     ADIL    /PLXT  /+34     ADRN    /PLXT  /+35
ADRX    /PLXT  /+36     ADRF    /PLXT  /+37     ADRL    /PLXT  /+40     RX      /REC   /+0      RY      /REC   /+1
R2      /REC   /+2      RT      /REC   /+3      NSIZE   /REC   /+4      K       /GROUND/+0      X1      /GROUND/+1
Z1      /GROUND/+25     X2      /GROUND/+51     Z2      /GROUND/+76     IEL     /GROUND/+123    AX      /ANT   /+0
AY      /ANT   /+1      AZ      /ANT   /+2      LAMBDA  /ANT   /+3      DAK     /ANT   /+4      DPI     /ANT   /+6
WR      /VAL   /+0      WI      /VAL   /+1      IPTDAT  /PLXT  /+0

SUBPROGRAMS
```

```
FORSE.  .JOFF   ALPHO.  ALPHI.  IFILE   OFILE   RINHP,  FLOUT.  FLIRT.  END.    REAL    CFD.2   EXP     CFM.2   RELEAS
VADOR.  DEFINE  RECNO.  RANAC.  EXIT

SCALARS

DPI     6               ILBL    967             TAU     970             I       991             LAMBDA  3
NEL     972             RX      0               RY      1               R2      2               RT      3
CFR1    373             CFR2    575             CFR3    577             CFS1    601             CFS2    603
CFS3    605             ACDR    607             ACDI    610             NRP     0               ADDI    611
ADDR    612             T0      613             ADIX    32              ADIN    31              ADIF    33
ADRX    30              ADRN    35              ADRF    37              RXFT    3               RYFI    7
RZFT    13              RTFT    17              AIFT    23              ARFT    27              RXMN    1
RXMX    2               RYMN    9               RYMX    6               RZMN    11              RZMX    12
RTMN    15              RTMX    16              AIMX    22              AIMN    21              ARMX    26
ARMN    25              RXLT    4               RYLT    10              RZLT    14              RTLT    20
AILT    24              ARLT    30              CON     614             ADIL    34              ADRL    40
NSIZE   4               K       0               IEL     123             AX      0               AY      1
AZ      2               OAK     4               HR      0               HI      1

ARRAYS

ILABL   616             IPTDAT  0               X       626             Y       692             Z       676
CF1     722             CF2     772             CF3     1042            X1      1               Z1      25
X2      51              Z2      76


ACDI       40     59     62     63     64     72     82     83     93    103    104    113    124
ACDR       47     60     65     66     67     73     84     85     94    105    106    114    124
ADDI       59    113    115    116    117    124
ADDR       60    114    118    119    120    124
ADIF        3     64
ADIL        3    117
ADIN        3     63    115
ADIX        3     62    116
ADRF        3     67
ADRL        3    120
ADRN        3     66    118
ADRX        3     65    119
AIFT        3     72
AILT        3     93
AIMN        3     83    104
AIMX        3     82    103
ANT        16
ARFT        3     73
ARLT        3     94
ARMN        3     85    106
ARMX        3     84    105
AX         16
AY         16
AZ         16
CF1        11     30
CF2        11     30
CF3        11     30
CFR1       39     47
CFR2       39     47
CFR3       39     47
CFS1       39     48
CFS2       39     48
CFS3       39     48
CON       107    113    114
OAK        16
DEFINE    133
DPI        16     21
EXIT      136
EXP       107
GROUND     15
HI         17
HR         17
I          34     30    133
IEL        15
IFILE      26
ILABL       1     37     33     35     36    131    133
ILBL       24     26     29     30    131
IPTDAT      2      0     31    134
K          15
LAMBDA     14     16     30
NEL        30
NRP         3      0     91     92
NSIZE      13
```

OFILE	30											
PLOT	3											
REAL	47	48										
REC	13											
RELEAS	130	135										
RT	13	39	61	71	80	81	92	101	102	107	112	124
RTFT	3	71										
RTLT	3	92										
RTMN	3	87	102									
RTMX	3	81	101									
RX	13	39	60	74	75	89	95	96	124			
RXFT	3	60										
RXLT	3	89										
RXMN	3	74	95									
RXMX	3	75	96									
RY	13	39	69	76	77	90	97	98	124			
RYFT	3	69										
RYLT	3	97										
RYMN	3	76	97									
RYMX	3	77	98									
RZ	13	39	70	78	79	91	99	100	124			
RZFT	3	72										
RZLT	3	91										
RZMN	3	78	100									
RZMX	3	79	99									
T0	81	107	112									
TAU	32	107										
VAL	17											
X	10	38										
X1	15											
X2	15											
Y	10	38										
Z	10	38										
Z1	15											
Z2	15											
30P	34	36										
40P	52	68										
203P	39	132										
201P	39	126										
1002P	32	33	35	36	37							
2000P	24	25	29									
2001P	22	23										
2002P	27	28										
2003P	124	125										
2005P	39	41										
2006P	131	132										

APPENDIX D GLDPLT

