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USERS' MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGATION EFFECTS ON THE INSTRUMENT LANDING SYSTEM

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16. Abstract

This manual presents the complete ILSS (revised ILSLOC) computer program package. In addition to including a thorough description of the program itself and a listing with comments, the manual contains a brief description of the ILS system and antenna patterns. To illustrate the program, a test case has been created and the figures of the case are incorporated in the report. Program DYNM and program ILSPLT are included as appendixes. The ILSPLT, complete with sample graphs, is a plotting routine for ILSLOC.

For a technical mathematical analysis of the system, see report FAA-RD-72-137 (AD754517), "Instrument Landing System Scattering."

This report revises in part an earlier report FAA-RD-73-76, "Users' Manual for ILSLOC: Simulation for Derogation Effects on the Localizer Portion of the Instrument Landing System." The revisions include the treatment of triangular scatterers and glide slope antenna systems.

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PREFACE

As part of the ILS Performance Prediction program, a first phase ILS Localizer performance prediction computer program package has been prepared. This package consists of the computer program and the present document which describes the capabilities and limitations of the computer model as well as the step by step running of the computer program.

The computer program is intended primarily as an aid in predicting the performance of different ILS antenna candidates for a proposed runway instrumentation or for the upgrading of an already instrumented runway in a known airport environment. It is also intended to provide a relatively inexpensive means by which the effect of proposed changes to an airport environment (addition of terminal buildings, hangars, etc.) on ILS performance may be predicted. Another computer program has been devised to treat the effects of terrain on glide slope performance.*

This document was prepared for the Transportation System Center (TSC) by D. Newsom who was assigned as a full-time programmer to the ILS Performance Prediction program. A. Watson and M. Scotto helped in the writing and editing. The report itself and the attached computer program are based on the theories and analyses which were developed by the TSC group (G. Chin, L. Jordan, D. Kahn, and S. Morin). The ILS program was sponsored by H. Butts of the Systems Research and Development Service of the Federal Aviation Administration.

The present report revises in part an earlier report, FAA-RD-73-76. The revisions include the treatment of triangular scatters and glide slope antenna systems. The revised ILSLOC program has been renamed ILSS-FOR (Instrument Landing System Scattering-Fortran). The use of the term ILSLOC in the body of this report refers to the generalized program, ILSS.

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*S. Morin et al, ILS Glide Slope Performance Prediction, Version A. Report No. FAA-RD-74-157 A. U.S. Department of Transportation, Transportation Systems Center, Cambridge MA 02142, September 1974.

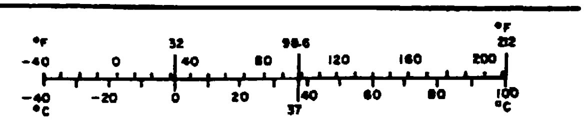
METRIC CONVERSION FACTORS

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. DEFINITION OF INSTRUMENT LANDING SYSTEM

The ILSLOC program has been written to simulate certain airport conditions which affect the localizer portion of the Instrument Landing System. 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 horizontal system is called the "localizer."

This system operates by the transmission of an RF carrier, amplitude modulated by two audio frequencies, beamed to approaching airborne receivers. In an instrumented aircraft, the localizer receiver serves to demodulate the RF signal, amplify and isolate the corresponding audio signals and derive a signal to drive the ILS horizontal display in the cockpit. The pilot, by reading the display, can determine if he is on course, to the left of the runway, or the right of the runway. These signals must be strong enough to cover a radius of twenty-five miles around the antenna.

The directional information is determined by the relative strengths of the transmitted sideband signals. The audio frequency modulations, which are fixed at 90 Hz and 150 Hz, are radiated in different angular patterns with respect to the runway centerline extended. 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 Hz 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 bearing is relative to the center line of the runway. The CDI is measured in microamps. The actual course generated by any particular ILS installation will deviate from the ideal due to the interference of spurious reflections from buildings present in the range of the transmitting antenna. The deviation, caused by these buildings, or scatterers of the CDI from what the receiver should read ideally at that point in space (e.g., on the center of the runway and CDI reading other than 0) is the derogation effect.

The Localizer 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. If a specific localizer system uses two antenna arrays, four sets of signals will be transmitted; if the system uses a single antenna array, two sets will be transmitted.

2. ANTENNA PATTERNS

The proper angular variation of the transmitted 90 Hz and the 150 Hz modulation is achieved by the radiation of two independent sideband patterns by the transmitting antenna arrays. Equal magnitudes of 90 Hz and 150 Hz modulation are transmitted in each of these patterns, however with different relative phases. One of the patterns is symmetrical with respect to the prescribed course. An unmodulated carrier wave is transmitted with the same pattern and the combination is commonly referred to as the "carrier plus sidebands" (C + S) signal. The other signal is transmitted in an "anti-symmetrical" pattern and is referred to as the "sidebands-only" signal.

Figure 1 illustrates how these features are used to obtain the desired directional CDI. The magnitudes of the C + S and SO sideband patterns as functions of angular deviation from the course are illustrated in Figures 1a. The sideband amplitude of the C + S pattern represents 20% modulation of the carrier wave (or a "depth of modulation" of 0.2) at both 90 Hz and 150 Hz. Considering the phases of both modulations of the C + S signal to be positive, the relative phases and typical amplitudes of the two SO modulations are as shown in Figures 1b. The resultant 90 Hz and 150 Hz modulation patterns in the total ILS signal are obtained by algebraically combining the respective C + S and SO sideband patterns (Figures 1c). The evident consequence is that the depth of modulation is greater for 90Hz than for 150 Hz to the left of the course as seen from an approaching aircraft, and the opposite is true to the right of the course. This difference when properly calibrated in relation to the total modulation (90 Hz + 150 Hz) reaching the aircraft receiver gives the CDI as appears in Figure 1d.

Since the strength of C + S and SO signals fall off at the same rate with distance from the transmitting antenna, the CDI is independent of range.

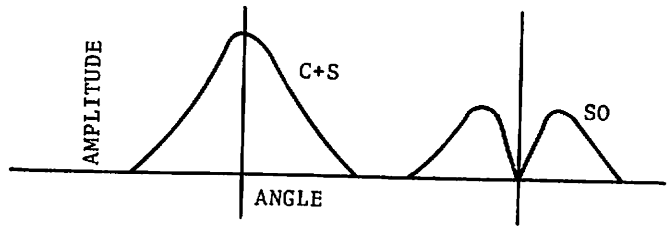


Figure 1a Sideband Pattern Magnitude

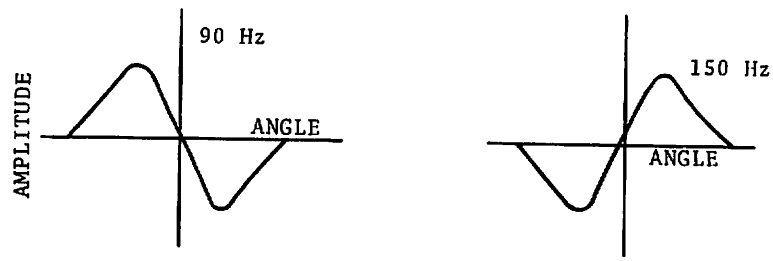


Figure 1b Relative Amplitudes and Phases In SO Pattern

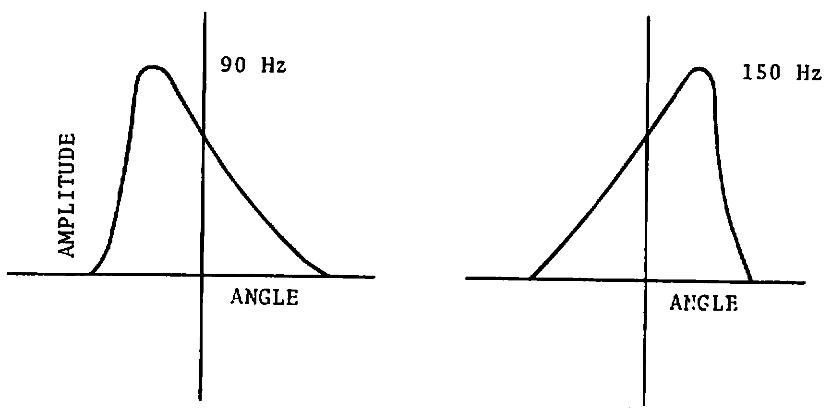


Figure 1c Resultant Modulation Patterns

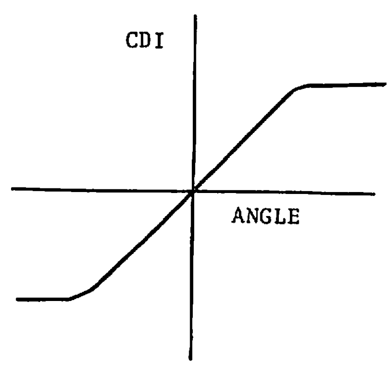


Figure 1d Course Deviation Indication (CDI)

Figure 1. Antenna Patterns Sketch

FAA standards for the ILS specify that within a certain narrow angular range about the course, the CDI should be closely proportional to the aircraft's angular deviation from course. This sector near the ideal approach is termed the "course sector" and usually extends between 1-1/2° and 3° to either side of the runway centerline. The wider sectors on either side of the course sector are called the "clearance sectors." In these sectors, which extend a minimum of 35° from the course, the CDI is required to always exceed a certain minimum magnitude. The presence of structures in the clearance sectors which scatter spurious signals into the course sector is the primary cause of derogation of the localizer CDI. Such structures are illuminated by carrier and sideband signals. The ratios of 150 Hz modulation to 90 Hz modulation in these signals are determined by the angular position of the structure with respect to the runway. In general these ratios are different from those transmitted toward the aircraft, due to the difference in angular position. The signals transmitted toward the scatterer will be reflected toward the aircraft. Thus the aircraft will receive the summations of the direct and scattered signals. Since, in general, the scattered signals will have improper ratios their effect is to distort the CDI. To combat this problem several new antenna systems have been designed. Two basic systems are used: the single antenna, and the "capture effect system."

The single antenna system radiates two patterns from one antenna array. The signal generated in the course sector is stronger than that generated in the clearance sector. However, because of the derogation effects, the signals are often not accurate enough to meet category II or III requirements and the more accurate "capture effect system" is used. This system uses one antenna array to broadcast a very narrow, powerful beam in the course sector. The second antenna array broadcasts a broader pattern, at a slightly different carrier frequency, which covers the clearance area. This system diminishes the derogation effects because of the dual frequency. The term "capture effect" has been used to describe this two-antenna array system because the airplane receiver is "captured" by the stronger transmission signal.

3. ILS SIMULATION DESCRIPTION

The ILS simulation program makes it possible for airport planners to determine what the effects of potential airport buildings on the ILS performance are going to be. Thus, for example, if a new terminal or hotel is planned, the information as to size and location of the building can be input to the program and the derogation effect of that building can be determined. Because the derogation effect of these scatterers is so important, the program can warn the planner ahead of time to change the orientation or location of the building, or it can assure him that the building would not jeopardize the airport's current FAA rating.

The output of this program is a magnetic tape of values of the CDI. Graphs are generated by a plotting routine (using the values derived from the ILSLOC program) to show the CDI in micro-amperes, along a flight path, for the scattering surfaces input. These generated graphs would serve the same purpose as the FAA strip charts which are generated for a certifying flight. The simulation graph differs from the actual recorded measurements due to limitations of the program which will be explained later in the text.

The ILSLOC program simulates: transmission from the various types of localizer antenna systems; the trajectory of an aircraft flight over which the CDI is to be determined; and the scattering from rectangular and cylindrical surfaces. The program permits various simulated flight paths.

The program is not an exact simulation of the certifying flight, due to certain simplifying assumptions which were made. These assumptions include:

a. A flat perfectly conducting ground plane

b. Perfectly conducting reflectors

c. Far-field scattering-- all scattering from a surface is assumed independent of all other surfaces; thus, multiple reflections from walls and near-field interactions are ignored

d. A noise-free environment

e. Relative field strengths-- the absolute field strengths involved are not calculated; thus while we can calculate the CDI's in microamperes, we do not ascertain the absolute electric-field intensities, and

f. An idealized ILS receiver model.

In addition to these assumptions the approximations of the scatterer can lose accuracy when the dimensions approach less than a few wavelengths. Since the program determines the scattering from a surface independently from all other scatterers, the shadowing of one structure on another is not included. Thus if one building is between the antenna system and another building, it will shield the second one from some of all of the ILS signal. The amount of energy reaching the second building will depend upon diffraction effects which are, in general, too complicated to analyze. It may be noted, however, that diffraction effects themselves are included as part of the physical optics approximation used.* By using rule of thumb approximations the analyst can determine roughly how much power will reach the second building. If the level is small the building may be ignored completely. If on the other hand the power level is large then the structure should probably be included as though there was no shielding effect. This will give a conservative CDI estimate (i.e., larger derogation than actual), but this will serve for most purposes. If the situation is critical, that is near category limits, then other means of analysis must be used.

*Chin, G., L. Jordon, D. Kahn, and S. Morin, TSC, "Instrument Landing System Scattering," FAA-RD-72-137, AD754517 (Dec. 1972).

4. TEST CASE FOR THE ILSLOC COMPUTER PROGRAM

To illustrate how the computer program is operated a very simple test case (with only 2 scatters) has been created and run. For this simulated airport the program computed the course width as 4.01 degrees. Both antenna arrays were set at an elevation of 13 feet above the ground plane. The clearance antenna array was used as the origin for the coordinate system. An 80 x 100 x 60 ft hangar and 75 x 110 ft cylinder were placed on opposite sides of the 9,350 ft runway. In this case the threshold is 10,000 ft from the course antenna. (See illustration--Figure 2.) Based on the size and locations of these two buildings, the model predicted the CDI on the runway centerline and for a clearance run at 10,000 ft range.

Using this model for input values, the following section presents a detailed follow through of the main program steps.

The Mode Card

The first input is the mode card. This card contains information on the type of localizer antenna used, the frequency of the ILS, the length of the runway, and the height of the antenna. The mode card format is shown immediately following Figure 2. In order to use the mode card, it is important that the user understand the coordinate system used. The x-axis is along the centerline of the runway, the threshold being in the positive direction. The z-axis is vertical, positive z being in the up direction. The y-axis completes a right-hand coordinate system; so that when one is standing at the origin facing in the x-direction, positive y is to the left. The origin is used as a reference to define the location of scatterers, antenna system components, and flight path sample points. The antennas are located along the x-axis, they need not be at the origin. As in our test case, it is usually convenient to place the course antenna at the origin.

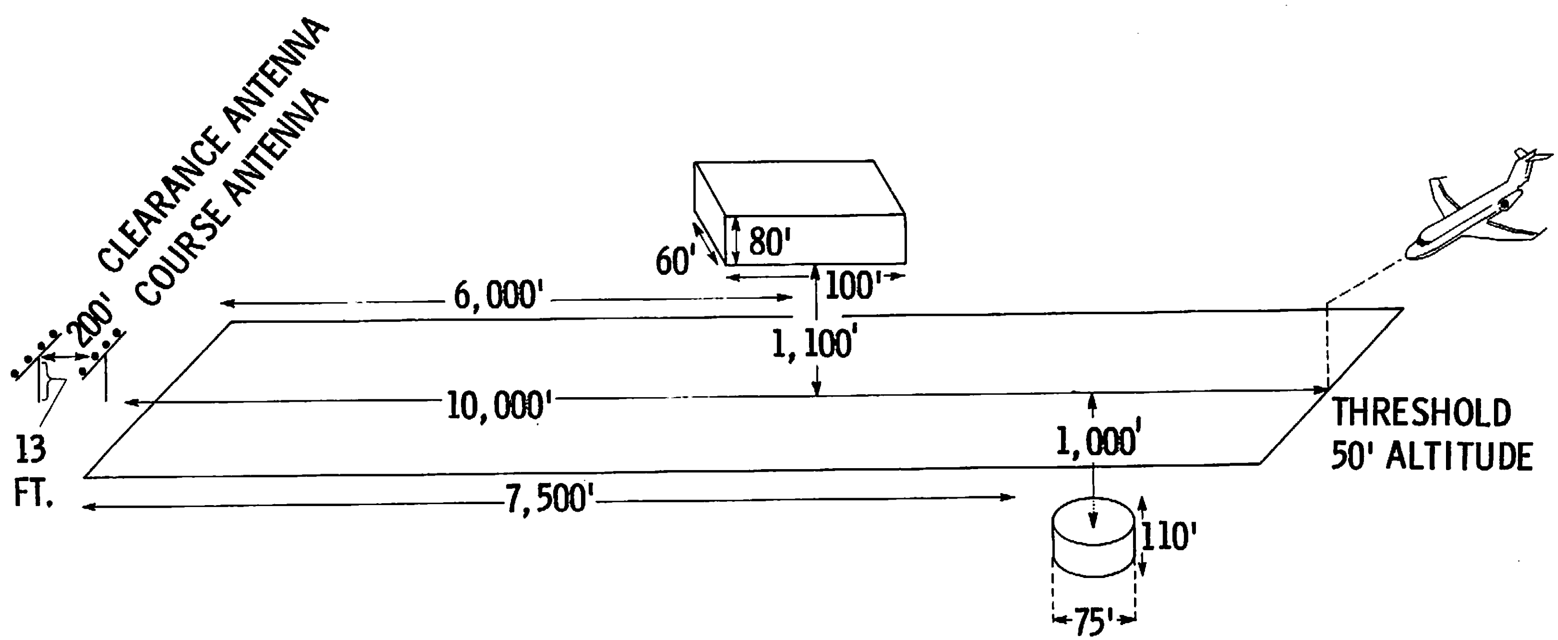


Figure 2. Simulation Airport

Model Card Format:

Col.	Symbol	Use	
1-2	Mode	= 1 (V-Ring) = 2 (8-Loop) = 3 (Wave Guide) = 4 Not Used = 5 (Measured Pattern) = 6 (Measured Capture Effect Patterns) = 7 (Theoretical Patterns) = 8 (Theoretical Capture Effect Patterns) =-1 (V-Ring Clearance =-2 (8-Loop Clearance) =-3 (Waveguide Clearance) =-4 (Measured Clearance Patterns)	Indicates Localizer Antenna Type
		=13 Null Reference =14 Sideband Reference =15 N-Array (Capture Effect)	Glide Slope Antennas
3-4	IET	= 0 (Half-wave dipole) = 1 (30° width pattern as from double wave reflector used with glideslope antennas)	Antenna Element Pattern
11-20	FRQ	Frequency of ILS in MHz	
21-30	XTH	Distance from the origin to the threshold of the runway, in feet. This number is used for both flight path orientation and for course width determination. The distance is given in feet.	
31-40	ZA(1)	There is always a non-zero antenna height, and it is input here.	
41-50	ZA(2)	This will be the clearance antenna height if a two-antenna system is used.	
51-60	SLP	Slope of runway in degrees used to adjust the flight path at threshold for runway slope.	