```
      DIMENSION ITYPE(3,2)
      DATA ITYPE/'STATI','C VAL','UES','DYNAM','IC VA','LUES'/
      DATA PID,PRD/'CDID','THEOD'/
      DIMENSION SPACE(4),IAX(2,3)
      DATA SPACE/1.,2.,2.5,5./
      DATA IAX/'DEGRE','ES',' FEET','     ','SECON','DS'/
      DATA PRX,PRY,PRZ,PRT,PAI,PAR/
     1'RX','RY','RZ','RT','CDI','THEO'/
      DIMENSION IPTDAT(33)
      COMMON /PTXXN/NRP,RXMN,RXMX,RXFT,RXLT,RYMN,RYMX,RYFT,RYLT,
     1RZMN,RZMX,RZFT,RZLT,RTMN,RTMX,RTFT,RTLT,
     2AIMN,AIMX,AIFT,AILT,ARMN,ARMX,ARFT,ARLT,
     3ADIN,ADIX,ADIF,ADIL,ADRN,ADRX,ADRF,ADRL
      EQUIVALENCE (IPTDAT(1),NRP)
      DIMENSION ILABL(8)
      DATA XLEN,YLEN,ITIC/20.,8.,21/
      DIMENSION DY1(2000)
      DIMENSION DX(2000),DY(2000)
      NAMELIST /FRED/ YLENG,YDEL,YSC,DMIN,DMAX,DEL,IP,XSC
      CALL PLOTS(IBUF,360,16)
3     WRITE(5,1006)
1006  FORMAT(' INPUT FILE NAME AND AXIS TYPES:',$)
      READ(5,1005) NAME,ISX,ISY,BOUND
1005  FORMAT(A5,I,I,F)
      IF(ISY .LT. 1) GO TO 204
      IF(ISY .GT. 2) GO TO 204
      IF(ISX .LT. 1) GO TO 204
      IF(ISX .GT. 3) GO TO 204
      CALL PLOT(0.,-12.,-3)
      CALL PLOT(0.,1.,-3)
      I=0
      CALL IFILE(20,NAME)
      READ(20) IPTDAT
      WRITE(3,1002) NRP
1002  FORMAT(' THERE ARE',I5,' RECEIVER POINTS.',/)
      WRITE(3,1003)
1003  FORMAT(14X,'MIN',9X,'MAX',8X,'FIRST',8X,'LAST',/)
1004  FORMAT(1X,A5,1X,4F12.4)
      WRITE(3,1004) PRX,RXMN,RXMX,RXFT,RXLT
      WRITE(3,1004) PRY,RYMN,RYMX,RYFT,RYLT
      WRITE(3,1004) PRZ,RZMN,RZMX,RZFT,RZLT
      WRITE(3,1004) PRT,RTMN,RTMX,RTFT,RTLT
      WRITE(3,1004) PAI,AIMN,AIMX,AIFT,AILT
      WRITE(3,1004) PAR,ARMN,ARMX,ARFT,ARLT
      WRITE(3,1004) PID,ADIN,ADIX,ADIF,ADIL
      WRITE(3,1004) PRD,ADRN,ADRX,ADRF,ADRL
      GASD=0.
      GASU=0.
      GACN=0.
      DO 7 II=1,3
      READ(20,100) ILABL
      WRITE(3,101) ILABL
101   FORMAT(1X,8A5)
```

```
100   FORMAT(8A5)
      CALL SYMBOL(0.,0.,.2,ILABL,90.,40)
7     CALL PLOT(.3,0.,-3)
      CALL SYMBOL(0.,0.,.2,ITYPE(1,ISY),90.,15)
      CALL PLOT(2.,0.,-3)
1     READ(20,1000,END=2) X,Y,Z,T,C,R,CD,RD
1000  FORMAT(8F)
      TEMP=SQRT(X*X+Y*Y)
      IF((TEMP .LT. 3500.) .OR. (TEMP .GT. 20720.)) GO TO 60
      GASU=GASU+C
      GASD=GASD+CD
      GACN=GACN+1.
60    CONTINUE
      I=I+1
      GO TO (300,301) ISY
300   CONTINUE
      DY(I)=C
      DY1(I)=R
      GO TO 302
301   DY(I)=CD
      DY1(I)=RD
302   CONTINUE
      GO TO (200,201,202) ISX
200   DX(I)=ATAN2(Z,SQRT(X*X+Y*Y))*57.2953
      GO TO 199
201   DX(I)=X
      GO TO 199
202   DX(I)=Y
      GO TO 199
199   IF(I .NE. 1) GO TO 198
      DMIN=DX(I)
      DMAX=DX(I)
198   DMIN=AMIN1(DMIN,DX(I))
      DMAX=AMAX1(DMAX,DX(I))
1001  FORMAT(5X,3F)
      IF( I .LT. 2000) GO TO 1
2     IF(I .LT. 2) GO TO 3
      YLENG=AMAX1(AIMX,ABS(BOUND),-AIMN,0.)
      IF(ABS(BOUND) .LT. 1.E-4) GO TO 10
      YDEL=YLENG
      GO TO 11
10     YLENG=AMAX1(YLENG,ARMX,-ARMN)
      YDEL=FLOAT(IFIX(YLENG/YLEN))
      YLENR=YDEL*YLEN
11    CALL AXIS3(0.,0.,-YLENG,YLENG,YDEL,YLEN,
     1'MICROAMPERES',12,0.0.,YSC)
      IP=IFIX(ALOG10(DMAX-DMIN))-1
      POW=10.**IP
      DO 120 J=1,4
      DEL=SPACE(J)*POW
      IT=IFIX(DMAX/DEL-1.)+1-IFIX(DMIN/DEL)
      IF(IT .LT. ITIC) GO TO 121
120   CONTINUE
```

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```
121     DMIN=FLOAT(IFIX(DMIN/DEL))*DEL
        DMAX=FLOAT(IFIX(-.1+DMAX/DEL)+1)*DEL
        IP=-IP+1
        IF(IP .LT. 0) IP=0
        CALL AXIS3(0.,0.,DMAX,DMIN,DEL,-XLEN,IAX(1,ISW),7,IP,0.,XSC)
        CALL PLOT(0.,YLEN/2.,-3)
        CALL PLOT(XLEN,0.,2)
        WRITE(5,PRED)
        CALL PLOT((DX(1)-DMIN)/XSC,DY(1)/YSC,3)
        WRITE(3,1001) DX(1),DY(1),DT(1)
        GASU=GASU*.7/GACN/150.
        GASD=GASD*.7/GACN/150.
        WRITE(3,1007) GASU,GASD,GACN
1007    FORMAT(' STATIC MEAN ANGLE ERROR=',E,/
       1' DYNAMIC MEAN ANGLE ERROR=',E,10X,'COUNT=',F6.0)
        DO 4 J=2,I
        WRITE(3,1001) DX(J),DY(J),DT(J)
4       CALL PLOT((DX(J)-DMIN)/XSC,DY(J)/YSC,2)
        IF(BOUND .LT. 0.) GO TO 8
        ISW=2
        CALL PLOT((DX(1)-DMIN)/XSC,YT(1)/YSC,3)
        DO 6 J=2,I
        CALL PLOT((DX(J)-DMIN)/XSC,YT(J)/YSC,ISW)
6       ISW=5-ISW
8       CALL PLOT(XLEN+2.,-5.,-3)
        GO TO 3
704     CALL PLOT(3.,0.,999)
        CALL EXIT
        STOP
        END
```

CONSTANTS

0	400002000590	1	202020000020	2	204600000000	3	200000000000	4	201400000000
5	300022000274	6	176631463146	7	207550000000	10	200000000050	11	177463146314
12	000032000217	13	272420000000	14	217503600000	15	214605400000	16	204712271430
17	204400000200	20	163643334272	21	466730351236	22	400332042644	23	426464020100
24	400002000200	25	202020000214	26	175631463146	27	000000000007	30	000000000002
31	400004000073	32	222546314631	33	210454700000	34	203500000000	35	202600000000
36	400000002747								

COMMON

XRP	/PTXXN /+0	RXMN	/PTXXN /+1	RXMX	/PTXXN /+2	RXFT	/PTXXN /+3	RXLT	/PTXXN /+4
RYMN	/PTXXN /+5	RYMX	/PTXXN /+6	RYFT	/PTXXN /+7	RYLT	/PTXXN /+10	RZMN	/PTXXN /+11
RZMX	/PTXXN /+12	RZFT	/PTXXN /+13	RZLT	/PTXXN /+14	RTMN	/PTXXN /+15	RTMX	/PTXXN /+16
RTFT	/PTXXN /+17	RTLT	/PTXXN /+20	AIMN	/PTXXN /+21	AIMX	/PTXXN /+22	AIFT	/PTXXN /+23
AILT	/PTXXN /+24	ARMN	/PTXXN /+25	ARMX	/PTXXN /+26	ARFT	/PTXXN /+27	ARLT	/PTXXN /+30
ADIN	/PTXXN /+31	ADIX	/PTXXN /+32	ADIF	/PTXXN /+33	ADIL	/PTXXN /+34	ADRN	/PTXXN /+35
ADRX	/PTXXN /+36	ADRF	/PTXXN /+37	ADRL	/PTXXN /+40	IPTDAT	/PTXXN /+0		

SUBPROGRAMS

```
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        FORSE.,  .JOFF    ALLIO.   PLOTS    ALPHO.   ALPHI.   INTO.    INTI.    FLOUT.   FLIRT,  PLOT     IFILE    BINWR.   SYMBOL   END.
        SORT     ATAN2    AMIN1    AMAX1    ABS      FLOAT    IFIX     AXIS3    ALOG10   EXP2.2  NMLST,   EXIT

        SCALARS

        PID      1230              PRD      1231              PRX      1232              PRY      1233              PRZ      1234
        PRT      1235              PAI      1236              PAR      1237              XLEN     1240              YLEN     1241
        ITIC     1242              VLENG    1243              YDEL     1244              YSC      1245              DMIN     1246
        DMAX     1247              DEL      1250              IP       1251              XSC      1252              IBUF     1253
        NAME     1254              ISX      1255              ISY      1256              BOUND    1257              I        1260
        NRP      0                 RXMN     1                 RXMX     2                 RXFT     3                 RXLT     4
        RYMN     5                 RYMX     6                 RYFT     7                 RYLT     10                RZMN     11
        RZMX     12                RZFT     13                RZLT     14                RTMN     15                RTMX     16
        RTFT     17                RTLT     20                AIMN     21                AIMX     22                AIFT     23
        AILT     24                ARMN     25                ARMX     26                ARFT     27                ARLT     30
        ADIN     31                ADIX     32                ADIF     33                ADIL     34                ADRN     35
        ADRX     36                ADRF     37                ADRL     40                GASD     1261              GASU     1262
        GACN     1263              II       1264              X        1265              Y        1266              Z        1267
        T        1270              C        1271              R        1272              CO       1273              RO       1274
        TEMP     1275              POW      1276              J        1277              IT       1300              ISW      1301

        ARRAYS

        ITYPE    1302              SPACE    1310              IAX      1314              IPTDAT   0                 ILABL    1322
        DY1      1332              DX       5252              DY       11172
```

ABS	91	92												
ADIF	10	45												
ADIL	10	45												
ADIN	10	45												
ADIX	10	45												
ADRF	10	46												
ADRL	10	46												
ADRN	10	46												
ADRX	10	46												
AIFT	10	43												
AILT	10	43												
AIMN	10	43	91											
AIMX	10	43	91											
ALOG10	100													
AMAX1	87	91	95											
AMIN1	86													
ARFT	10	44												
ARLT	10	44												
ARMN	10	44	95											
ARMX	10	44	95											
ATAN2	77													
AXIS3	98	111												
BOUND	23	91	92	125										
C	59	63	70											
CO	59	64	73											
DEL	19	103	104	107	108	111								
DMAX	19	85	87	100	104	108	111							
DMIN	19	84	86	100	104	107	111	115	124	127	129			
DX	18	77	79	81	84	85	86	87	115	116	123	124	127	129
DY	18	70	73	115	116	123	124							
DY1	17	71	74	116	123	127	129							
EXIT	134													
FLOAT	96	107	108											
FRED	19	114												
GACN	49	65	117	118	119									
GASO	47	64	118	119										
GASU	48	63	117	119										
I	31	67	70	71	73	74	77	79	81	83	84	85	86	87
	89	90	122	128										
IAX	4	6	111											
IBUF	20													
IFILE	32													
IFIX	96	100	104	107	108									
II	50													
ILABL	15	51	52	55										
IP	19	102	103	109	110	111								
IPTDAT	9	14	33											
ISW	126	129	130											
ISX	23	27	28	76	111									
ISY	23	25	26	57	68									
IT	104	105												
ITIC	16	105												
ITYPE	1	2	57											