Modes 1, 2, and 3 provide for standard localizer antenna types. These antennas are predetermined, the only variable being course width, the adjustment of which is controlled by the course width card.

When any antenna type other than mode 1, 2, or 3 is used, additional antenna description cards must be included. Mode 5 permits the input of a measured pattern for special cases on theoretical studies. When this mode is selected additional pattern cards are required. One pattern card must be used for each measurement. The angles must be given in ascending order. A maximum of 50 measurements may be given; if less than 50 cards are used a termination card with an angle greater than 360 degrees must be inserted.

Format of Pattern Card(s)

Col.	Symbol	Use
1-1∅	ANG	Angle of measurement, in degrees
11-2∅	AFPP	Amplitude of sideband only pattern, in relative units
21-3∅	AGPP	Amplitude of carrier plus sideband pattern, in relative units.

Mode 7 allows the generation of a theoretical array pattern from assumed element contributions. The antenna is to be a linear array of elements with identical radiation patterns. Each element has an arbitrary magnitude and phase for both carrier plus sideband and sideband only currents. The arrays are assumed to be alligned parallel to the y-axis. All elements have the same height, as given in the mode card. All elements have the same x-coordinate as given on the course width card. The y-coordinate, in wavelengths, is given for each element on the element description card. There must be one card for each element in the array, to a maximum of 26 elements. The element description card has the following format:

Col.	Symbol	Use
1-10	DT	Element displacement in the y-direction given in wavelengths
11-20	CT	Carrier plus sideband amplitude, in relative units
21-30	PC	Carrier plus sideband phase, in degrees
31-40	ST	Sideband only relative amplitude
41-50	PS	Sideband only phase, in degrees.

The phase of the sideband only currents is ideally in quadrature to the carrier plus the sideband currents. This 90-degree shift is added by the program. Thus a "PS" inputted as zero degrees is internally converted to 90 degrees out of phase with the sideband portion of the carrier plus sideband. To indicate termination when there are less than 26 elements used, an element card is placed with a carrier plus sideband phase value (PC) of more than 500.

The next step for this mode must be the input of the horizontal radiation pattern for the individual element. This pattern will be used for each of the elements previously described. The input is the relative signal strength measured every 10° starting at 0 and proceeding until 180°. This is total of 19 amplitudes; the values are read in, in records of 8F10.4 format, for a total of 3 records. This gives the pattern for angles from 0 to 180° and since the pattern is assumed to be symmetric the value for the negative angle will be the same as a positive one of equal magnitude.

There are two methods of inputing capture effect system descriptions. The most general way is to input each antenna separately. When using this method the clearance antenna must be input first. This input will follow the same steps as a single antenna system except that the mode number will be a negative. The negative mode card and the pattern or element cards (if any) must be followed by another mode card. This mode for the course antenna must be positive, and followed by the necessary pattern or element cards.

There are two cases for the second method of inputing antenna descriptions. The first case is used if both course and clearance antennas are to be given as measured patterns; a single mode 6 card is used followed by two sets of pattern cards: the first set is for the course antenna and the second set for the clearance antenna. In the second case, for a capture effect system which uses two theoretical array antennas, a mode 8 is used. This card is followed by the course antenna element description cards and the element radiation cards; a second set of array description cards is used in the clearance antenna.

In the above localizer antenna cases, IET has no effect on the simulated individual element patterns and may be input as zero.

FRQ is set to the frequency (in MHz) of the carrier for the antennas system.

XTH is the distance (in feet) from the orgin to the runway threshold. The flight path is set to cross the threshold at an altitude of ZUP (as given on flight path card).

ZA(1) (course) and ZA(2) (clearance) are the heights in feet of the antennae.

SLP is the slope of the runway in degrees. It is used with XTH in setting up the flight path. The ground plane assumed for the signal scattering is not tilted.

Modes 13, 14, and 15 are used for glide slope antennas. Although this program is intended for localizer simulation, it may be also used to study the effects of buildings on the glide slope system. The simulation will assume a perfect flat horizontal and infinite ground plane. If a glide slope antenna is chosen on the mode card, the next card must be as follows:

Col	Symbol	Use
1-10	YA	Antenna Offset (in feet)
11-20	TGS	Glide path angle (in degrees)

YA is the antennae offset (Y-coordinate) in feet. Positive is to the left from the origin facing the threshold. If the magnitude of YA is less than 300, YA will be defaulted to 1500, the sign depending on the sign of YA input. TGS is the intended glide path angle in degrees.

The measured pattern of a capture effect localizer is used in our test case:

Mode Card:

Col.	
1-2	6
11-20	110.
21-30	10000.
31-40	13.
41-50	13.

Pattern Cards: See attached Figure 3 for test case listing.

The antenna description cards are followed by the course width card. The format for this card is:

Col.	Symbol	Use
1-10	XXA(1)	Course array x-coordinate, in feet
11-20	XXA(2)	Clearance array x-coordinate, in feet
31-40	CW	Course width in degrees
41-50	CLS	Clearance signal strength relative to the course signal.

If CW is greater than 3° this value is used as the course width and the signal strengths of the course antenna are automatically adjusted to produce this value.

If CW is less than 3° the course width will be set to the FAA specification for a threshold to antenna distance, given by XTH, and the signal levels will be set accordingly.

CLS is the ratio of clearance signal strength to course signal strength.

-45.	-.012	0.006
-42.	-.020	0.014
-40.	-.014	0.020
-38.	0.000	0.020
-35.	0.018	0.000
-32.	0.008	-.025
-30.	-.010	-.020
-28.	-.011	0.000
-27.	-.008	0.010
-26.	0.000	0.017
-25.	0.011	0.019
-23.	0.020	0.000
-20.	0.000	-.039
-19.	-.010	-.041
-18.	-.015	-.035
-16.	0.000	0.000
-14.	0.016	0.024
-13.	0.015	0.035
-12.	0.000	0.050
-9.	-.180	0.140
-5.	-.535	0.535
-4.	-.535	0.660
-1.	-.165	0.996
0.	0.000	1.000
1.	0.165	0.996
4.	0.535	0.660
5.	0.535	0.535
9.	0.180	0.140
12.	0.000	0.050
13.	-.015	0.035
14.	-.016	0.024
16.	0.000	0.000
18.	0.015	-.035
19.	0.010	-.041
20.	0.000	-.039
23.	-.020	0.000
25.	-.011	0.019
26.	0.000	0.017
27.	0.008	0.010
28.	0.011	0.000
30.	0.010	-.020
32.	-.008	-.025
35.	-.018	0.000
38.	0.000	0.020
40.	0.014	0.020
42.	0.020	0.01[illegible]
45.	0.012	0.006
1000.		

Figure 3. Pattern Card Test Case Listing

-60.	0.000	0.000
-55.	-.085	0.018
-54.	-.096	0.019
-51.	-.145	0.008
-50.	-.160	0.002
-49.	-.175	0.005
-45.	-.245	0.050
-33.	-.411	0.400
-32.	-.414	0.430
-30.	-.426	0.475
-27.	-.464	0.497
-26.	-.475	0.499
-25.	-.490	0.497
-22.	-.545	0.486
-21.	-.565	0.485
-20.	-.585	0.486
-19.	-.602	0.490
-15.	-.676	0.540
-14.	-.680	0.560
-13.	-.680	0.585
-12.	-.675	0.620
-9.	-.610	0.730
-2.	-.160	0.980
0.	0.000	1.000
2.	0.160	0.980
9.	0.610	0.730
12.	0.675	0.620
13.	0.680	0.585
14.	0.680	0.560
15.	0.676	0.540
19.	0.602	0.490
20.	0.585	0.486
21.	0.565	0.485
22.	0.545	0.486
25.	0.490	0.497
26.	0.475	0.499
27.	0.464	0.497
30.	0.426	0.475
32.	0.414	0.430
33.	0.411	0.400
45.	0.245	0.050
49.	0.175	0.005
50.	0.160	0.002
51.	0.145	0.008
54.	0.096	0.019
55.	0.085	0.018
60.	0.000	0.000
1000.		

Figure 3. Pattern Card Test Case Listing (Cont'd)

The test case course width card would read:

1-10	0
11-20	-200
31-40	0 0
41-50	0.315

The label card follows the course width card. This card is put on the output tape ahead of the CDI records for this flight. It serves as an identifying record and is the label placed on the graph. Columns 180 are used. In our test case this card reads: THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT.

The program calculates the CDI at a point in space: for convenience, the program will permit calculation for a series of points. This set of points represents samples of a simulated flight path.

The program allows two types of flight paths. A straight line flight and a circular orbit. The flight path card has one of the following formats:

Straight Line Flight

Col.	Symbol	Use
1-10	XMIN	Starting distance from origin, in feet
11-20	XMAX	Ending distance from origin, in feet
21-30	DXR	Spacing between sample points, in feet
31-40	PHIR	Angle of approach, in degrees
41-50	PSIR	Glide angle, in degrees
61-70	ZUP	Height of aircraft at threshold, in feet.

XMIN is the x-coordinate of the starting location of the aircraft and XMAX is the x-coordinate of the ending location. The sample points are spaced along a straight line so that the difference in x-coordinates between successive samples is DXR.

The sign of the DXR will be set by the program so that the flight goes from XMIN to XMAX regardless of flight direction. If the DXR value would require more than 500 points the program will adjust the magnitude of DXR to give only 500 points. In some cases a flight will require more than 500 points. If this is necessary the flight must be broken up into smaller segments of not more than 500 points each. The procedure for doing this is explained in the control card section. The flight path is oriented in space so that an extension of the path crosses the threshold at the altitude of ZUP and intersects the z-axis. PHIR is the angle between the flight path and the vertical plane through the runway centerline. It is zero for a flight path along the centerline of the runway and is positive for an incoming flight (XMIN greater than XMAX) with decreasing y-displacement. PSIR is the glide angle between the flight path and the horizontal plane. It is zero for level flight and positive for a normal landing approach. The flight path is a straight line as described above except when the x-component is less than XTH, that is if the aircraft is on the antenna side of the threshold. In that case the aircraft altitude will be set up to ZUP.

Thus the values used in the test case would read:

Col.	1-10	40000
	11-20	20000
	21-30	-40
	31-40	0
	41-50	2 5
	51-60	50

The arc flight is a series of points at a constant height of ZUP and at a constant horizontal distance from origin of R. MIND is the starting angle for the arc, that is, the line of sight from the origin to the point makes a horizontal angle of MIND degree with the x-axis. The sample points are spaced at equal angles of DXR until the termination angle of MIND is reached. As in the straight line flight the sign of DXR will be adjusted appropriately. Likewise the magnitude of DXR will be set to yield not more than 500 points. Column 74 must be set to 1 to indicate a circular arc.

Circular Orbit Case

Col.	Symbol	Use
1-10	MIND	Starting angle, in degrees
11-20	MAXD	Ending angle, in degrees
21-30	DXR	Angular spacing between samples, in degrees
51-60	R	Radius of orbit, in feet
61-70	ZUP	Height of orbit, in feet
74	ICF	Must be set to 1 to indicate orbit case.

Following the flight path card must be the velocity card in the following format:

Col.	Symbol	Use
1-10	VEL	Velocity of aircraft, in feet/sec. This is used for the Doppler Effect on the receiver. The sign of the velocity will be made to agree with the directional motion from DXR. Test case assumes velocity of 200 ft/sec.

At this point we have described the antenna system and the trajectory of the aircraft; the derogating surfaces in proximity to the ILS must now be described. The program will simulate scattering from rectangular or cylindrical surfaces. We will now describe the method of inputting scatterers to simulate derogating structures.

The next card describes either the scatterer(s) or output and control. The usage is determined by the value of the ID field in columns 1 to 2. An ID of -1, 1, or 2 is used for scatterers, while the other values are used for control.

Col.	Symbol	Use
1-2	ID	Must be 1 for rectangle
3-8	XW(1)	x-coordinate of reference point, in feet
9-14	XW(2)	y-coordinate
15-20	XW(3)	z-coordinate
26-30	ALPHA	Angle between base and x-axis, in degrees
31-35	DELTA	Angle of tilt, in degrees
36-45	WW	Width of rectangle, in feet
46-55	HW	Height along rectangle, in feet.

The scatterer is a rectangle with the reference point at the middle of the base. The rectangle is assumed to be of infinite conductivity and zero thickness. It also has only one side. This can be thought of as the front surface of a metal wall. A wall with zero x-, y-, and z-coordinates and an alpha of zero is located at the origin with surface of the wall facing in the negative y direction (Figure 4, case I). A positive increase in alpha rotates the wall about the z-axis in a counterclockwise direction when viewed from above. Thus an alpha of 90 degrees faces the wall in the positive x-direction (Figure 4, case II). Alpha is the angle between the vertical projection of the base of the wall in the xy-plane and the x-axis, measured in degrees. Delta is the angle between the surface of the wall and the vertical direction, in degrees. A delta of zero is a wall perpendicular to the ground and a decrease in delta rotates the wall about the baseline in a direction so that a delta of minus ninety is a horizontal wall facing down (Figure 4, case III). WW is the width, in feet, of the wall measured along its base and HW is the height measured along the surface at right angles to the base. If the wall is

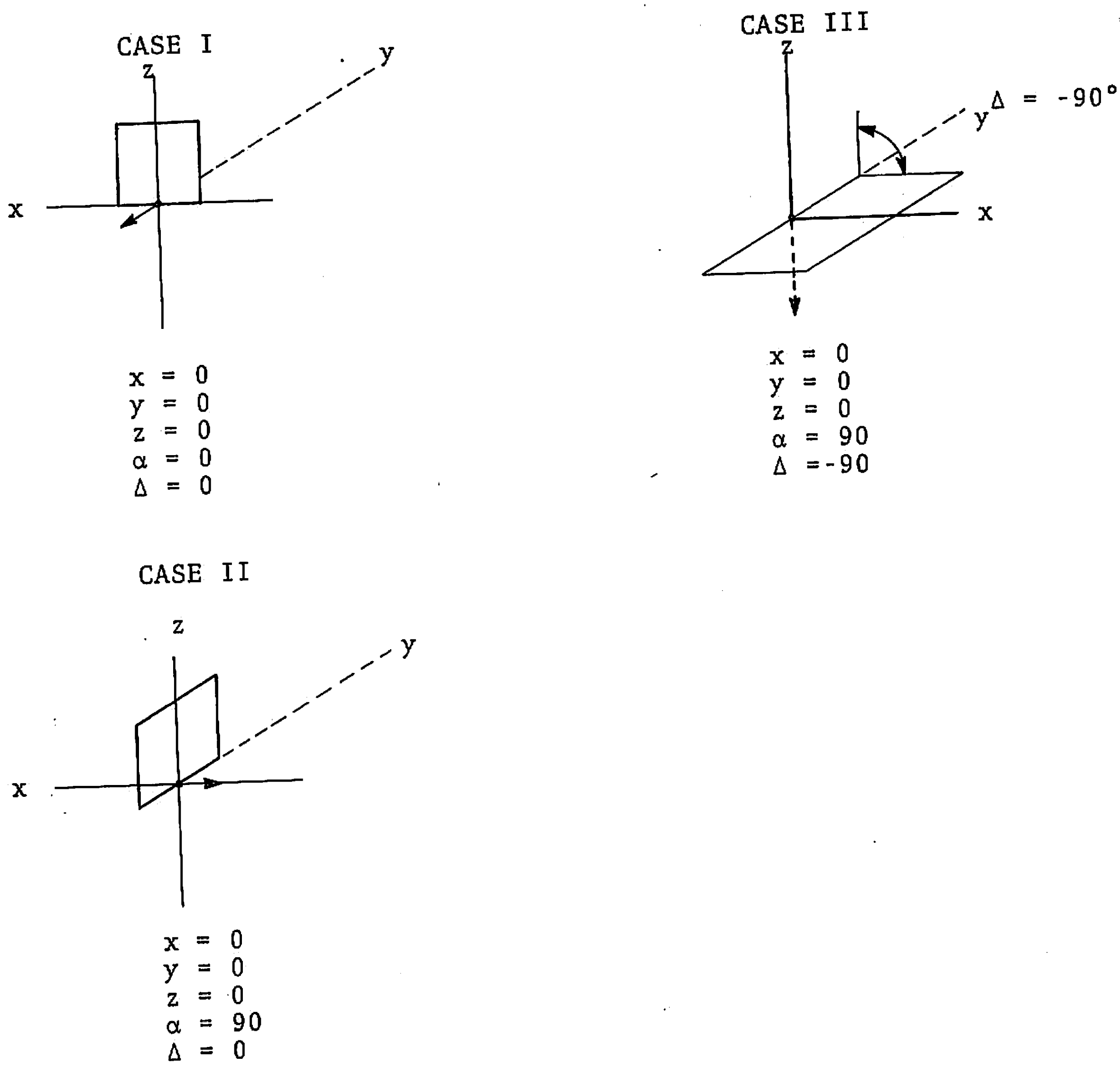


Figure 4. Illustration of Orientation Nomenclature for Rectangular Surface

oriented in such a fashion that the line of sight from the antenna to the wall passes through the back and not the front of the wall, the program will ignore the wall in the simulation.

An ID of -1 is used with the above format to describe a negative wall. This ID is used, for example, to create a wall with a rectangular hole in it. The entire surface is used; the hole is then subtracted by inputing a second card with an ID of -1 and the size, location, and orientation of the hole.

An ID of 2 is used for a cylindrical scatterer with the following format:

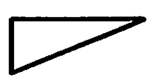
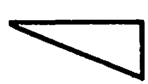
Col.	Symbol	Use
1-2	ID	Must be a 2
3-8	XW(1)	x- coordinates of the reference point, in feet
9-14	XW(2)	y- coordinates of the reference point, in feet
15-20	XW(3)	z- coordinates of the reference point, in feet
36-45	WW	Diameter of cylinder, in feet
46-55	HW	Height of cylinder, in feet.

The reference point is located at the base of the cylinder on the axis of rotation of the cylinder. The diameter is WW feet, with the base parallel to the xy-plane at an altitude of XW(3) feet. The cylinder extends upward for HW feet with the axis of rotation in the vertical direction. The cylinder is assumed to have infinite conductivity.