J	102	103	122	123	124	128	129					
NAME	23	32										
NRP	10	14	34									
PAI	7	43										
PAR	7	44										
PID	3	45										
PLOT	29	37	56	58	112	113	115	124	127	129	131	133
PLOTS	20											
POW	101	103										
PRD	3	46										
PRT	7	42										
PRX	7	39										
PRY	7	40										
PRZ	7	41										
PIXXN	10											
R	59	71										
RO	59	74										
RTFT	10	42										
RTLT	10	42										
RTMN	10	42										
RTMX	10	42										
RXFT	10	39										
RXLT	10	39										
RXMN	10	39										
RXMX	10	39										
RYFT	10	40										
RYLT	10	42										
RYMN	10	42										
RYMX	10	40										
RZFT	10	41										
RZLT	10	41										
RZMN	10	41										
RZMX	10	41										
SPACE	4	5	103									
SQRT	61	77										
SYMBOL	55	57										
T	59	81										
TEMP	61	62										
X	59	61	77	79								
XLEN	16	111	113	131								
XSC	19	111	115	124	127	129						
Y	59	61	77									
YDEL	19	93	96	97	98							
YLEN	16	96	97	98	112							
YLENG	19	91	93	95	96	97	98					
YSC	19	98	115	124	127	129						
Z	59	77										

1P	59	89							
2P	59	90							
3P	21	90	132						
4P	122	124							
6P	128	130							
7P	58	56							
8P	125	131							
10P	92	95							
11P	94	98							
60P	62	66							
100P	51	54							
101P	52	53							
120P	102	106							
121P	105	107							
198P	83	86							
199P	78	80	82	83					
200P	76	77							
201P	76	79							
202P	76	81							
204P	25	26	27	28	133				
300P	68	69							
301P	68	73							
302P	72	75							
1000P	59	60							
1001P	88	116	123						
1002P	34	35							
1003P	36	37							
1004P	38	39	40	41	42	43	44	45	46
1005P	23	24							
1006P	21	22							
1007P	119	120							

```
      SUBROUTINE AXIS3(X0,Y0,AMAX,AMIN,DELA,AINCH,BCD,NCR,NDEC,PWR,DELN)
      DIMENSION BCD(1)
      HT = .10
      DELX=SIGN(DELA,(AMAX-AMIN))
      W1=0.
      W2=0.
      W3 = 0.
      NEXP = 0
      NCH=IABS(NCR)
      IF(PWR.NE.0.) NEXP = 6
      CINCH=ABS(AINCH)
      IF(ABS(AMAX-AMIN)+ABS(DELX).LT.1.E-3) GO TO 50
      IF((AMAX-AMIN)/(DELX+1.E-5).GT.3.*CINCH) DELX = (AMAX-AMIN)/CINCH
      IF(NCR.LT.0) W3 = 1.
      NUM=IFIX((AMAX-AMIN)/DELX+1.9)
      ANC=CINCH/FLOAT(NUM-1)
      IF(AINCH.LT.0.)GO TO 5
      W2=1.
      GO TO 10
    5 W1=1.
   10 CALL PLOT(X0,Y0,3)
      DELN=DELX/10.**PWR/ANC
      ANUM=AMIN-DELX
      X=0.
      Y=0.
      XM=0.
      DO 40 I=1,NUM
      ANUM=ANUM+DELX
      II=0
   25 IF(ABS(ANUM)/10.**II.LT.1.)GO TO 20
      II=II+1
      GO TO 25
   20 IF(ANUM.LT.0.)II=II+1
      IF(ABS(ANUM).LT.1.) II=II+1
      IMORE=NDEC+1
      II=II+IMORE
      IF(IFIX(W1)*I.EQ.1) HT = AMIN1(HT ,ANC/FLOAT(II+2))
      CENTER = FLOAT(II)*HT/(1.+W1)
      OFF = .05
      XC = X - CENTER + W2*(W3*(.30+CENTER) - .15)
      IF(XC.LT.XM)XM=XC
      YC = Y - W1*(HT + .15 - W3*(HT+.3)) - W2*OFF
      CALL PLOT(X0+X,Y0+Y,2)
      CALL PLOT(X0+X+.1*W2,Y0+Y+.1*W1,3)
      CALL PLOT(X0+X-.1*W2,Y0+Y-.1*W1,2)
      CALL NUMBER(X0+XC,Y0+YC,HT,ANUM,0.,NDEC)
      CALL PLOT(X0+X,Y0+Y,3)
      X=X+ANC*W1
      Y=Y+ANC*W2
   40 CONTINUE
      BST = (CINCH - FLOAT(NCH+NEXP)*.12)/2.
      XXC = W1*(X0 + BST) + W2*(X0 + XM - OFF + W3*(2.*CENTER+.44))
      YYC = W1*(Y0 + YC - .17 + W3*(HT + .22) ) + W2*(Y0 + BST)
```

```
      CALL SYMBOL(XXC,YYC,.12,BCD,90.*W2,NCH)
      IF(PWR.EQ.0.) RETURN
      CALL WHERE (XQ,YQ,XXCX)
      CALL SYMBOL(XQ,YQ,.12,5H * 10,90.*W2,5)
      CALL WHERE (XO,YO,XXCX)
      X = XQ + (XXC-.08-XO)*W2
      Y = YQ + (YYC+.08-YO)*W1
      CALL NUMBER(X,Y,.09,PWR,90.*W2,-1)
      RETURN
   50 DELN = 1.E-3*10.**PWR/CINCH
      N=NCR/5
      WRITE(5,1000) AMAX,AMIN,DELA,PWR,(BCD(I),I=1,N)
 1000 FORMAT(1H0,27HINSUFFICIENT RANGE FOR AXIS ,
     1/,1X,4G,/,1X,13A5)
      CALL EXIT
      RETURN
      END
```