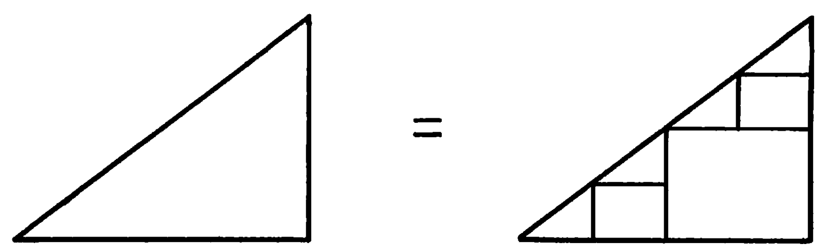
An ID of 3 or -3 is used for triangular scatters with the following format:

Col.	Symbol	Use	
1-2	ID	Must be 3 or -3	
3-8	xw(1)	X-	
9-14	xw(2)	Y-	Coordinates of the reference point, in feet.
15-20	xw(3)	z-	
26-30	Alpha	Angle between base and x-axis, in degrees	
31-35	Delta	Angle of tilt, in degrees	
36-45	WW	Width of base of triangle, in feet	
46-55	HW	Height along side of triangle, in feet.	

The variables have the same use as for the rectangular scatterer, with the exception of HW 4 WW. The magnitudes of WW & HW determine the size of the triangles, the signs of HW 4 WW are used to determine the orientation of the hypotenuse. The convention is as follows:

Triangle Orientation	Sign of HW	Sign of WW
	+	+
	+	−
	−	−
	−	+

If the size of the triangle exceeds the limits imposed by the Fresnel approximation the scatterer will be omitted and an error message given in the output. If this happens and one wishes to include scattering from this surface, the triangle must be broken up into triangular and rectangular pieces, for example:



The values for IH and IV will indicate the number of pieces horizontally and vertically the triangle must be broken up into.

After an ID of 1,-1, 2, 3, or -3, the program will calculate the electric field at the surface of the scatterer. This will be calculated from the signal from the transmission antenna array and from the ground reflection of the transmitted signal. Then, for each receiver point along the flight path, the program will calculate the electric field at that location from the scattered signal: from both the scatterer and reflected from the ground. Thus, the signal is received from four paths: (a) transmission antenna to scatterer to receiver, (b) antenna to ground to scatterer to receiver, (c) antenna to scatterer to ground to receiver, and (d) antenna to ground to scatterer to ground to receiver. This signal is decomposed into complex components induced in the receiving antenna at the different carrier and sideband frequencies. The program then loops back to read in another ID card, permitting the summation of the effects of many scatters. This allows the simulation of complex structures by breaking them up into cylinders and rectangles.

In the test case, we have only inputed three scattering surfaces. This was done because only two sides of the hangar and the cylinder are illuminated. The values for the scatterer cards read:

Col.	First card	Second card	Third card
1-2	1	1	2
3-8	6000	5950	7500
9-14	1100	1130	-1000
15-20	0	0	0
26-30	10	-80	0
31-35			
36-45	100	60	75
46-55	80	80	110

After all the scatters have been input, a control card is inserted to terminate the run. The control card format is:

Col.	Symbol	Use
1-2	ID	not -1, 1, or 2.

When a control card is read in, the program will add the direct, and ground reflected, signal from the transmission antenna to the scattered signal summations, thus giving the total received signal. The program then calculates the CDI that would be seen at each receiver point, and outputs the label, a header record describing the flight path and the values of the CDI on output tape. If the ID is equal to zero the program also outputs additional records for the strengths of sideband and carrier signals from course and clearance (if any) antenna arrays. The field summations are then cleared for the next run.

The program, having finished the previous run, now proceeds with the next input. The next run is generated by looping back to a point in the input stream, determined by the value on the control card.

Once an input sequence has begun the inputs following in the standard order must be given. The user must also keep in mind that all values on cards given before that entry point, in the previous run are still in effect. The following order is standard:

MODE CARD
(measured pattern for modes 5 and 6 or current description for modes 7 and 8)
(second mode card and patterns of currents if first mode was negative)
COURSE WIDTH CARD
LABEL CARD
FLIGHT PATH CARD
VELOCITY CARD
(set of scatterer cards)
CONTROL CARD.

The value of the ID on the control card guides the looping in the following manner:

Value of ID	Next card to be read in
0	MODE
3-10	SCATTERER
11-15	LABEL
16-20	MODE
21-50	COURSE WIDTH
>50	WILL CAUSE THE PROGRAM TO TERMINATE AFTER OUTPUTTING THE LAST CDI.

The looping permits the repetition of a run with changes in some or all of the variables. For example, ID values 3 through 10 permit a run with the same antenna system and flight path as the previous case, but with a new set of scatterer inputs.

ID values 11 to 15 permit a new flight path description and scatterer set to be input. This looping method can also be used for flights that would require more than 500 points. For reliable simulation, the spacing between receiver points (DXR) should be small enough so that the change in CDI between successive points is not more than ~20% of the peak value. Thus for long flights the flight path must be broken up into shorter segments. If the number of segments of this path does not exceed 4, the plotting program will connect them on a single graph. The control for this joining is the ID number. If the flight path finishes with an ID of 11 to 13, the graph of the next flight will continue the line of the graph. A long flight may be broken up into as many as four segments: with three segments terminating in 11 to 13 and a fourth, and final segment, terminating in 14 or 15. The flight segments must appear in the order in which they are to be flown, so that the XMIN of one section is the XMAX of the previous section. For each segment the programmer must re-input the same scatterers. If only one segment is to be plotted the control card should read 14 or 15.

ID's 16 through 20 start inputing at the mode card, thus allowing a completely new run.

An ID of 21 through 50 uses the same antenna description, but starts the inputing at the course width card. This permits the course width, clearance strength and antenna location to be varied.

The program is terminated after an ID greater than 50 is encountered. The direct signal will be added, and the CDI will be outputed before the program stops. The program will also stop if an end of file is encountered while the program is attempting to read any input card, or if certain of the variables are of improper value. In these cases the program terminates immediately, without outputing the last case.

The input of the test case flight path was done in four segments. The first segment is from 40,000 to 20,000 feet, the second segment is from 20,000 to 12,500 ft, the third segment is from 12,500 to 11,000 ft and the last is from 11,000 to 10,000 ft. An additional case for a simulated clearance flight by a circular orbit has also been included. The input cards for these test case flights are shown in Figure 5.

```
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 40000.     20000.       -40.                        2.5                 50.
200.
 16000. 1100.              10.        100.        80.
 15950. 1130.             -80.        60.         80.
 27500. -1000.  0.           0.    0.  75.         110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 20000.     12500.       -15.                        2.5                 50.
200.
 16000. 1100.              10.        100.        80.
 15950. 1130.             -80.        60.         80.
 27500. -1000.  0.           0.    0.  75.         110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 12500.     11000.        -3.                        2.5                 50.
200.
 16000. 1100.              10.        100.        80.
 15950. 1130.             -80.        60.         80.
 27500. -1000.  0.           0.    0.  75.         110.
13
 THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 11000.     10000.        -2.                        2.5                 50.
200.
 16000. 1100.              10.        100.        80.
 15950. 1130.             -80.        60.         80.
 27500. -1000.  0.           0.    0.  75.         110.
15

     THIS IS ORBIT CASE WITH SIGNAL STENGTHS
                                                           10000.      50.
   180.        180.       0.72
  200.
   16000. 1100.              10.        100.        80.
   15950. 1130.             -80.        60.         80.
   27500. -1000.  0.           0.    0.  75.         110.
```