CONSTANTS

0	175631463146	1	167406111564	2	160517426542	3	0174631463I	4	000000000003
5	201403000070	6	174631463146	7	177463146314	10	76463146314	11	000000000002
12	000000000070	13	175753412172	14	177702436560	15	76834121727	16	176702436560
17	201244036540	20	000000000000	21	000000000005	22	75907534121	23	175560507534

GLOBAL DUMMIES

X0	656	Y0	657	AMAX	660	AMIN	661	DELA	662
AINCH	663	BCD	664	NCR	665	NDEC	666	PWR	667
DELN	670								

SUBPROGRAMS

SIGN IABS ABS IFIX FLOAT PLOT EXP3.2 EXP2.2 AMIN1 NUMBER SYMBOL WHERE ALLIO. ALPHO. ALPHI.
EXIT

SCALARS

AXIS3	673	WT	674	DELX	675	DELA	662	AMAX	660
AMIN	661	W1	676	W2	677	W3	700	NEXP	701
NCH	702	NCR	665	PWR	667	CINCH	703	AINCH	663
NUM	704	ANC	705	X0	656	Y0	657	DELN	670
ANUM	706	X	707	Y	710	XM	711	I	712
II	713	IMORE	714	NDEC	666	CENTER	715	OFF	716
XC	717	YC	720	BST	721	XXC	722	YYC	723
XQ	724	YQ	725	XXCX	726	N	727		

ARRAYS

BCD 664

ABS	11	12	30	34									
AINCH	1	11	17										
AMAX	1	4	12	13	15	45							
AMIN	1	4	12	13	15	73	65						
AMIN1	37												
ANC	10	22	37	40	49								
ANUM	23	28	30	33	34	46							
AXIS3	1												
BCD	1	2	54	65									
BST	51	52	53										
CENTER	30	42	52										
CINCH	11	13	16	51	63								
DELA	1	4	65										
DELN	1	22	63										
DLLX	4	12	13	15	22	23	28						
EXIT	60												
FLOAT	16	37	30	51									
HT	3	37	30	42	46	53							
I	27	37	65										
IABS	9												
IFIX	15	37											
II	29	37	31	33	34	36	37	38					
IMORE	35	36											
N	64	65											
NCH	9	51	54										
NCR	1	9	14	64									
NDEC	1	35	46										
NEXP	8	10	51										
NUM	15	16	27										
NUMBER	46	61											
OFF	39	42	52										
PLOT	21	43	44	45	47								
PWR	1	10	22	55	61	63	65						
SIGN	4												
SYMBOL	54	57											
W1	5	20	37	38	42	44	45	48	52	53	60		
W2	6	10	40	42	44	45	49	52	53	54	57	59	61
W3	7	14	40	42	52	53							
WHERE	56	58											
X	24	40	43	44	45	47	48	59	61				
X0	1	21	43	44	45	46	47	52					
XC	40	41	46										
XM	26	41	52										
XQ	56	57	58	59									
XXC	52	54	59										
XXCX	56	58											
Y	25	42	43	44	45	47	49	60	61				
Y0	1	21	43	44	45	46	47	53					
YC	42	46	53										
YQ	56	57	58	60									
YYC	53	54	60										