Figure 5. Flight Case Inputs

APPENDIX A

MAIN PROGRAM LISTING

INCLUDING COMMENTS EXPLAINING

THE PROGRAM

```
C     ILS SINGLE REFLECTION INTERFERENCE PROGRAM  ILSS
C THIS PROGRAM SIMULATES THE EFFECTS OF RECTANGULAR
C AND CYLINDRICAL SCATTERERS ON LOCALIZER AND GLIDE SLOPE
C ILS SIGNALS. THIS PROGRAM IS AN EXTENSION OF THE ILSLOC PROGRAM
C WHICH TREATED LOCALIZER SIGNAL SCATTERING BY BUILDINGS.
C THESE COMMENTS SERVE AS THE PROGRAM DESCRIPTION
C FOR THE USER.  A USER'S MANUAL HAS BEEN WRITTEN AND
C THIS COMMENTARY IS WRITTEN ASSUMING THE USER HAS READ IT.
C
C
C
C ILBL IS USED TO IDENTIFY THE SIGNAL STRENGH OUTPUTS  AS
C TO TYPE AND SOURCE.  THE FIRST CHARACTER IS  'S' FOR
C SIDEBAND ONLY SIGNALS OR  'C' FOR CARRIER PLUS SIDEBAND.
C THE SECOND PAIR ARE 'CR' FOR COURSE ANTENNA OR 'CL' FOR
C CLEARANCE.
C
      DIMENSION ILBL(5)
C
C
C
      DIMENSION MEMO(14),DF(501)
      COMPLEX BESF,FAC,CE
      COMPLEX EP,EE,EM,EC,ZE(4),ZD(1),EWR,FPP,GPP,FPM,GPM,
     2        CS(25,2),SO(25,2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMPLEX  ZP(500),ZPC(500,2),ZM(500),ZMC(500,2)
      COMPLEX CB,IC,CLAM,LK,CEXPT
      DIMENSION XXRY(500,4)
      DIMENSION VCD(500,2),VPD(500,2),VMD(500,2)
      DIMENSION  XW(3),XWB(3)
      DIMENSION AN(3)
      DIMENSION AFOO(9),PHS(9)
      DIMENSION XY(10)
      REAL LAMBDA
      LOGICAL IMAGE
      COMMON/CD/ ARAD(50),AFPP(50),AGPP(50),BRAD(50),BFPP(50),BGPP(50)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON     ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2),VPC(2),VMC(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RACD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TGS,BT,SIG,CB,AK
      COMMON /ANT/ LOC,FPP,FPM,GPP,GPM,EWR(4,4),CWA(2),AS,CLS,DE(25,2),
     *            CS,SO,ET(20,2),ND(2),DUMXXX(48)
      EQUIVALENCE (ZP(1),ZD(1)),(XXRY(1,1),ZP(1))
      DATA ILBL/4HC CR,4HS CR,4HC CL,4HS CL,4H CDI/
      DATA RAD/57.2957795/
C
C
C THE OUPUT OF THE SIMULATION IS ON UNIT 8.  A TAPE WITH
C WRITE RING SHOULD BE PLACED THEREON.
C
      REWIND 8
```

```
C
C
C NC IS THE COUNT OF THE CASE BEING SIMULATED IT,S VALUE IS WRITTEN
C ON THE TAPE WITH THE OUTPUT RECORD.  THIS WOULD ALLOW
C SEARCHING FOR A PARTICULAR CASE BY NUMBER.
C
      NC=0
C
C THESE CONSTANTS ARE FILTER FACTORS FOR THE ASSUMED MODULATION
C FILTERS.
C
      TA=1./15.
      PTA = PI*TA
      W60T = 60.*PTA
      W90T = 90.*PTA
      W150T = 150.*PTA
C
C
C
C THIS IS THE STARTING POINT FOR A SIMULATION.  IT IS ALSO
C ENTERED FOR A RESTART FOLLOWING AN ID OF 0 OR 16 TO 20.
C
    1 ICP=0
      IMAGE = .TRUE.
C
C NEL IS THE NUMBER OF ANTENNAE IN THE SYSTEM.  DEFAULT
C CONDITION IS ONE ANTENNA
C
      NEL = 1
C
C
C EWR IS A COMPLEX MATRIX CONTAINING THE SIDEBAND ELECTRIC FIELD
C DESCRIPTION PRODUCED BY THE ANTENNA SURROUTINE.  EWR(I,J)
C IS THE FIELD FOR THE 'I'TH ANTENNA.  AND THE 'J' VALUES
C HAVE THE FOLLOWING SIGNIFICANCE+
C        J          USAGE
C        1         SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                   FOR THE COURSE SECTION OF THIS ANTENNA
C        2         SIDEBAND ONLY FOR THE COURSE
C        3         SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                   FOR THE CLEARANCE SECTION
C        4         SIDEBAND ONLY FOR THE CLEARANCE
C
C  THIS SURROUTINE CALL IS USED TO CLEAR EWR BEFORE
C STARTING THE SIMULATION
C
      CALL CLEAR(EWR,16)
C
    2 CONTINUE
C
C
C THIS IS THE INPUT FOR THE MODE CARD, THE VARIABLES HAVE
C THE FOLLOWING USES.
```

```
C
C        SYMBOL  USE
C        MODE    ANTENNA TYPE
C        =1      V-RING COURSE
C        =2      8-LOOP COURSE
C        =3      WAVEGUIDE COURSE
C        =4      NOT USED
C        =5      MEASURED COURSE PATTERN
C        =6      MEASURED COURSE AND CLEARANCE PATTERNS
C        =7      THEORETCAL COURSE ARRAY
C        =8      THEORETICAL COURSE AND CLEARANCE ARRAY
C        =-1     V-RING CLEARANCE
C        =-2     8-LOOP CLEARANCE
C        =-3     WAVEGUIDE CLEARANCE
C        =-5     MEASURED CLEARANCE PATTERN
C        =-7     THEORETICAL CLEARANCE ARRAY
C
C GLIDE SLOPE ANTENNA CODES
C         13     NULL REFERENCE
C         14     SIDEBAND REFERENCE
C         15     M ARRAY ( CAPTURE EFFECT ).
C GS ELEMENT PATTERN CODES
C   IET =  0     HALF WAVE DIPOLE
C          1     30 DEG PATTERN
CC
C        FRQ     FREQUENCY OF TRANSMISSION
C        XTH     DISTANCE TO THRESHOLD
C        ZA(I)   'I'TH ANTENNA HEIGHT
C
C ORIGIN IS AT THE CENTER OF COORDINATE SYSTEM.
C X-AXIS IS ALONG RUNWAY
C Z-AXIS IS STRAIGHT UP
C Y-AXIS COMPLETES A RIGHT HANDED SYSTEM
C
      READ (5,1001,END=50) MODE,IET,FRQ,XTH,ZA,SLP
C
C
C THIS IS THE INITIALIZATION SECTION.  LAMBDA IS THE WAVELENGTH
C IN FEET AND AK IS THE PHASE SHIFT/DISTANCE IN RADIANS/FOOT.
C YA IS THE Y-COORDINATE OF THE ANTENNAE.  THIS IS ASSUMED TO
C BE ZERO IN ALL LOCALIZER CASES.
C
      LAMBDA=11808./FRQ/12.
      AK=2.*PI/LAMBDA
      YA(1)=0.0
      YA(2) = 0.0
      Z = 0.
C
C
C THIS IS A TEST FOR INVALID ANTENNA TYPE.  THE PROGRAM ABORTS IN CASE
C OF ERROR.  THIS IS USUALLY CAUSED BY OMISSION OF OTHER CARDS
C WHICH CAUSE SOMETHING OTHER THAN A MODE CARD TO BE READ AT
C THIS POINT.
```

```
C
      IF( MODE .LT. -7) GO TO 98
      IF( MODE .EQ. 0) GO TO 98
      IF( MODE .LT. 11 ) GO TO 3
C
C CP AND CM ARE THE AMOUNTS OF MODULATION ON THE CARRIER
C FOR THE CARRIER PLUS SIDEBAND.  CP IS THE COURSE MODULATION
C AND CM THE CLEARANCE.
C
      SM = 857.14
      CP = 0.4
      CM = 0.45
C
C  TGS = COMMISSIONED GLIDE PATH ANGLE STATED IN DEGREES.,
C
      READ (5,1000,END=58) YA,TGS
      GO TO 6
C
    3 CP = 0.2
      CM = 0.2
      SM = 367.
C
C THIS IS TEST FOR NEGATIVE MODE  INDICATING CLEARANCE ANTENNA.
C IF MODE IS POSITIVE FLOW IS TO STATEMENT 4
C
      IF( MODE .GT. 0 ) GO TO 4
C
C ICP IS THE ANTENNA TYPE FOR THE CLEARANCE ANTENNA
C
      ICP = - MODE
C
C
C IF THERE IS A CLEARANCE ANTENNA THEN THE NUMBER OF ANTENNAE
C IS SET TO 2.
C
      NEL = 2
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY A MEASURED PATTERN IT IS
C NOW READ IN BY SUBROUTINE PATTRN.
C
      IF( ICP .EQ. 5 ) CALL PATTRN(BRAD,RFPP,BGPP)
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY ARRAY PARAMETERS THE INPUT
C DATA FOR  THE ARRAY IS NOW READ IN BY  CRRNTS.
C
      IF(ICP .EQ. 7) CALL CRRNTS (DE(1,2),CS(1,2),SO(1,2),ET(1,2),ND(2))
C
C
C THE FLOW IS NOW BACK TO STATEMENT 2 TO READ IN
C MODE CARD FOR COURSE ANTENNA.
C
```

```
      GO TO 2
C
C
C THIS IS THE INPUT SECTION FOR THE COURSE ANTENNA IF PATTERNS OR
C ARRAY DESCRIPTION MUST BE GIVEN, OTHERWISE FLOW IS TC THE
C INITIALIZATION SECTION.
C
    4 IF( MODE .LT. 5 ) GO TO 6
C
C
C THIS STATEMENT CONTROLS THE INPUT METHOD, PATTERN CR ARRAY,
C ACCORDING TO MODE TYPE.
C
      IF (MODE .GT. 6) GO TO 5
      CALL PATTRN(ARAD,AFPP,AGPP)
C
C
C THIS IS TO INPUT THE SECOND PATTERN FOR CLEARANCE ANTENNA IF
C MODE IS 6.
C
      IF( MODE .EQ. 5) GO TO 6
      CALL PATTRN(BRAD,BFPP,BGPP)
C
C THE NUMBER OF ANTENNAE AND THE ICP TYPE ARE SET, THEN FLOW IS TO
C INITILAIZATION,
C
      NEL = 2
      MODE=5
      ICP = 5
      GO TO 6
C
C
C THIS IS THE INPUT FOR COURSE ARRAY DATA,
C
    5 CALL CRRNTS (DE,CS,SO,ET,ND(1))
C
C
C THIS TEST IS FOR CLEARANCE ARRAY IF MODE
C IS TYPE 8
C
      IF ( MODE .EQ. 7) GO TO 6
      CALL CRRNTS (DE(1,2),CS(1,2),SO(1,2),ET(1,2),NC(2))
      MODE=7
      ICP=7
      NEL=2
C
C
C THIS IS THE COURSE WIDTH INPUT.
C XXA(1) IS THE X-COORDINATE OF THE COURSE ANTENNA
C XXA(2) IS THE X-COORDINATE OF THE CLEARANCE ANTENNA
C CW IS THE COURSE WIDTH
C CLS IS THE RATIO OF CLEARANCE TO COURSE SIGNAL STRENGTH,
C
```

```
      6 READ (5,1000,END=58) XXA,CW,CLS
C
C
C SET THE DEFAULT CONDITION ON CLS OF 1.
C
        IF( CLS .LE. 0.0 )  CLS = 1.0
C
C
C CWA(I) IS THE COURSE WIDTH ADJUSTMENT ON THE I:TH ANTENNA
C IT SETS THE SIDEBAND TO CARRIER RATIO. THE CLEARANCE ANTENNA
C (CWA(2)) IS ALWAYS 1.0 .  THE COURSE WIDTH IS ADJUSTED
C BY VARING THE COURSE ANTENNA (CWA(1)).
C
        CWA(1) = 1.0
        CWA(2)=1.0
C
        IF( MODE .GT. 10 ) GO TO 12
C
C THE PROGRAM WILL NOW CALCULATE THE CDI FOR 2.5 DEGREE COURSE
C OFFSET.  THIS IS USED TO NORMALIZE THE SIDEBAND LEVEL TO
C ACHIEVE THE DESIRED COURSE WIDTH.  LOC IS THE TYPE OF ANTENNA
C USED BY THE ANTENNA SUBROUTINE, PSI(1) IS THE ANGULAR ALTITUDE
C OF THE REFERENCE POINT AND PHI(1) IS THE AZIMUTH OF THE POINT.
C
        PSI(1) = 5.E-03
        PHI(1) = 2.5*RADD
        LOC = MODE
C
C
C THE MODE IS USED TO DETERMINE WHICH ANTENNA SUBROUTINE TO CALL.
C CSP IS THE STANDARD ANTENNA ROUTINE, IT COVERS THE V-RING
C 8-LOOP AND WAVEGUIDE.  LNAR IS THE ARRAY ANTENNA SUBROUTINE.
C ANTP IS THE MEASURED PATTERN SUBROUTINE. THE SUBROUTINE WILL
C RETURN FPP AND GPP FOR THE POINT AT PHI,PSI AND UNIT RANGE.
C FPP IS THE SIDEBAND ONLY LEVEL.  GPP IS THE SIDEBAND LEVEL
C FOR THE CARRIER PLUS SIDEBAND.  AFTER THE RETURN, FLOW IS TO
C STATEMENT 9.
C
        IF (MODE .GE. 7) GO TO 8
        IF(MODE .GE. 5) GO TO 7
        CALL CSP
        GO TO 9
      7 CALL ANTP (FPP,GPP,ARAD,AFPP,AGPP)
        GO TO 9
      8 CALL LNAR ( FPP,GPP,PHI,DE,CS,SO,ET,ND)
        GO TO 9
C
C
C THE SIGNAL LEVELS ARE IN FPP AND GPP.  TEMP IS THE APPARENT
C COURSE WIDTH WITH CWA'S OF 1.0.
C
      9 TEMP= 1.9375/REAL(FPP/GPP)
C
```

```
      C
      C THE COURSE WIDTH READ IN IS USED IF IT IS LARGER THAN 3 DEGREES
      C OTHERWISE THE STANDARD VALUE BY FAA SPECIFICATIONS IS
      C DETERMINED AND THIS VALUE USED.  THE COURSE WIDTH IS LIMITED
      C TO A RANGE OF 3 TO 6 DEGREES.
      C
          IF( CW - 3.0 ) 10,10,11
       10 CW = 2.*ATAN(350./XTH ) * RAD
          IF( CW .LT. 3.0 ) CW = 3.0
          IF(CW .GT. 6.0) CW=6.0
      C
      C
      C THE CWA(1) IS ADJUSTED TO PRODUCE THE DESIRED COURSE WIDTH.
      C
       11 CWA(1) = TEMP/CW
      C
          GO TO 13
      C
       12 IF( CW .LE. 0.0 ) CW = 1.4
          CALL GSCAL(CW)
       13 CONTINUE
      C
      C THE VALUES, READ IN AND CALCULATED, FOR THE ANTENNA SYSTEM(S)
      C ARE OUTPUT ON THE LINE PRINTER (ASSUMED TO BE UNIT 6)
      C
          WRITE(6,1003) MODE,ICP,FRQ,XTH,ZA,XXA,CW
          WRITE(6,1000) TEMP,CWA
          WRITE(6,1002) CLS
      C
      C THIS IS THE LOOP BACK POINT FOR NEW FLIGHT PATH.  IC'S 11 TO 15.
      C MEMO IS THE LABEL FOR HEADER RECORDS AND GRAPHS.
      C INPUT DATA FOR FLIGHT PATH.
      C         XMIN    STARTING POINT
      C         XMAX    ENDING POINT
      C         DXR     SAMPLE POINT SPACING
      C         PHIR    ANGLE OF APPROACH
      C         PSIR    GLIDE ANGLE
      C         R       RADIUS OF ORBIT
      C         ZUP     ALTITUDE AT THRESHOLD OR OF ORBIT
      C         ICF     FLAG 0 FOR STRAIGHT LINE, 1 FOR ORBIT
      C
       14 CONTINUE
          READ (5,1005,END=50) MEMO
          WRITE(6,1004) MEMO
          READ (5,1006,END=50) XMIN,XMAX,DXR,PHIR,PSIR,R,ZUP,ICF
      C
      C
      C THE SIGN OF DXR IS ADJUSTED FOR FLIGHT FROM XMIN TO XMAX.
      C
          DXR=SIGN(DXR,(XMAX-XMIN))
      C
      C
      C THE VELOCITY OF THE AIRCRAFT IS INPUT.
```

```
C
      READ (5,1006,END=58) VEL
      WRITE (6,1007) VEL
C
C THE SIGN OF THE VELOCITY IS SET TO AGREE WITH THAT OF DXR.
C
      VEL=SIGN(VEL,DXR)
C
C
C THE NUMBER OF RECEIVER POINTS IS DETERMINED.  IF THIS IS
C LESS THAN 502 FLOW PROCEEDS TO STATEMENT 16, OTHERWISE THE
C MAGNITUDE OF DXR IS INCREASED TO GIVE ONLY 501 POINTS.
C
      NR =IFIX( (XMAX-XMIN)/DXR + 1.)
      IF(NR .LT. 1) GO TO 15
      IF(NR-501) 16,16,15
   15 WRITE (6,1008)
      DXR=(XMAX-XMIN)/500.
      IF(APS(DXR) .LT. 1.E-5) GO TO 58
      NR = 501
   16 CONTINUE
C
C
C THE FLIGHT PATH DESCRIPTION IS OUTPUT.  THE FORMAT BEING DETERMINED
C BY THE TYPE OF FLIGHT.  IN THE CASE OF STRAIGHT LINE THE
C NECESSARY CONSTANTS FOR DOPPLER EFFECTS AND POSITION ARE
C DETERMINED.
C AFTER OUTPUT FLOW IS TO STATEMENT 19.
C
      IF (ICF) 18,18,17
   17 WRITE (6,1015) XMIN,XMAX,DXR,R,ZUP,ICF
      GO TO 19
   18 CONTINUE
      WRITE (6,1009) XMIN,XMAX,DXR,PHIR,PSIR,XTH,ZUP
      PHIR=PHIR/RAD
      PSIR=PSIR/RAD
      SPSI = SIN(PSIR)
      TANSR=SPSI/COS(PSIR)
      COSPIR=COS(PHIR)
      SINPIR=SIN(PHIR)
      VX=VEL*COS(PSIR)*COS(PHIR)
      VY=VEL*COS(PSIR)*SIN(PHIR)
      VZ=VEL*SIN(PSIR)
   19 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT TO START A NEW SIMULATION WITH
C PREVIOUS ANTENNA SYSTEM AND FLIGHT PATH.  THE COMPLEX FIELD
C SUMMATION MATRICIES ARE CLEARED, THE CASE NUMBER IS
C INCREMENTED BY ONE AND THE LINEPRINTER HEADERS ARE WRITTEN.
C
   20 CONTINUE
      CALL CLEAR(ZP,4500)
```

```
      NC = NC + 1
      WRITE (6,1010)
      WRITE (6,1011)
C
C
C XY IS AN ARRAY OF DATA ON THE ANTENNA AND FLIGHT PATH AND IS
C OUTPUT AS PART OF THE HEADER RECORD ON THE OUTPUT TAPE.
C
      XY(1) = PHIR
      XY(2) = PSIR
      XY(3) = ZUP
      XY(4) = FLOAT(NC)
      XY(5) = VEL
      XY(6) = FLOAT(MODE)
      XY(7) = FLOAT(ICP)
      XY(9) = DXR
      XY(8) = XMIN
C
C
C THIS IS THE INPUT FOR A NEW SCATTERER OR CONTROL CARD.  THE
C FORMAT AND USAGE OF THE VARIABLES WILL BE FOUND IN THE USER'S MANUAL.
C
   21 READ (5,1012,END=58) ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HW
C
C
C A NEGATIVE ID IS USED ON A SCATTERER TO CAUSE THE FIELDS TO
C BE SUBTRACTED FROM THE SUM.  THUS IDA IS USED TO DETERMINE
C THE TYPE OF SCATTERER AND THE SIGN OF ID IS USED FOR THE
C SIGN DTERMINATION OF THE FIELDS.
C
      IDA=IABS(ID)
C
C
C THE RECEIVER POINT LOCATION VARIABLES ARE INITIALIZED.  XR IS
C THE X-COORDINATE OF THE LOCATION, ZR IS THE Z-COORDINATE
C AND CDEG IS THE AZIMUTH.  THE USE OF THESE VARIABLES IS CONTROLLED
C BY THE VALUE OF ICF.
C
C
C
      IF (ICF) 23,23,22
   22 CDEG=XMIN-DXR
      ZR=ZUP
      GO TO 24
   23 RXR=XMIN-DXR
   24 CONTINUE
C
C
C
C IF IDA IS NOT 1, 2, OR 3 THEN THIS CARD IS A CONTROL CARD
C AND FLOW PASSES TO STATEMENT 43 TO OUTPUT THE CDI AND FOR
C LOOPING CONTROL.
C
```

```
      IF(IDA .GT. 3) GO TO 43
      IF(IDA .EQ. 0) GO TO 43
C
C
C THIS SECTION SETS CERTAIN VARIABLES FOR THE CYLINDER CASE.
C AKA IS A CONSTANT USED IN THE SCATTERERING AND DELTA IS SET TO
C ZERO FOR A VERTICAL CYLINDER.
C
      IF(IDA .NE. 2) GO TO 25
      DELTA=0.
      AKA=WW*AK/2.
   25 CONTINUE
C
C
C THE INPUT ANGLES ARE CONVERTED TO RADIANS AND
C THEIR SINES AND COSINES ARE CALCULATED.
C
      ALPHA=ALPHA/RAD
      DELTA=DELTA/RAD
      COSD=COS(DELTA)
      SIND=SIN(DELTA)
      COSA=COS(ALPHA)
      SINA=SIN(ALPHA)
C
C
C BECAUSE OF CERTAIN APPROXIMATIONS MADE IN THE ANALYSIS
C THERE IS A LIMIT ON THE SIZE OF THE SCATTERERS THAT MAY
C BE SIMULATED.  TO AVOID THIS PROBLEM AS MUCH AS
C POSSIBLE, FOR THE RECTANGULAR SURFACE,
C THE PROGRAM WILL BREAK UP TOO LARGE A WALL INTO
C SMALLER PIECES.  TO AVOID PROBLEMS WITH OTHER TYPES
C OF SCATTERERS THE VARIABLES INVOLVED ARE SET TO DEFAULT
C VALUES AND THE BREAKING UP SECTION IS SKIPPED.
C
      IH=1
      IV=1
      DX=0.
      DY=0.
      DZ=0.
      DXZ=0.
      DYZ=0.
      IF(IDA .NE. 1) WRITE (6,1013)
     . ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HW
      GO TO (62,27,62) IDA
C
C
C TEMP IS THE MAXIMUM DISTANCE FROM THE REFERENCE POINT ON THE
C WALL THAT WILL GIVE A REASONABLE ERROR IN THE APPROXIMATION.
C
   62 TEMP=SQRT(LAMBDA*SQRT((XXA(1)-XW(1))**2+(YA(1)-XW(2))**2))/5.
C
C
C IH IS THE NUMBER OF PIECES HORIZONTALLY INTO WHICH THE WALL MUST BE
```

```
C DIVIDED.
C
      IH=IFIX(HW/2./TEMP)+1
C
C
C IV IS THE THE NUMBER OF PIECES VERTICALLY.
C
      IV=IFIX(HH/2./TEMP)+1
C
C
      WRITE(6,1013) ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HW,IH,IV
      IF( IDA .EQ. 3 ) GO TO 26
C HW AND HH ARE SET TO NEW VALUES. THESE ARE THE SIZES OF THE
C PIECES.  DX AND DY ARE THE CHANGE IN X- AND Y-COORDINATES BETWEEN
C PIECES IN THE HORIZONTAL ROWS.   DZ IS THE CHANGE IN ELEVATION
C BETWEEN ROWS VERTICALLY.  DXZ AND DYZ ARE THE CHANGE IN X AND Y
C BETWEEN ROWS.  THIS CHANGE OCCURS ONLY IN TILTED WALLS (SIND
C NOT EQUAL TO ZERO).
C
      AI=IH
      WW=WW/AI
      TEMP=WW*(AI-1.)/2.
      DX=ABS (COSA*WW)
      XW(1)=XW(1)-ABS(COSA*TEMP)
      DY=SIGN(SINA*WW,SINA*COSA)
      XW(2)=XW(2)-SIGN(SINA*TEMP,SINA*COSA)
      HW=HW/FLOAT(IV)
   26 DZ=COSD*HH
      DXZ=-SIND*HH*SINA
      DYZ=SIND*HH*COSA
      CLAM=CMPLX(0.,1./LAMBDA)
      IF( IDA .NE. 3 ) GO TO 27
      IF( (IH .EQ. 1 ) .AND. ( IV .EQ. 1 ) ) GO TO 27
      WRITE (6,1019)
      GO TO 21
C
C
C XW IS THE COORDINATE VECTOR USED FOR THE LOCATION OF THE
C REFERENCE POINT OF EACH PIECE OF THE WALL.  XW0 IS USED
C AS ORIGIN OF THE WALL.  AS EACH PIECE IS USED FOR THE
C SCATTERING  XW IS INCREMENTED.  XW0 IS USED TO RESET XW
C FOR LOOPING ON ROWS.
C
   27 XW0(1)=XW(1)-DX-DXZ/2.
      XW0(2)=XW(2)-DY-DYZ/2.
      XW0(3)=XW(3)-DZ/2.
C
C
C THIS LOOP IS FOR THE ROWS
C
      DO 42 IB=1,IV
      XW0(1)=XW0(1)+DXZ
      XW0(2)=XW0(2)+DYZ
```

```
      XW0(3)=XW0(3)+DZ
      XW(1)=XW0(1)
      XW(2)=XW0(2)
      XW(3)=XW0(3)
C
C
C THIS LOOP IS WITHIN EACH ROW AND IS FOR HORIZONTALLY SEPARATED
C PIECES.
C
      DO 41 IA=1,IH
C
C
C XW IS THE COORDINATE VECTOR OF THE REFERENCE POINT ON THE
C PIECE BEING SIMULATTED.
C
      XW(1)=XW(1)+DX
      XW(2)=XW(2)+DY
C
C
C SUBROUTINE FLC IS USED TO CALCULATE THE FIELDS GENERATED BY THE
C ANTNNAE SYSTEM AT THE REFERENCE POINT.   AFTER THE CALL
C THE FIELDS AT THE REFERENCE POINT FOR ALL ANTENNAE ARE  IN
C EWR,
C
      CALL FLC(XW(1),XW(2),XW(3))
C
C THIS LOOP IS ON THE ANTENNAE.  FOR EACH PIECE THE PROGRAM
C CALCULATES THE SCATTERED FIELD FROM ALL ANTENNAE.
C IEL IS THE NUMBER OF THE ANTENNA BEING SIMULATED.
C
C
      DO 40 IEL=1,NEL
C
C
C XA,YA,HA ARE THE X-,Y- AND Z- COORDINATES OF THE
C ANTENNA.
C
      XA = XXA(IEL)
      HA=ZA(IEL)
      IF( (XW(1).LT.XA) .AND. (MODE.GT. 10) )  GO TO 34
C
C
C THIS SECTION INITIALIZES THE RECEIVER POINT
C LOCATION VARIABLES.  IR IS THE NUMBER OF THE RECEIVER POINT.
C
      IR=0
      IF(ICF.EQ.0) GO TO 29
      CDEG = XMIN - DXR
      GO TO 30
   29 RXR = XMIN - DXR
   30 CONTINUE
      IF(MODE.GT.0) ZZ = ZA(IEL)
C
```

```
C
C DW IS THE HORIZONTAL DISTANCE FROM THE ANTENNA TO THE
C REFERENCE POINT.
C R1 IS THE DISTANCE FROM THE ANTENNA TO THE REFERENCE
C POINT.
C
C

      DW = SQRT((XW(1)-XA)**2 + (XW(2)-YA(IEL))**2)
      R1=SQRT((XW(1)-XA)**2+(XW(2)-YA(IEL))**2+(XW(3)-HA)**2)
C
C THETA IS THE ANGLE BETWEEN THE HORIZONTAL PLANE
C AND THE LINE BETWEEN THE ANTENNA AND THE REFERENCE
C POINT ON THE SCATTERER.  CTH AND STH ARE THE COSINE
C AND THE SINE OF THETA RESPECTIVELY.
C
      CTH=DW/R1
      STH=(XW(3)-HA)/R1
C
C BB AND CEXPT ARE USED IN THE SECTION WHICH
C COMPUTES THE GAIN FOR THE SCATTERING.  SINCE THEY DO
C NOT DEPEND ON THE LOCATION OF THE RECEIVER POINT,
C THEY ARE COMPUTED HERE.
C
C IF CEXPT = 0 THE ANTENNA IMAGE IS TREATED AS A SEPARATE ELEMENT.
      BB=CTH*SIND*COSG+STH*COSD
      CEXPT = (0.0,0.0)
      IF( IMAGE ) CEXPT=CEXP(CMPLX(0.,2.*AK*HA*XW(3)/DW))
C
C
C AN IS A VECTOR WHOSE COORDINATES ARE THE DIRECTION COSINES
C FROM THE REFERENCE POINT ON THE SURFACE  OF THE SCATTERER TO
C THE ANTENNA.  THE REFERENCE SYSTEM USED IS ALIGNED WITH
C THE SIDES OF THE RECTANGLE AND THE THIRD AXIS IS
C THE OUTWARD NORMAL.  IN THE CASE OF THE CYLINDER THE
C NORMAL IS ASSUMED TO LIE IN A HORIZONTAL PLANE AND
C TO POINT AT THE ANTENNA.
C
      IF(IDA .NE. 2) GO TO 32
      AN(1)=(XA-XW(1))/DW
      AN(2)=(YA(IEL)-XW(2))/DW
      AN(3)=0.
      GO TO 33
   32 CONTINUE
      AN(1)=SINA
      AN(2)=-COSA
      AN(3)=0.
   33 CONTINUE
C
C
C THE HORIZONTAL ANGLE BEWTEEN THE NORMAL TO THE SURFACE AND
C THE LINE OF SIGHT TO THE ANTENNA IS GAMMA.  SING AND COSG
C ARE THE SINE AND COSINE OF GAMMA.
```

```
C
      COSG=(-AN(1)*(XW(1)-XA)-AN(2)*(XW(2)-YA(IEL)))/DW
      SING = (-AN(2)*(XW(1)-XA) + AN(1)*(XW(2)-YA(IEL)))/DW
C
C
C IF THE COSG IS NEGATIVE THEN THE LINE OF SIGHT IS
C THRU THE BACK OF THE SCATTERER AND THE ILLUMINATION OF
C THE FRONT SURFACE IS ASSUMED TO BE OF ZERO INTENSITY
C AND THE FIELD FROM THIS SCATTERING IS IGNORED.
C
      IF (COSG) 34,34,35
   34 WRITE (6,1017) IA,IB,IEL
      GO TO 40
   35 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT FOR THE RECEIVER POINTS.
C FOR EACH PIECE OF SCATTERER AND FOR EACH ANTENNA
C THE PROGRAM CALCULATES ALL THE FIELDS AT ALL THE
C RECEIVER POINTS BEFORE GOING ON TO THE NEXT PIECE
C OR ANTENNA.  XR,YR, AND ZR ARE THE COORDINATES
C OF THE RECEIVER LOCATION. VX,VY AND VZ ARE THE
C VELOCITIES IN THOSE DIRECTIONS.  THE LOCATION
C IS DETERMINED BY SLIGHTLY DIFFERENT METHODS DEPENDING
C ON THE FLIGHT TYPE.  THE VALUE OF ICF IS THE CONTROL.
C IR IS THE RECEIVER POINT NUMBER AND IS USED TO
C DETERMINE WHERE THE FIELDS FROM THE SCATTERING
C ARE TO BE SUMMED.
C
   36 CONTINUE
      IF(ICF .LE. 0) GO TO 37
      CDEG=CDEG+DXR
      IF( (CDEG-XMAX)*DXR .GE. 0.) GO TO 40
      XR=R*COS(CDEG/RAD)
      YR=R*SIN(CDEG/RAD)
      VX = - VEL*YR/R
      VY =   VEL*XR/R
      VZ = 0.0
      GO TO 39
   37 CONTINUE
      RXR=RXR+DXR
      IF( (RXR-XMAX)*DXR .GE. 0.) GO TO 40
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 38
      ZR=ZUP+TANSR*TEMP
      VZ = VEL*SPSI
      GO TO 39
   38 VZ = 0.0
      ZR=ZUP
   39 CONTINUE
      IF(IR .GT. 499) GO TO 40
```

```
      IR=IR+1
C
C
C RW IS THE DISTANCE FROM THE RECEIVER POINT TO THE
C SCATTERER REFERENCE POINT.
C
      RW=SQRT((XR-XW(1))**2+(YR-XW(2))**2+(ZR-XW(3))**2)
C
C
C RR IS THE HORIZONTAL DISTANCE FROM THE RECEIVER TO THE
C REFERENCE POINT.
C
      RR=SQRT((XR-XW(1))**2+(YR-XW(2))**2)
C
C
C BETA IS THE HORIZONTAL ANGLE BETWEEN THE SURFACE NORMAL AND
C THE LINE OF SIGHT TO THE RECEIVER POINT.  SINB AND COSB
C ARE THE SINE AND COSINE OF BETA.
C
      COSB=(AN(1)*(XR-XW(1))+AN(2)*(YR-XW(2)))/RR
      SINB=(-AN(2)*(XR-XW(1))+AN(1)*(YR-XW(2)))/RR
C
C
C DR IS THE DISTANCE FROM THE ANTENNA TO THE
C RECEIVER POINT.
C
      DR = SQRT((XR-XA)**2 + (YR-YA(IEL))**2 + (ZR-ZZ)**2 )
C
C
C THIS SECTION EVALUATES THE SCATTERING FROM THE SURFACE.
C THE COMPLEX VARIABLE 'FAC' REPRESENTS THE GAIN FACTOR
C FROM THE REFERENCE POINT ON THE SURFACE TO THE
C RECEIVER POINT.
C
C
C
C PHID AND PHIJD ARE THE RELATIVE FREQUENCY SHIFTS DUE TO DOPPLER
C EFFECT FROM THE AIRCRAFT VELOCITY.
C
      PHID = AK*(VX*(XR-XA) + VY*(YR-YA(IEL)) + VZ*(ZR-ZZ))/DR
      PHIJD = AK*(VX*(XR-XW(1))+VY*(YR-XW(2))+VZ*(ZR-XW(3)))/RW
C
C
C THESE CONSTANTS ARE THE GAIN FACTORS FOR THE VARIOUS CROSSTALK
C CASES.
C
      UT=(PHIJD-PHID)*TA/2.
      SNCUC(1) = SINC(UT+W00T)**2
      SNCUC(2) = SINC(UT+W150T)**2
      SNCUT = SINC(UT)
      SNCUD = SINC(UT+W60T)
C
C
```

```
C THE GAIN FOR THE ACTUAL SCATTERING IS COMPUTED BELOW,
C THERE ARE FOUR TYPES OF TRIANGLES, THEY ARE ENCODED
C BY THE USE OF MINUS SIGNS ON THEIR WIDTHS
C AND HEIGHTS.  THE CASES ARE AS FOLLOWS:
C
C
C     ORIENTATION OF THE RIGHT ANGLE           SIGN HEIGHT    SIGN WIDTH
C
C          LOWER RIGHT                              +              +
C          UPPER LEFT                               -              -
C          LOWER LEFT                               +              -
C          UPPER RIGHT                              -              +
C
C
C
   28 FAC=CMPLX(0.,0.)
      IF (IDA.EQ.3) LK=SIGN(1.,WW*HW)*CMPLX(2.,WW/AK)
      RP=RW
      SE2=(ZR-XW(3))/RP
      DO 65 M=1,2
      CE2=RR/RP
      AP=CTH*SING-CE2*SINB
      BP=BB+CE2*COSB*SIND-SE2*COSD
      BPP=BP+2.*HA*COSD/DH
      IF (IDA.EQ.3) GO TO 61
      IC=WW*(HW*SINC(AK*BP*HW/2.) -CEXPT*HW*SINC(AK*BPP*HW/2.))
      IF( IDA .EQ. 1 ) IC = IC*SINC(AK*AP*WW/2.)
      IF( IDA .EQ. 2 ) IC = IC*BESF(AKA,COSB,SINB)/2.
      GO TO 63
   61 W=AK*(CTH*SING-CE2*SINB)
      WP=W+(AK*BPP*HW)/WW
      W=W+(AK*BP*HW)/WW
      IC=LK*(SINC(AK*AP*WW/2.)*(CEXP(CMPLX(0.,-AK*BP*HW/2.))/BP
     1   -CEXPT*CEXP(CMPLX(0.,-AK*BPP*HW/2.))/BPP)
     1   -SINC(W*WW/2.)/BP+CEXPT*SINC(WP*WW/2.)/BPP)
   63 CB=CLAM*CEXP(CMPLX(0.,AK*RP))*IC/RP
      FAC=-CE2*(CTH*COSD*COSB-STH*SIND*(COSB*COSG-SINB*SING))*CB-FAC
      IF (M.EQ.2)  GO TO 65
      RP=SQRT(RR*RR+(XW(3)+ZR)**2)
      SE2=-(ZR+XW(3))/RP
   65 CONTINUE
C
C
C IF ID IS NEGATIVE THE GAIN IS TAKEN IN THE OPPOSITE
C SENSE.
C
   31 IF( ID .LT. 0) FAC=-FAC
C
C
C THE GAIN IS MULTIPLIED BY THE SIGNALS AT THE REFERENCE
C POINT TO GIVE THE SIGNALS AT THE RECEIVER.  THESE SIGNALS ARE COMPLEX
C MAGNITUDES.  EP IS THE SIDEBAND PORTION OF THE CARRIER
```

```
C PLUS SIDEBAND FOR THE COURSE ANTENNA AND EE THE SICEBAND
C ONLY.  EM IS THE SIDEBAND PORTION OF THE CARRIER PLUS SIDEBAND
C FOR THE CLEARANCE AND EC THE SIDEBAND ONLY.
C
      EP = FAC*EWR(IEL,1)
      EE = FAC*EWR(IEL,2)
      EM = FAC*EWR(IEL,3)
      EC = FAC*EWR(IEL,4)
C
C
C THESE ARE THE COMPLEX PHASORS FOR THE SIGNALS AT THE RECEIVER
C POINT  FOR THE DIFFERENT ANTENNAE AND FREQUENCIES.
C THEY HAVE THE FOLLOWING SIGNIFIGANCE,
C          SYMBOL  USAGE
C          ZJP     CARRIER FROM THE COURSE ANTENNA
C          ZJPC(1) 90 HZ SIDEBAND FOR COURSE
C          ZJPC(2) 150 HZ SIDEBAND FOR COURSE
C          ZJM     CARRIER FROM CLEARANCE
C          ZJMC(1) 90 HZ FROM CLEARANCE
C          ZJMC(2) 150 HZ FROM CLEARANCE
C
      ZJP = EP/CMPLX(CP,0.0)
      ZJPC(1) = EP - EE
      ZJPC(2) = EP + EE
      ZJM = EM/CMPLX(CM,0.0)
      ZJMC(1) = EM - EC
      ZJMC(2) = EM + EC
C
C
C SUBROUTINE VARCAL ADDS THE FIELDS TO THE FIELDS
C ACCUMULATED FOR THE 'IR'TH RECEIVER POINT.
C
      CALL VARCAL (IR)
C
C
C THE PROGRAM LOOPS BACK TO THE NEXT RECEIVER POINT.
C
      GO TO 36
   40 CONTINUE
   41 CONTINUE
   42 CONTINUE
C
C
C THIS IS THE TRANSFER BACK TO PICK UP THE
C NEXT SCATTERER OR CONTROL CARD.
C
      GO TO 21
C
C
C  AT THIS POINT THE PROGRAM HAS ACCUMULATED THE SCATTERED FIELDS
C AND HAS READ IN A CONTROL CARD TERMINATING THE RUN.
C THE PROGRAM WILL ADD IN THE DIRECT UNSCATTERED FIELD, BOTH
C DIRECTLY FROM THE ANTENNA AND REFLECTED FROM THE GROUND.
```

```
C THEN THE APPROPRIATE RECORDS WILL BE OUTPUT,
C
   43 CONTINUE
      IR=0
      SNCUT = 1.0
      SNCUD = 0.0
      SNCUC(1) = 0.
      SNCUC(2) = 0.
C
C
C FROM THIS STATEMENT THROUGH JUST BEFORE STATEMENT 51 IS
C THE LOOP ON RECEIVER POINT.  THE LOOPING IS DONE THE SAME
C AS THE SECTION FOLLOWING STATEMENT 35,
C
   44 IF(ICF .GT, 0) GO TO 46
      RXR =RXR + DXR
      IF( (RXR-XMAX)*DXR .GE. 0. ) GO TO 51
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 45
      ZR=ZUP+TANSR*TEMP
      VZ = VEL*SPSI
      GO TO 47
   45 VZ = 0.0
      ZR = ZUP
      GO TO 47
   46 CDEG = CDEG + DXR
      IF((CDEG-XMAX)*DXR .GE. 0. ) GO TO 51
      TEMP = CDEG/RAD
      XR = R*COS(TEMP)
      YR = R*SIN(TEMP)
   47 IR=IR+1
      CALL CLEAR(ZE,4)
C
C
C THIS CALL TO FLC CAUSES THE CALCULATION OF THE FIELD LEVELS
C AT THE RECEIVER POINT.
C
      CALL FLC(XR,YR,ZR)
C
C
C THIS IS THE LOOP FOR THE DIFFERENT ANTENNAE,  IEL IS THE
C ANTENNA NUMBER,  NEL IS TOTAL NUMBER OF ANTENNAE BEING
C USED.
C
      DO 49 IEL=1,NEL
C
C THIS SECTION CALCULATES THE FIELDS FOR THE VARIOUS SIGNALS
C AT THE RECEIVER POINT.
C
      HA = ZA(IEL)
      XA = XXA(IEL)
```

```
      RD=SQRT(RA(IEL)**2+(ZR-HA)**2)
       CE=CMPLX(RD/RA(IEL),0.)
      RD=2.*AK*HA*ZR/RD
      IF( IMAGE ) CE=CE*CMPLX(1.-COS(RD),-SIN(RD))
      DO 50 J = 1,4
      EWR(IEL,J)=EWR(IEL,J)*CE
   50 ZE(J)=ZE(J)+EWR(IEL,J)
      ZJP = EWR(IEL,1)/CMPLX(CP,0.0)
      ZJPC(1) = EWR(IEL,1) - EWR(IEL,2)
      ZJPC(2) = EWR(IEL,1) + EWR(IEL,2)
      ZJM = EWR(IEL,3)/CMPLX(CM,0.0)
      ZJMC(1) = EWR(IEL,3) - EWR(IEL,4)
      ZJMC(2) = EWR(IEL,3) + EWR(IEL,4)
C
C
C THIS CALL TO VARCAL ADDS THE FIELDS TO THE ONES ACCUMULATED
C FROM THE SCATTERERS.
C
      CALL VARCAL (IR)
   49 CONTINUE
C
C
C DETEC TAKES THE COMPLEX FIELD PHASORS AND EVALUATES
C THE COURSE DEVIATION INDICATION (CDI).  IR IS THE RECEIVER POINT
C NUMBER AND IS USED IN THE SUBROUTINE TO SELECT WHICH FIELDS
C ARE TO BE USED.  DF(IR) IS THE LOCATION IN THE ARRAY WHERE
C THE CDI IS TO BE PLACED.
C
      CALL DETEC (IR,DF(IR))
      IF(IR .GT. 499) GO TO 51
      GO TO 44
   51 CONTINUE
      XY(IR)=FLOAT(IR)
      WRITE(6,1010) ID,NC,IR,ICF
C
C
C THIS SECTION OUTPUTS THE CDI ON UNIT 8.  THE OUTPUT IS A LABEL
C RECORD (MEMO). TWO RECORDS OF FLIGHT AND ANTENNA DESCRIPTION,
C AND THE CDI RECORDS.
C
      IF(ID .EQ. 0) MEMO(13)=ILBL(5)
      WRITE (8,1005) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
      WRITE(8,1016) (DF(I),I=1,IR)
C
C IF THE ID IS NOT 0 THE FLOW IS TO STATEMENT 57 TO PROCESS
C THE ID VALUE FROM THE CONTROL CARD.  OTHERWISE THE SIGNAL
C STRENGTHS ARE OUTPUT.
C
      IF( ID .NE. 0 ) GO TO 57
C
C
C IX IS THE NUMBER OF SIGNAL TYPES THAT ARE TO BE OUTPUT.  TWO
```

```
C FOR SIMPLE ANTENNA SYSTEMS, FOUR FOR CAPTURE EFFECT.
C
      IX=4
      IF((NEL .EQ. 1).OR.((MODE.GT. 10).AND. (MODE.LT. 15)) ) IX=2
C
C
C THESE LOOPS CALCULATE THE SIGNAL STRENGTHS.  THE VALUES ARE
C PLACED IN XXRY(I,J).  WHERE I IS THE RECEIVER POINT NUMBER AND
C J HAS THE FOLLOWING USAGE?
C        J       USAGE
C        1       CARRIER LEVEL FOR COURSE ANTENNA
C        2       SIDEBAND LEVEL FOR COURSE ANTENNA
C        3       CARRIER LEVEL FOR CLEARANCE
C        4       SIDEBAND LEVEL FOR CLEARANCE
C XXRY OCCUPIES THE SAME LOCATION IN CORE AS ZP AND ZM.
C
      DO 52 I=1,IR
   52 XXRY(I,1)=CABS(ZP(I))*CP
      DO 53 I=1,IR
   53 XXRY(I,2)=CABS(ZPC(I,1)-ZPC(I,2))/2.
      DO 54 I=1,IR
   54 XXRY(I,3)=CABS(ZM(I))*CM
      DO 55 I=1,IR
   55 XXRY(I,4)=CABS(ZMC(I,1)-ZMC(I,2))/2.
C
C
C THIS LOOP OUTPUTS THE APPROPRIATE NUMBER OF SIGNALS ON UNIT 8.
C THE LABEL RECORD FOR EACH CASE IS ALTERED SLIGHTLY AS EXPLAINED
C IN THE DATA STATEMENT FOR ILBL.
C
      DO 56 J = 1,IX
      MEMO(13)=ILBL(J)
      WRITE(8,1005) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
   56 WRITE(8,1016) (XXRY(I,J),I=1,IR)
C
C
C THIS SECTION CONTROLS THE FLOW OF THE PROGRAM AFTER THE OUPUT
C FOR THE CASE IS FINISHED.  THE CONTROL IS BY THE VALUE OF THE
C ID READ IN ON THE LAST CONTROL CARD.  THIS ABSOLUTE
C VALUE OF ID IS IN IDA.  DEPENDING ON THE VALUE OF IDA THE
C PROGRAM LOOPS BACK AND READS IN THE NEXT DATA CARD FOR THE
C NEXTCASE TO BE RUN.  THE VALUE WILL CAUSE THE TRANSFER IN
C THE FOLLOWING?
C        IDA     NEXT TYPE OF CARD READ
C        0       MODE
C        3-10    SCATTERER
C        11-15   LABEL
C        16-20   MODE
C        21-50   COURSE WIDTH
C
   57 CONTINUE
      IF(IDA .EQ. 0) GO TO 1
```

```
      IF(IDA .LE. 10) GO TO 20
      IF(IDA .LE. 15) GO TO 14
      IF(IDA .LE. 20) GO TO 1
      IF(IDA .LE. 50) GO TO 6
   50 CONTINUE
      END FILE 8
      REWIND 8
      STOP
 1000 FORMAT (8F10.3)
 1001 FORMAT(2I2,6X,7F10.3)
 1002 FORMAT(5X,4HCLS=,F9.4)
 1003 FORMAT(9H0MODE =  2I4/10H FRQ =     F7.2/
     1  8H XTH =        F9.2/ 8H ZA =      3F9.2/
     2  8H XA =     3F9.2/14H COURSE WIDTH  F7.2,8H DEGREES   )
 1004 FORMAT (3X,13A5,A2)
 1005 FORMAT (13A5,A2)
 1006 FORMAT (7F10.0,2X,3I2)
 1007 FORMAT(6H0 VEL=,E11.4)
 1008 FORMAT(26H OVER 500 RECEIVER POINTS )
 1009 FORMAT(6H0XMIN=,E11.4,7H  XMAX=,E11.4,7H  DXR=,E11.4,7H  PHIR=,E11
     X.4,7H  PSIR=,E11.4,6H  XTH=,E11.4,5H ZUP=,E11.4)
 1010 FORMAT(16H0 STRUCTURE DATA)
 1011 FORMAT(56H ID        XW           YW            ZW        ALPHA
     X,6HDELTA ,9X,23H  WH            HH        ,5X,1HH
     X,5X,13H V  SECTIONS  )
 1012 FORMAT (I2,3F6.0,5X,2F5.0,3F10.0)
 1013 FORMAT (I3,1X,7E12.4,5X,I3,4X,I3)
 1014 FORMAT(1X,7E18.9,/ 3F18.9,I10,10X,2I10)
 1015 FORMAT(6H0MIND=,E11.4,7H  MAXD=,E11.4,7H  DDEG=,E11.4,4H  R=,
     XE11.4,7H  ZUP=,E11.4,7H  ICF=,I2)
 1016 FORMAT( 7E15.8 )
 1017 FORMAT(27H SURFACE IS NOT ILLUMINATED  ,
     X5H  H=,I2,5H  V=,I2,6H  IEL=,I2)
 1018 FORMAT (2X,3HID= ,I3,5X,3HNC= ,I3,5X,3HIR= ,I3,5X,4HICF= ,I2,//)
 1019 FORMAT (' *** ABOVE TRIANGLE TOO LARGE,  SCATTERER ',
     1 'OMITTED ***')
      END

CONSTANTS

0     1754210421°4   1     000000000020   2     216560600000   3     204600000000   4     212654443656
5     177631463146   6     177714631463   7     176631463146   10    171507934121   11    202600000000
12    201546314631   13    211764000000   14    160517426542   15    000000010624   16    203560000000
17    201400000000   20    000000000000   21    000000000000   22    000000000004

COMMON

ARAD    /CD        /+0       AEPP    /CD        /+62      AGPP    /CD        /+144     BRAD    /CD        /+226     BFPP    /CD        /+310
BGPP    /CD        /+372     ZJM     /AB        /+0       ZJP     /AB        /+2       ZJPC    /AB        /+4       ZJMC    /AB        /+10
ZP      /.COMM./+0           ZPC     /.COMM./+1750        ZM      /.COMM./+5670        ZMC     /.COMM./+7640        VCD     /.COMM./+13560
VPD     /.COMM./+1553        VMD     /.COMM./+17500       SM      /VAR       /+0       SNCUT   /VAR       /+1       SNCUD   /VAR       /+2
SNCUC   /VAR       /+3       VPC     /VAR       /+5       VMC     /VAR       /+7       MODE    /SUB       /+0       ICP     /SUB       /+1
ICM     /SUB       /+2       IET     /SUB       /+3       FRQ     /SUB       /+4       LAMBDA  /SUB       /+5       PI      /SUB       /+6
```