5P	17	22
10P	19	21
20P	30	31
25P	30	32
40P	27	52
50P	12	63
1000P	65	66

APPENDIX E FMAKE

```
      DIMENSION IDUM(2)
      DATA IDUM(2)/'.DAT'/
      COMMON XX,YY,ZZ,TT
      DIMENSION ILABL(8)
      DIMENSION X(20),Y(20),Z(20)
      IMPLICIT COMPLEX (C)
      DIMENSION C1(20),C2(20),C3(20)
      COMMON /GROUND/ K,X1(20),Z1(20),X2(0/20),Z2(0/20),IEL
C
C    THIS SECTION ACCEPTS THE INPUT OF THE SWITCH (ONE CHARACTER) TO
C DETERMINE WHAT KIND OF FILE TO GENERATE.
C       <BLANK> TO END THE PROGRAM
C       Y       TO SET ANTENNA OFFSET AND XMISSION WAVELENGTH
C       G       FOR GROUND DESCRIPTION
C       P       FOR FLIGHT PATH
C       A       FOR ANTENNA DESCRIPTION
2     WRITE(5,1013)
      READ(5,1000) NAME
      IF(NAME .EQ.' ') GO TO 3
      IF(NAME .EQ. 'Y') GO TO 20
      IF(NAME .EQ. 'G') GO TO 21
      IF(NAME .EQ. 'P') GO TO 22
      IF(NAME .EQ. 'A') GO TO 23
      WRITE(5,1012)
      GO TO 2
C
C       THIS IS THE INPUT FOR THE ANTENNA OFFSET AND FOR THE
C TRANSMISSION WAVELENGTH, BOTH ARE IN FEET AND ARE FLOATING POINT.
20    WRITE(5,1011)
      READ(5,101) Y0,RL
      GO TO 2
C
C       THIS SECTION IS FOR  GROUND DESCRIPTION
21    WRITE(5,1014)
C
C       THIS IS TO INPUT THE FILE NAME FOR GROUND DESCRIPTION
      READ(5,105) IDUM(1)
      WRITE(5,104)
C
C       THIS IS TO INPUT THE PLOT LABEL FOR GROUND DESCRIPTION
      READ(5,105) ILABL
      WRITE(5,100)
C
C       THIS IS THE INPUT FOR THE GROUND STRIP EDGE COORINATES
C       R       DELTA X-COORDINATE FOR CARTESIAN AND
C               RANGE FOR POLAR COORDINATES
C       ZZ      DELTA Y-COORDINATE FOR CARTESIAN AND
C               USUALLY ZERO FOR POLAR COORDINATES
C       THETA   ZERO FOR CARTESIAN COORDINATES AND
C               THE ELEVAION ANGLE FOR POLAR
C       THIS IS THE INPUT FOR THE STARTING EDGE OF THE FIRST STRIP
      READ(5,101,END=2) R,ZZ,THETA
      X2(0)=R*COSD(THETA)-ZZ*SIND(THETA)
```

```
      Z2(0)=R*SIND(THETA)+ZZ*COSD(THETA)
      K=0
      WRITE(5,102)
C
C        THIS IS THE INPUT LOOP FOR THE REST OF THE STRIP EDGES. THE
C EDGES ARE THE TRAILINE EDGE OF THE PREVIOUS STRIP AND THE
C LEADING EDGE OF THE NEXT.  THE LOOP WILL CONTINUE TO A MAXIMUM OF
C TWENTY STRIPS OR UNTIL BOTH 'R' AND 'ZZ' ARE ZERO.
11    READ(5,101,END=2) R,ZZ,THETA
      IF(R.NE.0.) GO TO 5
      IF(ZZ.NE.0.) GO TO 5
      IF(K.EQ.0) GO TO 2
      GO TO 4
5     K=K+1
      X1(K)=X2(K-1)
      Z1(K)=Z2(K-1)
      X2(K)=X2(K-1)+R*COSD(THETA)-ZZ*SIND(THETA)
      Z2(K)=Z2(K-1)+R*SIND(THETA)+ZZ*COSD(THETA)
      IF(K.LT.20) GO TO 6
      WRITE(5,103)
      GO TO 4
6     WRITE(5,102)
      GO TO 11
C
C        THIS OPENS A FILE FOR THE GROUND DESCRIPTION, OUTPUTS IT
C IN BINARY AND CLOSES THE FILE. FLOW THEN RETURNS TO THE SWITCH POINT.
4     CALL OFILE(20,IDUM(1))
      WRITE(20,105) ILABL
      WRITE(20) K,X1,Z1,X2,Z2
      CALL RELEAS(20)
      GO TO 2
C
C        THIS IS THE SECTION TO GENERATE A FLIGHT PATH FILE.
22    WRITE(5,1015)
C
C        THIS INPUTS THE FLIGT PATH FILE NAME
      READ(5,105) IDUM(1)
C
C        THIS IS TO CREATE THE FILE IF ONE DOES NOT ALREADY EXIST.
C THIS IS NECESSARY AS JOVRAX DOES NOT CREATE FILES.
      CALL OFILE (20,IDUM(1))
      CALL RELEAS(20)
C
C        THIS IS TO OEN THE FILE FOR JOVVRAX
      CALL JOVSET(1,IDUM(1),NSIZE)
      WRITE(5,1003)
C
C        THIS IS TO INPUT THE FLIGHT PATH PLOT LABEL AND OUTPUT IT TO
C THE FILE

      READ(5,105) ILABL
      CALL JOVWO(1,ILABL,0,0)
      WRITE(5,1000)
```

```
C
C       THIS SWITCH IS TO SELECT EITHER STRIGHT LINE FLIGHT OR
C HYPERBOLIC.  'G' INPUT WILL SELECT HYPERBOLIC ANYTHING ELSE WILL
C GIVE STRIGHT LINE.
        READ(5,1009) I
        IF(I .NE. 'G') GO TO 12
C
C       THIS IS THE HYPERBOLIC FLIGT SECTION
        WRITE(5,1010)
C
C       THIS IS THE INPUT TO DESCRIBE THE FLIGHT
C       X0      STARTING X-COORDINATE
C       XF      ENDING X-COORDINATE
C       H       HEIGHT OF MAIN ELEMENT USED TO DETRMINE GLIDE ANGLE
C               AND HEIGHT ABOVE GROUND OF ZERO CDI SURFACE AT CLOSEST
C               APPROACH
        READ(5,101) X0,XF,H
        WRITE(5,1006)
C
C       THIS INPUT IS FOR THE FLIGHT PATH QUANTIZATION PARAMETERS
C       NK      IS THE NUMBER OF POINTS ALONG THE FLIGHT PATH
C       V       IS THE VELOCITY (FT./SEC.) OF THE AIRCRAFT
C       TAU     IS THE TIME CONSTANT (SEC.) FOR THE DYNAMIC CDI
        READ(5,1007) NK,V,TAU
        IF(NK .LE. 0) GO TO 22
        CALL JOVWO(1,TAU,1,0)
C
C       THIS LOOP GENERATES THE COORINATES OF THE POINTS ALONG THE
C HYPERBOLA AND OUTPUTS THEM TO THE FLIGHT PATH FILE
        A1=RL*RL*.25-H*H-YE*YE
        A2=1./(1.-4.*H*H/RL/RL)
        DX=(XF-X0)/FLOAT(NK-1)
        XX=X0
        YY=0.
        TT=0.
        XOL=XX
        ZOL=SQRT((A1-XX*XX)*A2)
        DO 13 I=1,NK
        ZZ=SQRT((A1-XX*XX)*A2)
        TEMP=XX-XOL
        TEMP2=ZZ-ZOL
        TT=TT+SQRT(TEMP*TEMP+TEMP2*TEMP2)/V
        CALL JOVWO(1,XX,4,0)
        XOL=XX
        ZOL=ZZ
        XX=XX+DX
13      CONTINUE
        GO TO 14
C
C       THIS SECTION IS FOR STRIGHT LINE FLIGHT
12      CONTINUE
        WRITE(5,1004)
C
```

```
C         THESE INPUTS ARE TO DESCRIBE THE FLIGHT PATH
C         XX      STARTING X-COORDINATE (FEET)
C         YY      STARTING Y-COORDINATE (FEET)
C         ZZ      STARTING Z-COORDINATE (FEET)
C         XF      ENDING X-COORDINATE (FEET)
C         YF      ENDING Y-COORDINATE (FEET)
C         ZF      ENDING Z-COORDINATE
C         NK      NUMBER OF POINTS ALONG THE FLIGHT PATH
C         V       VELOCITY OF AIRCRAFT (FEET/SEC.)
C         TAU     TIME CONTANT FOR DYNAMIC CDI (SE)
        READ(5,101) XX,YY,ZZ
        WRITE(5,1005)
        READ(5,101) XF,YF,ZF
        WRITE(5,1006)
        READ(5,1007) NK,V,TAU
        IF( NK .LE. 0) GO TO 22
        CALL JOVWO(1,TAU,1,0)
        FN=NK-1
        DX=(XF-XX)/FN
        DY=(YF-YY)/FN
        DZ=(ZF-ZZ)/FN
        DT=SQRT(DX*DX+DY*DY+DZ*DZ)/V
        TT=0.
C
C         LOOP TO GENERATE X-,Y-, AND Z-COORDINATES AND OUTPUT THEM
C TO THE FLIGHT PATH FILE
        DO 1 I=1,NK
        CALL JOVWO(1,XX,4,0)
        XX=XX+DX
        YY=YY+DY
        ZZ=ZZ+DZ
1       TT=TT+DT
C
C         THIS CLOSES THE FLIGHT PATH FILE AND RETURNS TO SWITCH POINT
14      CALL JOVREL(1)
        GO TO 2
C
C         THIS SECTION IS TO GENERATE ANTENNA DESCRIPTION FILE
23      N=0
        WRITE(5,107)
C
C         INPUT FOR ANTENNA FILE NAME
        READ(5,2000) ILBL
        WRITE(5,100)
C
C         INPUT FOR ANTENNA PLOT LABEL
        READ(5,105) ILABL
        N=1
C
C         THIS IS THE INPUT FOR ELEMENT DESCRIPTION
C         X(I)    X-COORDINATE OF I'TH ELEMENT (FEET)
C         Z(I)    Z-COORDINATE OF I'TH ELEMENT (FEET)
C         C1(I)   COMPLEX AMPLITUDE OF CARRIER COMPONENT OF I'TH ELEMENT
```

```
C        C2(I)   COMPLEX AMPLITUDE OF 150 HZ SIDEBAND OF I'TH ELEMENT
C        C3(I)   COMPLEX AMPLITUDE OF 90 HZ SIDEBAND OF I'TH ELEMENT
C THE PROGRAM WILL LOOP THRU 10 FOR ADDITIONAL ELEMENTS UNTIL A
C       ZERO IS ENCOUNTERED FOR Z(N)
      WRITE(5,1017)
10    READ(5,2001) X(N),Z(N),C1(N),C2(N),C3(N)
      IF( Z(N) .EQ. 0) GO TO 9
C
C        THIS SECTION DETERMINES THE Y OFFSET OF EACH ELEMENT.  THIS
C IS NOMINALLY Y0 BUT THERE IS A SMALL CHANGE (LESS THEN ONE WAVELENGTH)
C FOR NEAR FIELD CORRECTION PURPOSES
      SW=SIGN(1.,Z(N)-Z(1))
      IF(N .NE. 1) GO TO 15
      Y(1)=Y0
      F=SQRT(Y0*Y0+Z(1)*Z(1))
      GO TO 16
15    X0=Y0-SQRT(F*F-Z(N)*Z(N))
      IF(X0*SW .LT. 0.) GO TO 17
19    XP=Y0-SQRT((F+RL)*(F+RL)-Z(N)*Z(N))
      IF(XP*SW .LT. 0.) GO TO 18
      F=F+RL*SW
      X0=XP
      GO TO 19
17    F=F-RL*SW
      GO TO 15
18    Y(N)=Y0-X0
16    CONTINUE
      N=N+1
      GO TO 10
C
C        THIS SECTION OUTPUTS THE ANTENNA DESCRIPTION TO THE FILE
C AND ON THE LINE PRINTER, CLOSES THE FILE ANF RETURNS TO THE SWITCH
C POINT
9     NEL=N-1
      CALL OFILE(20,ILBL)
      WRITE(20,105) ILABL
      WRITE(20) RL,NEL,(X(I),Y(I),Z(I),C1(I),C2(I),C3(I),I=1,NEL)
      WRITE(3,1016) ILABL
      WRITE(3,2001) (X(I),Y(I),Z(I),C1(I),C2(I),C3(I),I=1,NEL)
      CALL RELEAS(20)
      GO TO 2
C
C        THIS IS THE PROGRAM TERMINATION POINT
3     CALL EXIT
      STOP
1012  FORMAT('+ UNKNOWN SWITCH,')
1013  FORMAT(' INPUT SWITCH:',$)
1014  FORMAT(' INPUT GROUND FILE NAME:',$)
1015  FORMAT(' INPUT FLIGHT PATH FILE NAME:',$)
1017  FORMAT(' INPUT ELEMENT VALUES,.',/)
1016  FORMAT(2X,8A5)
104   FORMAT(' INPUT GROUND LABEL',/)
105   FORMAT(8A5)
```

```
        100  FORMAT(' INPUT GROUND SEGMENTS.  STARTING FROM ANTENNA.',/,
            1' GIVE CONSECUTIVELY EITHER X AND Z INCREMENTS, OR THE',/,
            2' LENGTH AND ANGLE FROM HORIZONTAL IN DEGREES, SEPARATED',/,
            3' BY A ZERO.  HIT CARRIAGE RETURN FOR END OF DATA.',/,
            4' OR IF THERE ARE NO MORE STRIPS.',/,' *',$)
        101  FORMAT(3F)
        103  FORMAT(' ONLY 20 GROUND SEGMENTS ALLOWED.  COMPUTATION WILL ',/,
            1' PROCEED WITH DATA ALREADY OBTAINED.',/)
        102  FORMAT(' *',$)
        1003 FORMAT(' INPUT FLIGHT PATH TITLE',/)
        1000 FORMAT(' INPUT FLIGHT PATH TYPE:',$)
        1008 FORMAT(A1)
        1010 FORMAT(' INPUT XP,XF,H:',$)
        1011 FORMAT(' INPUT Y2,LAMBDA:',$)
        1004 FORMAT(' INPUT XO,YO,ZO:',$)
        1005 FORMAT(' INPUT XF,YF,ZF:',$)
        1006 FORMAT(' INPUT # OF POINTS, VELOCITY, TIME CONSTANT:',$)
        1007 FORMAT(I,2F)
        107  FORMAT(' INPUT ANTENNA FILE NAME:',$)
        2000 FORMAT(A5)
        106  FORMAT(' INPUT ANTENNA DESCRIPTION',/)
        2001 FORMAT(9F)
             END

CONSTANTS

0       201004020100    1       545004020100    2       435004020100    3       501004020100    4       405004020100
5       000000003024    6       000000000201    7       200000000010    10      000000000000    11      000000000004
12      201400000000

COMMON

XX      /.COMM./+0      YY      /.COMM./+1      ZZ      /.COMM./+2      TT      /.COMM./+3      K       /GROUND/+0
X1      /GROUND/+1      Z1      /GROUND/+25     X2      /GROUND/+51     Z2      /GROUND/+76     IEL     /GROUND/+123

SUBPROGRAMS

FORSE.  .JBFF   END.    COSD    SIND    OF.LE   BINWR.  RELEAS  JOVSET  JOVWO   FLOAT   SORT    JOVREL  SIGN    EXIT
ALPHO.  ALPHI.  FLOUT.  FLIRT.  INTO.   INTI.

SCALARS

NAME    1410            Y0      1411            RL      1412            R       1413            Z2      2
THETA   1414            K       0               ISIZE   1415            I       1416            X0      1417
XF      1420            H       1421            NK      1422            V       1423            TAU     1424
A1      1425            A2      1426            DX      1427            XX      0               YY      1
TT      3               XOL     1432            ZOL     1431            TEMP    1432            TEMP2   1433
YF      1434            ZF      1435            FN      1436            DY      1437            DZ      1440
DT      1441            N       1442            ILBL    1443            SW      1444            F       1445
XP      1446            NEL     1447            IEL     123

ARRAYS
```

```
FMAKE.F4        F40     V27(360)        22-APR-76       11:04

        IDUM    1450            ILABL   1452            X       1462            Y       1506            Z       1532
        C1      1556            C2      1626            C3      1676            X1      1               Z1      29
        X2      51              Z2      76

A1        136   143   145
A2        137   143   145
C1          7   218   249   251
C2          7   218   249   251
C3          7   218   249   251
COSD       53    54    70    71
DT        101   191
DX        130   152   178   181   188
DY        179   181   187
DZ        180   181   190
EXIT      296
F         227   229   231   233   236
FLOAT     130
FN        177   178   179   190
GROUND      8
H         123   136   137
I         111   112   144   106   249   251
IDUM        1     2    37    80    90    94    98
IEL         8
ILABL       4    41    81   104   105   206   240   250
ILBL      202   247
JOVREL    194
JOVSRT     98
JOVWO     105   132   149   176   187
K           8    55    65    67    68    69    70    71    72    82
N         198   207   210   219   224   225   229   231   238   240   246
NAME       18    19    20    21    22    23
NEL       246   249   251
NK        130   131   138   144   174   175   177   186
NSIZE      90
OFILE      88    94   247
R          52    53    54    62    63    70    71
RELEAS     23    95   252
RL         30   136   137   231   233   236   249
SIGN      224
SIND       53    54    70    71
SQRT      143   145   140   181   227   229   231
SW        224   230   232   233   236
TAU       130   132   174   176
TEMP      146   140
TEMP2     147   140
THETA      52    53    54    62    70    71
TT          3   141   140   182   191
V         130   140   174   181
X           5   218   249   251
X0        123   130   139   229   230   234   238
X1          8    60    82
X2          8    53    60    70    82
XF        123   130   172   178
XOL       142   146   190
XP        231   232   234
XX          3   139   142   143   145   146   149   150   152   178   170   187   188
Y           5   226   230   249   251
```