RADD	/SUB	/+7	PHI	/SUB	/+10	PSI	/SUB	/+13	NEL	/SUB	/+16	XTM	/SUB	/+17
SLP	/SUB	/+20	XXA	/SUB	/+21	YA	/SUB	/+24	ZA	/SUB	/+27	RA	/SUB	/+32
TGS	/SUB	/+35	BT	/SUB	/+36	SIG	/SUB	/+37	DB	/SUB	/+40	AK	/SUB	/+41
LOC	/ANT	/+0	FPP	/ANT	/+1	FPM	/ANT	/+3	GPP	/ANT	/+5	GPM	/ANT	/+7
EWR	/ANT	/+11	CWA	/ANT	/+51	AS	/ANT	/+53	CLS	/ANT	/+54	DE	/ANT	/+55
CS	/ANT	/+137	SO	/ANT	/+303	ET	/ANT	/+447	ND	/ANT	/+517	DUMXXX	/ANT	/+521
ZD	/,COMM,	/+0	XXRY	/,COMM,	/+0									

SUBPROGRAMS

FORSE, .JAFF TPFCN, CLEAR END. PATTRN CRRNTS CSP ANTP LNAR REAL CFD.2 ATAN GSCAL SIGN
IFIX ABS SIN COS FLOAT IABS SQRT CMPLX FLC CEXP SINC CFM.0 CFM.4 CFMM.0 BESP
CFD.0 CFM.2 VARCAL CFMM.2 DETEC CABS EXIT FLOUT, FLIRT, INTO, INTI, ALPHO, ALPHI,

SCALARS

RAD	3753	NC	3754	TA	3755	PTA	3756	PI	6
W60T	3757	W90T	3760	W150T	3761	ICP	1	IMAGE	3762
NEL	16	MODE	0	IET	3	FRQ	4	XTM	17
SLP	20	LAMBDA	5	AK	41	ZZ	3763	SM	0
CP	3764	CM	3765	TGS	35	CW	3766	CLS	54
RADD	7	LOC	0	FPP	1	GPP	5	TEMP	3767
XMIN	3770	XMAX	3771	DXR	3772	PHIR	3773	PSIR	3774
R	3775	ZUP	3776	ICF	3777	VEL	4000	NR	4001
SPSI	4002	TANSR	4003	COSPIR	4004	SINPIR	4005	VX	4006
VY	4007	VZ	4010	IQ	4011	ALPHA	4012	DELTA	4013
WW	4014	HW	4015	IDA	4016	CDEG	4017	ZR	4020
RXR	4021	AKA	4022	COSD	4023	SIND	4024	COSA	4025
SINA	4026	IH	4027	IV	4030	DX	4031	DY	4032
DZ	4033	DXZ	4034	DYZ	4035	AI	4036	CLAM	4037
IB	4041	IA	4042	IEL	4043	XA	4044	HA	4045
IR	4046	DW	4047	R1	4050	CTH	4051	STH	4052
BB	4053	COSG	4054	CEXPT	4055	SING	4057	XR	4060
YR	4061	RW	4062	RR	4063	COSB	4064	SINB	4065
DR	4066	PHID	4067	PHIJO	4070	UT	4071	SNOUT	1
SNCUD	2	FAC	4072	LK	4074	RP	4076	SEZ	4077
M	4100	CEZ	4101	AP	4102	BP	4103	BPP	4104
IC	4105	W	4107	WP	4110	CB	4111	EP	4113
EE	4115	EM	4117	EC	4121	ZJP	2	ZJM	0
RO	4123	CE	4124	J	4126	I	4127	IX	4130
ICM	2	BT	36	SIG	37	DB	40	FPM	3
GPM	7	AS	53						

ARRAYS

ILBL	4131	MEMO	4136	DF	4154	ZE	5141	ZD	0
CS	137	SO	303	ZJPC	4	ZJMC	10	ZP	0
ZPC	1750	EM	5670	ZMC	7640	XXRY	0	VOD	13560
VPD	15530	VMD	17500	XW	5151	XW0	5154	AN	5157
AFOO	5162	PHS	5173	XY	5204	ARAD	0	AFPP	62
AGPP	144	BRAD	226	BFPP	310	BGPP	372	SNOUC	3
VPC	5	VMC	7	PHI	10	PSI	13	XXA	21
YA	24	ZA	27	RA	32	EWR	11	CWA	51

DE 55 ET 447 ND 517 DUMXXX 521

AB	38													
ABS	390	553	554											
AFOO	33													
AFPP	37	227	308											
AGPP	37	227	308											
AI	550	551	552											
AK	41	150	408	664	782	783	812	821	822	825	826	827	828	831
	957													
AKA	488	823												
ALPHA	447	495	499	500	519	541								
AN	32	676	677	678	681	682	683	691	692	762	763			
ANT	43													
ANTP	308													
AP	817	822	828											
ARAD	37	227	308											
AS	43													
ATAN	326													
BB	662	818												
BESF	23	823												
BFPP	37	201	234											
BGPP	37	201	234											
BP	818	819	821	827	828									
BPP	819	821	826	828										
BRAD	37	201	234											
BT	41													
CABS	1025	1027	1029	1031										
CB	28	831	832											
CD	37													
CDEG	466	631	721	722	723	724	929	930	931					
CE	23	956	958	960										
CE2	816	817	818	825	832									
CEXP	664	828	831											
CEXPT	28	663	664	821	828									
CLAM	28	561	831											
CLEAR	100	424	935											
CLS	43	266	271	346										
CM	171	179	873	965	1029	831	870	873	956	958	962	965		
CMPLX	561	664	811	812	828									
COS	409	410	412	413	497	499	723	932	950					
COSA	499	553	554	555	556	560	682							
COSB	762	818	823	832										
COSD	497	558	662	818	819	832								
COSG	662	691	700	832										
COSPIR	410	732	919											
CP	170	178	870	962	1025									
CRRNTS	207	247	254											
CS	24	43	207	247	254	310								
CSP	306													
CTH	653	662	817	825	832									
CW	266	325	326	327	328	333	337	338	344					
CWA	43	279	280	333	345									
DB	41													
DE	43	207	247	254	310									

DELTA	447	487	496	497	498	519	541							
DETEC	983													
DF	22	983	998											
DR	769	782												
DUMXXX	43													
DW	645	653	664	676	677	691	692	819						
DX	514	553	574	599										
DXR	363	368	378	385	389	390	402	425	440	466	469	631	633	721
	722	730	731	917	918	929	930							
DXZ	517	559	574	582										
DY	515	555	575	600										
DYZ	518	560	575	583										
DZ	516	558	576	584										
EC	24	856	874	875										
EE	24	854	871	872										
EM	24	855	873	874	875									
EP	24	853	870	871	872									
ET	43	207	247	254	310									
EWR	24	43	108	853	854	855	856	960	961	962	963	964	965	966
	967													
FAC	23	811	832	843	853	854	855	856						
FLC	608	941												
FLOAT	436	438	439	557	987									
FPM	24	43												
FPP	24	43	308	310	317									
FRQ	41	141	149	344										
GPM	24	43												
GPP	24	43	308	310	317									
GSCAL	330													
HA	622	646	654	664	819	953	955	957						
HW	447	519	538	541	557	558	559	560	812	821	826	827	828	
I	998	1024	1025	1026	1027	1028	1029	1030	1031	1042				
IA	593	701												
IABS	455													
IB	581	701												
IC	28	821	822	823	828	831								
ICF	363	401	402	465	638	720	916	988	997	1041				
ICM	41													
ICP	41	76	189	201	207	241	256	344	439					
ID	447	455	519	541	843	988	995	997	1004	1041				
IDA	455	478	479	486	519	521	542	562	675	812	820	822	823	1060
	1061	1062	1063	1064										
IEL	615	621	622	635	645	646	677	691	692	701	769	782	853	854
	855	856	948	953	954	955	956	960	961	962	963	964	965	966
	967													
IET	41	141												
IFIX	385	533	538											
IH	512	533	541	558	563	593								
ILBL	18	46	995	1039										
IMAGE	36	77	664	958										
IR	629	742	743	881	905	934	973	983	984	987	988	998	1024	1026
	1028	1030	1042											
IV	513	538	541	557	563	581								

IX	1010	1011	1030										
J	959	960	961	1038	1039	1042							
LAMBDA	35	41	149	150	527	561							
LK	28	812	820										
LNAM	310												
LOC	43	292											
M	815	833											
MEMO	22	361	362	995	996	1039	1040						
MODE	41	141	161	162	163	185	189	220	226	233	240	253	255	282
	292	304	305	344	438	623	635	1011					
NC	60	425	436	988	997	1041							
ND	43	207	247	254	310								
NEL	41	82	195	239	257	615	940	1011					
NR	385	386	387	391									
PATTRN	201	227	234										
PHI	41	291	310										
PHID	782	789											
PHIJD	783	789											
PHIM	363	405	406	410	411	412	413	433					
PHS	33												
PI	41	66	150										
PSI	41	290											
PSIM	363	405	407	408	409	412	413	414	434				
PTA	66	67	68	69									
R	363	402	723	724	725	726	932	933					
R1	646	653	654										
RA	41	955	956										
RAD	47	326	406	407	495	496	723	724	931				
RADD	41	291											
RD	955	956	957	958									
REAL	317												
RP	813	814	816	831	834	835							
RR	755	762	763	816	834								
RW	749	783	813										
RXR	469	633	730	731	732	733	734	917	918	919	920	921	
SE2	814	818	835										
SIG	41												
SIGN	368	370	555	556	812								
SIN	408	411	413	414	498	500	724	933	958				
SINA	500	555	556	559	681								
SINB	763	817	823	825	832								
SINC	790	791	792	793	821	822	828						
SIND	498	559	560	662	818	832							
SING	692	817	825	832									
SINPIR	411	733	920										
SLP	41	141											
SM	40	169	180										
SNCUC	40	790	791	908	909								
SNCUD	40	793	907										
SNCUT	40	792	906										
SO	24	43	207	247	254	310							
SPSI	408	409	737	924									
SQRT	527	645	646	734	749	755	769	834	921	955			

STH	654	662	832											
SUB	41													
TA	65	66	789											
TANSQ	409	736	923											
TEMP	317	333	345	527	533	538	552	554	556	734	735	736	921	922
	923	931	932	933										
TGS	41	175												
UT	789	790	791	792	793									
VAR	40													
VARCAL	881	973												
VCD	30	39												
VEL	373	374	378	412	413	414	437	725	726	737	924			
VMC	40													
VMD	30	39												
VPC	40													
VPD	30	39												
VX	412	725	782	783										
VY	413	726	782	783										
VZ	414	727	737	739	782	783	924	926						
W	825	826	827	828										
W150T	69	791												
W60T	67	793												
W90T	68	790												
WP	826	828												
WW	447	488	519	533	541	551	552	553	555	812	821	822	826	827
	828													
XA	621	623	645	646	676	691	692	769	782	954				
XMAX	363	368	385	389	402	405	722	731	918	938				
XMIN	363	368	385	389	402	405	441	466	469	631	633			
XR	723	726	732	734	749	755	762	763	769	782	783	919	921	932
	941													
XTH	41	141	326	344	405	734	921							
XW	31	447	519	527	541	554	556	574	575	576	585	586	587	599
	600	608	623	645	646	654	664	676	677	691	692	749	755	762
	763	783	814	834	835									
XWB	31	574	575	576	582	583	584	585	586	587				
XXA	41	266	344	527	621	954								
XXRY	29	45	1025	1027	1029	1031	1042							
XY	34	433	434	435	436	437	438	439	440	441	987	997	1041	
YA	41	151	152	175	527	645	646	677	691	692	769	782		
YR	724	725	733	749	755	762	763	769	782	783	928	933	941	
ZA	41	141	344	622	635	953								
ZD	24	45												
ZE	24	935	961											
ZJM	26	38	873	965										
ZJMC	26	38	874	875	966	967								
ZJP	26	38	870	962										
ZJPC	26	38	871	872	963	964								
ZM	27	39	1029											
ZMC	27	39	1031											
ZP	27	39	45	424	1025									
ZPC	27	39	1027											
ZR	467	736	740	749	769	782	783	814	834	835	923	927	941	955
	957													
ZUP	363	402	405	435	467	736	740	923	927					
ZZ	153	635	769	782										

1P	76	1060	1063								
2P	102	213									
3P	163	170									
4P	185	220									
5P	226	247									
6P	176	220	233	242	253	266	1064				
7P	305	308									
8P	304	310									
9P	307	309	311	317							
10P	325	326									
11P	325	333									
12P	282	337									
13P	335	339									
14P	360	1062									
15P	386	387	388								
16P	387	392									
17P	401	402									
18P	401	404									
19P	403	415									
20P	423	1061									
21P	447	565	895								
22P	465	466									
23P	465	469									
24P	468	470									
25P	486	489									
26P	542	558									
27P	521	562	563	574							
28P	811										
29P	630	633									
30P	632	634									
31P	843										
32P	675	680									
33P	679	684									
34P	623	700	701								
35P	700	703									
36P	719	886									
37P	720	729									
38P	735	739									
39P	728	738	741								
40P	615	702	722	731	742	887					
41P	593	888									
42P	581	889									
43P	478	479	904								
44P	916	985									
45P	922	926									
46P	916	929									
47P	925	928	934								
49P	948	974									
50P	959	961									
51P	918	930	984	986							
52P	1024	1025									
53P	1026	1027									
54P	1028	1029									
55P	1030	1031									
56P	1038	1042									
57P	1004	1059									
58P	141	161	162	175	266	361	363	373	390	447	1065
61P	820	825									
62P	521	527									
63P	824	831									
64P	815	833	836								
1000P	175	266	345	1069							
1001P	141	1070									
1002P	346	1071									
1003P	344	1072									
1004P	362	1075									
1005P	361	996	1040	1076							
1006P	363	373	1077								