Y0	30	136	226	227	229	23[illegible]	230							
YF	172	179												
YY	3	142	170	179	189									
Z	5	218	219	224	227	229	231	249	251					
Z1	8	69	82											
Z2	8	54	69	71	82									
ZF	172	180												
ZO	143	147	151											
ZZ	3	52	53	54	62	64	70	71	145	147	151	170	180	190
1P	186	191												
2P	17	25	31	52	62	65	84	195	253					
3P	19	255												
4P	66	74	80											
5P	63	64	67											
6P	72	75												
9P	219	246												
10P	218	241												
11P	62	76												
12P	112	157												
13P	144	153												
14P	154	194												
15P	225	229	237											
16P	228	239												
17P	230	236												
18P	232	238												
19P	231	235												
20P	20	29												
21P	21	34												
22P	22	87	131	175										
23P	23	198												
100P	42	266												
101P	30	52	62	123	70	172	271							
102P	56	75	274											
103P	73	272												
104P	38	264												
105P	37	41	81	90	104	206	248	265						
107P	199	284												
108P	203	286												
1003P	99	2[illegible]												
1004P	150	200												
1005P	171	231												
1006P	124	173	2[illegible]											
1007P	130	174	[illegible]											
1008P	106	276												
1009P	18	111	277											
1010P	119	278												
1011P	29	279												
1012P	24	258												
1013P	17	259												
1014P	34	260												
1015P	87	2[illegible]1												
1016P	250	26[illegible]												
1017P	217	262												
2000P	282	285												
2001P	210	251	28[illegible]											