1007P	374	1078	
1008P	388	1079	
1009P	405	1080	
1010P	426	1082	
1011P	427	1083	
1012P	447	1086	
1013P	519	541	1087
1014P	997	1041	1088
1015P	402	1089	
1016P	998	1042	1091
1017P	701	1092	
1018P	988	1094	
1019P	564	1095	

```
  1        C
  2        C
  3        C THIS SUBROUTINE IS USED TO ZERO OUT THE CONTENTS OF
  4        C VARIOUS MATRACIES.
  5        C
  6              SUBROUTINE CLEAR (X,N)
  7              COMPLEX X(1)
  8              DO 1 I = 1,N
  9            1 X(I) = (0.,0.)
 10              RETURN
 11              END

   CONSTANTS

   0      000000000000    1       000000000000

   GLOBAL DUMMIES

   X      34              N       35

   SCALARS

   CLEAR  36              I       37            N      35

   ARRAYS

   X      34

   IP          8     9
   CLEAR       6
   I           8     9
   N           6     8
   X           6     7     9
```

```
 1         C
 2         C  SCALAR PRODUCT OF VECTORS A AND B
 3               FUNCTION  SP( A, B )
 4               DIMENSION A(3), B(3)
 5               SP = A(1)*B(1)+A(2)*B(2)+A(3)*B(3)
 6               RETURN
 7               END

     GLOBAL DUMMIES

     A       44           B       45

     SCALARS

     SP      46

     ARRAYS

     A       44           B       45

A            3       4       5
B            3       4       5
SP           3       5
```

```
C
C
C  THIS ROUTINE CONVERTS PLANE POLAR COORDINATES TO PLANE RECTANGULAR CO-
C  ORDINATES.
C
      SUBROUTINE P2R ( X, Y, R, T )
      COMPLEX Z
      Z = R*CEXP(CMPLX(0.0,T))
      X = REAL( Z )
      Y = AIMAG( Z )
      RETURN
      END

CONSTANTS

0        000000000000

GLOBAL DUMMIES

X        51             Y        52             R        53             T        54

SUBPROGRAMS

CEXP     CMPLX    CFM.2    REAL     AIMAG

SCALARS

P2R      57             Z        60             R        53             T        54             X        51
Y        52

AIMAG           10
CEXP             8
CMPLX            8
P2R              6
R                6        8
REAL             9
T                6        8
X                6        9
Y                6       10
Z                7        8        9       10
```

```
C
      SUBROUTINE GSCAL(CW)
      REAL LAMBDA
      COMPLEX PPP,GPP,E,C(50),S(50),CJA,CJB,FPM,GPM,CMP,GP,FP
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CHA(2),AS(2),D(50),C,S,
     2             ET(20,2),ND(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XA(3),YA(3),ZA(3),RAA(3),TGS,BT,SIG,CB,AK
      COMMON /WG/ TH(3,2),BH(3,2),CJA(30),CJB(30)
      DIMENSION RH(3)
      EQUIVALENCE  (FPM,FPP(2)), (GPM,GPP(2)), (CLS,AS(2))
      NAMELIST /GCAL/ MODE,IET,XTH,SLP,TGS,BT,SIG,BH,TH,CHH,CHA,XA,YA,ZA
     1 ,ICP,ICM,FRQ,LAMBDA,PI,H1,FPP,GPP,X,Z,AS,E
      DATA FR /0.5 /
      TTS(X) = SIN(X*RADD)/COS(X*RADD) - SLP
      ICP = MODE
      ICM = MODE
      CHH=CW
      CHA(1) = 1.0
      CHA(2) = 1.0
      IF( XA(1).GT.(XTH-3000.) ) GO TO 20
      IF( MODE .GT. 12 ) GO TO 2
      ZA(1) = AMAX1( 35.0,ZA(1) )
      H1 = ZA(1)
      GO TO 3
    2 H1 = 0.
    3 XA(1) = XTH - ( 50. - H1 )/TTS(TGS)
   20 IF( ABS(YA(1)) .GT. 300. ) GO TO 30
      IF( MODE - 12 ) 22,22,23
   22 YA(1) = SIGN(750.,YA(1))
      GO TO 30
   23 YA(1) = SIGN(500.,YA(1))
   30 IF( ZA(1) .GT. 5. ) GO TO 40
      IF( MODE .GT. 12 ) GO TO 32
      ZA(1) = (XA(1) - XTH)*TTS(TGS) + 50.
      GO TO 40
   32 H1 =  0.25*LAMBDA/SIN(TGS*RADD)
      IF( MODE - 14 ) 33,34,35
C   NULL REFERENCE MODE = 13
   33 ZA(1) = H1
      ZA(2) = 2.*H1
      GO TO 40
C   SIDEBAND REFERENCE MODE  =  14
   34 ZA(1) = H1/2.
      ZA(2) = 3.0*ZA(1)
      GO TO 40
C   M - ARRAY  MODE = 15
   35 ZA(1) =  H1
      ZA(2) = 2.*H1
      ZA(3) = 3.*H1
   40 IF( MODE - 12 ) 50,60,70
   50 CONTINUE
   60 IF( ABS(SIG) .GT. 1.0E-05 ) GO TO 61
```

```
      SIG = ATAN2((XA(1)-XTH)*TTS(TGS)*50.,-ZA(1),-YA(1))/RADD
   61 XA(2) = XA(1)
      YA(2) = YA(1)
      ZA(2) = -ZA(1)
      CALL P2R( BH(1,1),BH(3,1),1.0,TGS*RADD)
      BH(2,1) = 0.
      CALL P2R( TH(1,1),TH(2,1),1.0,-SIG*RADD)
      TH(3,1) = BH(1,1)*TH(1,1)
      TH(1,1) = -BH(3,1)*TH(1,1)
      RH(2) = 0.0
      CALL P2R( RH(1),RH(3),1.0,(TGS-0.5*FR*CW)*RADD)
      CALL GNG( FPP(1),GPP(1),RH,TH,BH )
      CALL P2R( RH(1),RH(3),1.0,TGS*RADD )
      CALL GNG( FPM,GPM,RH,TH,BH )
      DM0 = REAL( FPM/GPM )
      DM1 = REAL( FPP(1)/GPP(1) )
      BT = TGS - 0.5*FR*CW*DM0/( DM1 - DM0 )
      CALL P2R( BH(1,1),BH(3,1),1.0,BT*RADD )
      CWA(1) = 0.218*FR/( DM1 - DM0 )
      CWA(2) = CWA(1)
      BH(1,2) = BH(1,1)
      BH(2,2) = BH(2,1)
      BH(3,2) = -BH(3,1)
      CALL P2R( TH(1,1),TH(2,1),1.0,-SIG*RADD)
      TH(3,1) = BH(1,1)*TH(1,1)
      TH(1,1) = -BH(3,1)*TH(1,1)
      TH(1,2) = TH(1,1)
      TH(2,2) = TH(2,1)
      TH(3,2) = -TH(3,1)
C     CLS MAY BE USED AS AN EXTERNAL CONTROL OF COMPENSATOR AMPLITUDE HERE.
      CALL GNG( FPP(1),GPP,RH,TH(1,2),BH(1,2))
      CMP = 0.5*(0.0,1.0)*CLS*FPP(1)/SIN(AK*SP(RH,TH(1,2))*D(20))
      S(20) = CMP
      S(1)  = -CMP
      GO TO 99
   70 XA(2) = XA(1)
      XA(3) = XA(1)
      IF ( MODE .EQ. 15 )  GO TO 71
      NEL = 2
      GO TO 72
   71 NEL = 3
C     OFFSET ADJUSTMENTS FOR PROXIMITY
C
   72 RA = SQRT( ZA(1)*ZA(1) +YA(1)*YA(1) )
      YA(2) = SIGN(SQRT(RA*RA-ZA(2)*ZA(2)),YA(1))
      IF( NEL .EQ. 3 ) YA(3) = SIGN(SQRT(RA*RA-ZA(3)*ZA(3)),YA(1))
C     THIS SECTION CALIBRATES THE COURSE WIDTH OF IMAGE TYPE ARRAYS TO THE VALUE
C     SPECIFIED BY CW.
      CALL P2R( X,Z,1.0E+04,(TGS+0.5*FR*CW)*RADD )
      CALL FLC( X + XA(1), 0., Z )
      GP = (0.,0.)
      FP = (0.,0.)
      DO 73 I = 1,NEL
```

```
      RD = 2.*AK*ZA(I)*Z/X
      CE = ( 1.-CEXP(CMPLX(0.,RD)))
      GP = GP + E(I,1)*CE
   73 FP = FP + E(I,2)*CE
      CWA(1) = .210*FR/ABS(REAL(FP/GP))
   99 WRITE (6,GCAL)
      RETURN
      END

 CONSTANTS

 0   214567000000    1   206430000000    2   211454000000    3   212567000000    4   211744000000
 5   160517426542    6   201400000000    7   176676355442   10   000000000000   11   201400000000
 12  216470400000   13   000000000000   14   000000000000   15   201400000000   16   000000000000

 GLOBAL DUMMIES

 CN      1110

 COMMON

 LOC    /ANT   /+0     FPP    /ANT   /+1     GPP    /ANT   /+5     E      /ANT   /+411   CWA    /ANT   /+51
 AS     /ANT   /+53    D      /ANT   /+55    C      /ANT   /+137   S      /ANT   /+303   ET     /ANT   /+447
 ND     /ANT   /+517   MODE   /SUB   /+0     ICP    /SUB   /+1     ICM    /SUB   /+2     IET    /SUB   /+3
 FRO    /SUB   /+4     LAMBDA /SUB   /+5     PI     /SUB   /+6     RADD   /SUB   /+7     PHI    /SUB   /+10
 PSI    /SUB   /+13    NEL    /SUB   /+16    XTH    /SUB   /+17    SLP    /SUB   /+20    XA     /SUB   /+21
 YA     /SUB   /+24    ZA     /SUB   /+27    RAA    /SUB   /+32    TGS    /SUB   /+35    BT     /SUB   /+36
 SIG    /SUB   /+37    DB     /SUB   /+40    AK     /SUB   /+41    TH     /WG    /+0     BH     /WG    /+6
 CJA    /WG    /+14    CJB    /WG    /+110   FPM    /ANT   /+3     GPM    /ANT   /+7     CLS    /ANT   /+54

 SUBPROGRAMS

 ALLIO,  SIN     COS     AMAX1   ABS     SIGN    ATAN2   P2R     GWG     REAL    CFD,2   SP      CFM,2   SQRT    FLC
 CEXP    CMPLX   NMLST,

 SCALARS

 GSCAL   1116        MODE    0           IET     3           XTH     17          SLP     20
 TGS     35          BT      36          SIG     37          CNW     1117        ICP     1
 ICM     2           FRO     4           LAMBDA  5           PI      6           H1      1120
 X       1121        Z       1122        FR      1123        RADD    7           CN      1110
 FPM     3           GPM     7           DMP     1124        DM1     1125        CMP     1126
 CLS     54          AK      41          NEL     16          RA      1130        GP      1131
 FP      1133        I       1135        RD      1136        CE      1137        LOC     0
 DB      40

 ARRAYS

 C       137         S       303         FPP     1           GPP     5           E       11
 CWA     51          AS      53          D       55          ET      447         ND      517
 PHI     10          PSI     13          XA      21          YA      24          ZA      27
 RAA     32          TH      0           BH      6           CJA     14          CJB     110
 RH      1140
```

ABS	28	53	111											
AK	7	85	107											
AMAX1	23													
ANT	5													
AS	5	11	12											
ATAN2	54													
BN	9	12	58	59	61	62	65	67	71	74	75	76	78	79
	84													
BT	7	12	78	71										
C	4	5												
CE	108	109	110											
CEXP	108													
CJA	4	9												
CJB	4	9												
CLS	11	85												
CMP	4	85	86	87										
CMPLX	103													
COS	15													
CW	2	10	64	70	102									
CWA	5	12	19	20	72	73	111							
CWW	12	18												
D	5	85												
DB	7													
DM0	68	70	72											
DM1	69	70	72											
E	4	5	12	109	110									
ET	5													
FLC	103													
FP	4	105	110	111										
FPM	4	11	67	68										
FPP	4	5	11	12	65	69	84	85						
FR	14	64	70	72	102	111								
FRQ	7	12												
GCAL	12	112												
GP	4	104	109	111										
GPM	4	11	67	68										
GPP	4	5	11	12	65	69	84							
GSCAL	2													
GWG	65	67	84											
H1	12	24	26	27	37	40	41	44	48	49	58			
I	106	107	109	110										
ICM	7	12	17											
ICP	7	12	16											
IET	7	12												
LAMBDA	3	7	12	37										
LOC	5													
MODE	7	12	16	17	22	29	34	38	51	91				
ND	5													
NEL	7	93	94	99	106									
PZR	58	60	64	66	71	77	102							
PHI	7													
PI	7	12												
PSI	7													
RA	97	98	99											
RAA	7													
RADQ	7	15	37	54	58	60	64	66	71	77	102			
RD	107	108												
REAL	68	69	111											
RM	10	63	64	65	66	67	84	85						
S	4	5	86	87										
SIG	7	12	93	94	60	77								
SIGN	38	39	98	99										
SIN	15	37	65											
SLP	7	12	15											
SP	85													
SQRT	97	98	99											
SUB	7													
TOS	7	12	27	35	37	54	58	64	66	78	102			

TH	9	12	60	61	62	65	67	77	78	79	80	81	82	84
	85													
TTS	15	27	35	54										
WG	9													
X	12	15	102	103	107									
XA	7	12	21	27	33	54	55	89	98	103				
XTW	7	12	21	27	33	94								
YA	7	12	20	31	32	54	56	97	98	99				
Z	12	102	103	107										
ZA	7	12	23	24	33	35	40	41	44	45	48	49	53	54
	57	97	98	99	107									

2P	22	26			
3P	25	27			
20P	21	28			
22P	29	30			
23P	29	32			
30P	28	31	33		
32P	34	37			
33P	38	40			
34P	38	44			
35P	38	40			
40P	33	36	42	46	51
50P	51	52			
60P	51	53			
61P	53	55			
70P	51	89			
71P	91	94			
72P	93	97			
73P	106	110			
90P	88	112			

```
C
C THIS SUBROUTINE IS USED TO INPUT DATA FOR CALCULATING THEORECTICAL
C PATTERNS FOR ARRAY TYPE ANTENNAE.
C
      SUBROUTINE CRRNTS( D, C, S, ET, NE )
      DIMENSION ET(19),D(1)
       COMPLEX C(1),S(1)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TGS,BT,SIG,CB
      I = 1
C
C
C THIS IS THE INPUT FOR THE ELEMENT LOCATION AND CURRENT DESCRIPTION
C DT IS THE ELEMENT DISPLACEMENT IN THE Y-DIRECTION, MEASURED
C         IN WAVELENGTHS,
C CT IS THE CARRIER PLUS SIDEBAND AMPLITUDE, IN RELATIVE UNITS
C PC IS THE CARRIER PLUS SIDEBAND PHASE, IN DEGREES
C ST IS THE SIDEBAND ONLY AMPLITUDE, IN RELATIVE UNITS
C PS IS THE SIDEBAND ONLY PHASE, IN DEGREES
C
    1 READ (5,1000) DT, CT, PC, ST, PS
C
C THIS TEST IS TO SEE IF THE END OF THE ELEMENT CARDS HAS BEEN
C REACHED.  IF THE CARRIER PHASE IS GREATER THAN 500 FLOW
C IS TO THE ELEMENT PATTERN SECTION.
C
      IF( PC .GT. 500.) GO TO 2
C
C THIS IS THE 90 DEGREE PHASE SHIFT FOR THE QUADRATURE OF
C THE SIDEBAND ONLY TO THE SIDEBAND IN THE CARRIER PLUS SIDEBAND.
C
      PS = PS+90.0
      WRITE (6,1000) DT,CT,PC,ST,PS
      D(I) = DT*2.*PI
      C(I)=CT*CEXP(CMPLX(0.,PC*RADD))
      S(I) = ST*CEXP(CMPLX(0.,PS*RADD))
      I = I + 1
C
C
C THIS STATEMENT LOOPS BACK FOR THE NEXT ELEMENT IF THE TOTAL
C NUMBER OF ELEMENTS DOES NOT EXCEED THE AVAILABLE SPACE.
      IF( I .LT. 26) GO TO 1
C
C
C THIS SECTION READS IN THE PATTERN FOR THE ELMENTS. NE IS THE
C NUMBER OF ELEMENTS.  ALL ELEMENTS ARE ASSUMED TO HAVE THE SAME
C PATTERNS.
C
    2  NE = I - 1
C
C
C ET WILL CONTAIN THE ELEMENT PATTERN.  THE VALUES ARE IN
C RELATIVE AMPLITUDES.  ET(1) IS THE VALUE AT ZERO DEGEES AND
```

```
      C SUCCESSIVE VALUES ARE AT 10 DEGREE SPACING UP TO 180.  THUS
      C THERE ARE 19 POINTS GIVEN. THE PATTERN IS SYMETRIC ABOUT
      C THE ZERO DEGREE POINT.
      C
            READ (5,1000) ET
            WRITE(6,1000) ET
            RETURN
       1000 FORMAT( 8F10.4 )
            END

CONSTANTS

0         000000000000P0

GLOBAL DUMMIES

D         156             C         157             S         160             ET        161

COMMON

MODE      /SUB     /+0    ICP       /SUB     /+1    ICM       /SUB     /+2    IET       /SUB     /+3
LAMBDA    /SUB     /+5    PI        /SUB     /+6    RADD      /SUB     /+7    PHI       /SUB     /+10
NEL       /SUB     /+16   XTH       /SUB     /+17   SLP       /SUB     /+20   XXA       /SUB     /+21
ZA        /SUB     /+27   RA        /SUB     /+32   TGS       /SUB     /+35   BT        /SUB     /+36
DB        /SUB     /+40

SUBPROGRAMS

CEXP      CMPLX    CFM.0    FLOUT.   FLIRT.

SCALARS

CRRNTS    166             I         167             DT        170             CT        171
ST        173             PS        174             PI        6               RADD      7
MODE      0               ICP       1               ICM       2               IET       3
LAMBDA    5               NEL       16              XTH       17              SLP       20
RT        36              SIG       37              DB        40

ARRAYS

ET        161             D         156             C         157             S         160
PSI       13              XXA       21              YA        24              ZA        27

BT            8
C             5       7       35
CEXP          35      36
CMPLX         35      36
CRRNTS        5
CT            21      33      35
D             5       6       34
DB            8
DT            21      33      34
ET            5       6       58      59
FRQ           8
I             10      34      35      36      37      42      49
ICM           8
ICP           8
IET           8
LAMBDA        8
MODE          8
NE            5       49
NEL           8
PC            21      27      33      35
PHI           8
PI            8       34
PS            21      32      33      36
PSI           8
RA            8
RADD          8       35      36
S             5       7       36
SIG           8
SLP           8
ST            21      33      36
SUB           8
TGS           8
XTH           8
XXA           8
YA            8
ZA            8

        1P        21      42
        2P        27      49
     1000P        21      33      58      59      61
```

```
C
C
C THIS SUBROUTINE INPUTS THE ANTENNA PATTERNS FOR THE MEASURED
C PATTERN ANTENNA CASES.
C
      SUBROUTINE PATTRN ( ARAD, AFPP, AGPP )
      DIMENSION ARAD(50), AFPP(50), AGPP(50)
      DATA  RAD /  57.2957795  /
      IX = 1
    1 READ(5,1000) ANG, AFPP(IX), AGPP(IX)
      AFPP(IX)=AFPP(IX)+100000.
      AGPP(IX)=AGPP(IX)+103600.
      ARAD(IX)=ANG      /RAD
      IX=IX+1
      IF( IX .GE. 51) GO TO 2
      IF( ANG .LT. 361.) GO TO 1
      IF( IX .LE. 2) GO TO 4
    2 WRITE (6,1001)
      WRITE (6,1002)
      IY=IX-2
      DO 3 I=1,IY
      ANG=ARAD(I)*RAD+.00001
    3 WRITE (6,1003) ANG,AFPP(I),AGPP(I)
      GO TO 5
    5 RETURN
    4 WRITE (6,1004)
      END FILE 8
      STOP
 1000 FORMAT(8F10.0)
 1001 FORMAT(28H0ANTENNA PATTERN MEASUREMENT)
 1002 FORMAT(34H ANGLE READ    SIDEBAND    CARRIER)
 1003 FORMAT (3E12.4)
 1004 FORMAT(33H MEASURED ANTENNA PATTERN MISSING )
      END

CONSTANTS

0       221606500000    1       221624540000    2       165517426542

GLOBAL DUMMIES

ARAD    172             AFPP    173             AGPP    174

SUBPROGRAMS

TPFCN,  EXIT    FLOUT,  FLIRT,

SCALARS

PATTRN  175             RAD     176             IX      177             ANG     200
I       202

ARRAYS
```

ARAD 172 AFPP 173 AGPP 174

AFPP	6	7	10	11	23				
AGPP	6	7	10	12	23				
ANG	10	13	16	22	23				
ARAD	6	7	13	22					
I	21	22	23						
IX	9	10	11	12	13	14	15	17	20
IY	20	21							
PATIRN	6								
RAD	8	13	22						
1P	10	16							
2P	15	18							
3P	21	23							
4P	17	26							
5P	24	25							
1000P	10	29							
1001P	18	30							
1002P	19	31							
1003P	23	32							
1004P	26	33							

```
C
C
C THIS SUBROUTINE SIMULATES THE BEHAVIOR OF THE ILS RECEIVER
C SYSTEM.  FOR THE IR'TH RECEIVER POINT IT CALCULATES THE CDI
C THAT WOULD BE OBSERVED WITH THE FIELD LEVELS IN ZP,ZM
C ZPC AND ZMC.
C
      SUBROUTINE DETEC (IR,CDI)
      DOUBLE PRECISION G000
      REAL N
      COMPLEX  ZP(500),ZPC(500,2),
     2         ZM(500),ZMC(500,2)
      DIMENSION VCD(500,2),VPD(500,2),VMD(500,2)
      DIMENSION V(2),G000(26)
      COMMON ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2),VPC(2),VMC(2)
      DATA NG /5/
      DATA G000/ .10000D+1,-.2500000D+00,
     1-.46875000000000D-01,-.19531250000000D-01,-.10681152343750D-01,
     1-.67291259765625D-02,-.46262741088867D-02,-.33752918243408D-02,
     1-.25710230693221D-02,-.20234903786331D-02,-.16339684887463D-02,
     1-.13470112062350D-02,-.11295250218950D-02,-.96276462661180D-03,
     1-.82718893235079D-03,-.71965437114510D-03,-.63188593716750D-03,
     1-.55911546169754D-03,-.49828577826285D-03,-.44684985629829D-03,
     1-.40382875164631D-03,-.36532323235967D-03,-.33267812946882D-03,
     1-.30422125733489D-03,-.27926560731914D-03,-.25725947746239D-03/
      CALL DTC(ZP(IR),VP,VPC)
      CALL DTC(ZM(IR),VM,VMC)
      BK2 = 4.0*VP*VM/(VP+VM)**2
      UW = VM/VP
      IF( UW .EQ. 0.) GO TO 2
      N = NG
      N1 = N + 1.
      CC = 0.0
      CP = 0.0
      CM = 0.0
    1 IF( N1 .LE. 0 ) GO TO 3
      G = G000(N1)
      CC = CC*BK2 + G
      CP = CP*BK2 + G*(1.+N*(UW-1.))
      CM = CM*BK2 + G*(1.+N*(1./UW-1.))
      N1 = N1 - 1
      N=N1-1
      GO TO 1
    2 CC= 1.0
      CP = 1.0
      CM = 0.0
    3 DO 4  I = 1,2
      VD2I = CP*CP*VPD(IR,I) + CM*CM*VMD(IR,I) + CC*CC*VCD(IR,I)
      VCI = CP*VPC(I) + CM*VMC(I)
    4 V(I) = SQRT( VCI*VCI  + VD2I )
      CDI = SM*(V(2)-V(1))/(V(2)+V(1))
      RETURN
```

```
54              END

   CONSTANTS

   3       201400000030

   GLOBAL DUMMIES

   IR      214              CDI     215

   COMMON

   ZP      /,COMM,/+0       ZPC     /,COMM,/+1750    ZM      /,COMM,/+5670    ZMC     /,COMM,/+7640    VCD     /,COMM,/+13560
   VPD     /,COMM,/+15530   VMD     /,COMM,/+17500   SM      /VAR   /+0       SNCUT   /VAR   /+1       SNCUD   /VAR   /+2
   SNCUC   /VAR   /+3       VPC     /VAR   /+5       VMC     /VAR   /+7

   SUBPROGRAMS

   DTC     FLOAT    IFIX    SQRT

   SCALARS

   DETEC   217              NG      220              IR      214              VP      221              VM      222
   BK2     223              UW      224              N       225              N1      226              CC      227
   CP      230              CM      231              G       232              I       233              VD2I    234
   VCI     235              CDI     215              SM      0                SNCUT   1                SNCUD   2

   ARRAYS

   ZP      0                ZPC     1750             ZM      5670             ZMC     7640             VCD     13560
   VPD     15530            VMD     17500            V       236              G00W    240              SNCUC   3
   VPC     5                VMC     7

BK2        29      39      40      41
CC         34      39      45      49
CDI         8      52
CM         36      41      47      49      50
CP         35      40      46      49      50
DETEC       8
DTC        27      28
G          38      39      40      41
G00W        9      14      18      38
I          48      49      50      51
IR          8      27      28      49
N          10      32      33      40      41      43
N1         33      37      38      42      43
NG         17      32
SM         16      52
SNCUC      16
SNCUD      16
SNCUT      16
SQRT       51
UW         30      31      40      41
V          14      51      52
VAR        16
VCD        13      15      49
VCI        50      51
VD2I       49      51
VM         20      29      30
VMC        16      28      50
VMD        13      15      49
VP         27      29      30
VPC        16      27      50
VPD        13      15      49
ZM         11      15      20
ZMC        11      15
ZP         11      15      27
ZPC        11      15
     1P    37      44
     2P    31      45
     3P    37      48
     4P    40      51
```

```
C
C
C THIS SUBROUTINE SIMULATES THE EFFECTS OF PHASE SHIFT BETWEEN
C CARRIER AND SIDEBANDS ON DETECTED 90 AND 150 HZ AMPLITUDE.
C
      SUBROUTINE DTC ( ZN,VN, VNC )
      COMPLEX ZN, ZH
      DIMENSION ZN(500,1),VNC(1)
      VN = CABS(ZN(1,1))
      ZH = 1.0
      IF( VN .GT. 0. ) ZH = CONJG(ZN(1,1))/VN
      DO 1  I = 1,2
    1 VNC(I) = ZH*ZN(1,I+1)
      RETURN
      END

 CONSTANTS

 P      20140000?0?0    1       R000P000R000

 GLOBAL DUMMIES

 ZN     73              VN      74              VNC     75

 SUBPROGRAMS

 CABS   CONJG   CF?,9   CFM,2

 SCALARS

 DTC    76              VN      74              ZH      77              I       101

 ARRAYS

 ZN     73              VNC     75
CABS     9
CONJG   11
DTC      6
I       12      13
VN       6       9      11
VNC      6       8      13
ZH       7      10      11      13
ZN       6       7       8       9      11      13
    1P  12      13
```

```
C
C THIS SUBROUTINE ADDS THE FIELDS IN ZJP, ZJM, ZJPC, AND ZJMC
C TO THE SUMMATIONS IN ZPC, ZMC, VCD, VPD AND VMD.  THE ARRAYS
C CONTAIN THE COMPLEX SUMS FOR EACH RECEIVER POINT.  THE SYMBOLS
C HAVE THE FOLLOWING USAGE.
C        SYMBOL  USAGE
C        ZP      CARRIER FROM COURSE ANTENNA
C        ZM      CARRIER FROM CLEARANCE
C        ZPC(IR,1)         90 HZ SIDEBAND FROM COURSE
C        ZPC(IR,2)         150 HZ SIDEBAND FROM COURSE
C        ZMC(IR,1)         90 HZ SIDEBAND FROM CLEARANCE
C        ZMC(IR,2)         150 HZ SIDEBAND FROM CLEARANCE
C        VCD(IR,1)         *
C        VCD(IR,2)         *
C        VPD(IR,1)         * THESE ARE INTERNAL VARIABLES USED FOR
C        VPD(IR,2)         * DOPPLER EFFECTS.  THEY HAVE NO DIRECT
C        VMD(IR,1)         * PHYSICAL MEANING.
C        VMD(IR,2)         *
C
C SNCUT IS THE GAIN FACTOR FROM THE DIFFERENCE OF THE SCATTERED
C SIGNAL FROM THE DIRECT SIGNAL FREQUENCY.  THIS FRECUENCY
C SHIFT IS CAUSED BY THE DIFFERENT VELOCITIES OF THE AIRCRAFT
C RELATIVE TO THE ILS ANTENNA AND THE SCATTERERS. SNCUC(1) IS
C THE GAIN OF THE CROSS TALK FROM THE CARRIER THROUGH THE 90 HZ
C FILTER.  SINCUC(2) IS THE CROSS TALK AT 150 HZ.
C SNCUD IS THE CROSS TALK FACTOR BETWEEN THE 90 HZ AND 150 HZ
C SIGNALS FROM THE DOPPLER SHIFT.
C
      SUBROUTINE VARCAL (IR)
      COMPLEX Z
      COMPLEX  ZP(500),ZPC(500,2),
     2         ZM(500),ZMC(500,2)
      DIMENSION VCD(500,2),VPD(500,2),VMC(500,2)
      COMMON     ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      CAB2(Z) = REAL(Z*CONJG(Z))
      ZP(IR) = ZP(IR) + ZJP
      ZM(IR) = ZM(IR) + ZJM
      DO 1 I=1, 2
      ZPC(IR,I) = ZPC(IR,I) + ZJPC(I)*SNCUT
      ZMC(IR,I) = ZMC(IR,I) + ZJMC(I)*SNCUT
      VCD(IR,I) = VCD(IR,I) + (CAB2(ZJP   ) + CAB2(ZJM   ))*SNCUC(I)
      J=3-I
      SNCUD2 = SNCUD*SNCUD
      VPD(IR,J) = VPD(IR,J) + CAB2(ZJPC(I)) *SNCUD2
    1 VMD(IR,J) = VMD(IR,J) + CAB2(ZJMC(I)) *SNCUD2
      RETURN
      END
```

GLOBAL DUMMIES

```
IR        215

COMMON

ZP      /.COMM./+0        ZPC    /.COMM./+1750    ZM      /.COMM./+5670   ZMC      /.COMM./+7640   VCD     /.COMM./+13560
VPD     /.COMM./+15530    VMD    /.COMM./+17500   SM      /VAR    /+0     SNCUT    /VAR   /+1      SNCUD   /VAR    /+2
SNCUC   /VAR    /+3       ZJM    /AB     /+0      ZJP     /AB     /+2     ZJPC     /AB    /+4      ZJMC    /AB     /+10

SUBPROGRAMS

REAL    CONJG   CFM.0   CFM.2

SCALARS

VARCAL  221               IR     215              ZJP     2               ZJM      0               I       222
SNCUT   1                 J      223              SNCUD2  224             SNCUD    2               SM      0

ARRAYS

ZP      0                 ZPC    1750             ZM      5670            ZMC      7640            VCD     13560
VPD     15530             VMD    17500            SNCUC   3               ZJPC     4               ZJMC    10

AB       37
CAB2     38    44    47    48
CONJG    38
I        41    42    43    44    45    47    48
IR       29    39    40    42    43    44    47    48
J        45    47    48
REAL     38
SM       35
SNCUC    35    44
SNCUD    35    46
SNCUD2   46    47    48
SNCUT    35    42    43
VAR      35
VARCAL   29
VCD      33    34    44
VMD      33    34    48
VPD      33    34    47
Z        30    38
ZJM      36    37    40    44
ZJMC     36    37    43    48
ZJP      36    37    39    44
ZJPC     36    37    42    47
ZM       31    34    40
ZMC      31    34    43
ZP       31    34    39
ZPC      31    34    42

  1P     41    48
```

```
C
C
C THIS SUBROUTINE CALCULATES THE ELECTRIC FIELDS FOR THE
C SIDEBANDS AT LOCATION (X1,Y,Z).  ARRAY E IS THE SAME AS
C ARRAY EWP IN THE MAIN PROGRAM.
C
      SUBROUTINE FLC(X1,Y1,Z)
      COMPLEX E,F,FPP,GPP,C(25,2),S(25,2),CJA,CJB
      COMMON/CD/ ARAD(50),AFPP(50),AGPP(50),BRAD(50),BFPP(50),BGPP(50)
      COMMON /SUB/ LC(3),IET,FRQ,WAMDA,PI,RADD,PHI,P(2),PSI,TT(2),NEL,
     1 XTH,SLP, XXA(3),YA(3),HA(3),RA(3),TGS,BT,SIG,CB,AK
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CHA(2),AS(2),D(25,2),C,S,
     2             ET(20,2),ND(2),GC(4,3,4)
      COMMON /WG/ TH(3,2),BH(3,2),CJA(30),CJB(30)
      DIMENSION RH(3)
      JA = 1
C
C
C THIS IS THE LOOP ON ANTENNA NUMBER.
C
      DO 11 J=1,NEL
      CALL CLEAR (FPP,4)
C
C
C LOC IS THE TYPE FOR ANTENNA 'J'
C
      LOC = LC(J)
C
C X IS THE DISTANCE FROM THE ANTENNA TO THE POINT.
C
      X = X1 - XXA(J)
      Y = Y1 - YA(J)
      R=SQRT(X**2+Y**2+(Z-HA(J))**2)
      RA(J) = R
      IF ( LOC .GT. 10 ) GO TO 2
      PHI=ATAN2(Y,X)
      PSI = ATAN2(Z-HA(J),X)
      JA=1+150*(J-1)
      IF( LOC .LT. 4) CALL CSP
      IF(LOC .EQ. 5) CALL ANTP(FPP(J),GPP(J),ARAD(JA),AFPP(JA),AGPP(JA))
      IF(LOC .EQ. 7) CALL LNAR(FPP(J),GPP(J),PHI,D(1,J),C(1,J),
     ,S(1,J),ET(1,J),ND(J))
      GO TO 10
    2 CONTINUE
      RH(1) = X/R
      RH(2) = Y/R
      RH(3) = (Z-HA(J))/R
      IF( LOC .GT. 12 ) GO TO 3
      CALL GWG( FPP, GPP, RH, TH(1,J), BH(1,J) )
      GO TO 10
    3 CALL GSA ( GC(1,J,LOC-12),RH,IET )
   10 CON3 = AK*R
C
```

```
C
C F IS THE COMPLEX GAIN FACTOR FOR THE TRANSMISSION LOSS FROM THE
C ANTENNA TO THE POINT.
C
      F = CEXP(CMPLX(0.,CON3))/R
      DO 11 JC=1,2
      JB=2*JC-1
C
C
C GPP IS THE SIGNAL LEVEL FOR THE SIDEBAND PORTION OF THE CARRIER
C PLUS SIDEBAND.
C
      GPP(JC)= GPP(JC)*AS(JC)
C
C
C FPP IS THE COMPLEX PHASOR FOR THE SIDEBAND ONLY.
C
      FPP(JC)=FPP(JC)*CHA(JC)*AS(JC)
      E(J,JB)=GPP(JC)*F
   11 E(J,JB+1)= FPP(JC)*F
      RETURN
      END
```

CONSTANTS

9	000000002024	1	000000000000

GLOBAL DUMMIES

X1	354	Y1	355	Z	356

COMMON

ARAD	/CD	/+0	AFPP	/CD	/+62	AGPP	/CD	/+144	BRAD	/CD	/+226	BFPP	/CD	/+310
BGPP	/CD	/+372	LC	/SUB	/+0	IET	/SUB	/+3	FRQ	/SUB	/+4	WANDA	/SUB	/+5
PI	/SUB	/+6	RADD	/SUB	/+7	PHI	/SUB	/+10	P	/SUB	/+11	PSI	/SUB	/+13
TT	/SUB	/+14	NEL	/SUB	/+16	XTH	/SUB	/+17	SLP	/SUB	/+20	XXA	/SUB	/+21
YA	/SUB	/+24	HA	/SUB	/+27	RA	/SUB	/+32	TGS	/SUB	/+35	BT	/SUB	/+36
SIG	/SUB	/+37	DB	/SUB	/+40	AK	/SUB	/+41	LOC	/ANT	/+0	FPP	/ANT	/+1
GPP	/ANT	/+5	E	/ANT	/+11	CHA	/ANT	/+51	AS	/ANT	/+53	D	/ANT	/+55
C	/ANT	/+137	S	/ANT	/+303	ET	/ANT	/+447	ND	/ANT	/+517	GC	/ANT	/+521
TH	/WG	/+0	BH	/WG	/+6	GJA	/WG	/+14	CJB	/WG	/+110			

SUBPROGRAMS

CLEAR SQRT ATAN2 CSP ANTP LNAR GWG GSA CEXP CMPLX CFD.0 CFMN.2 CFM.2

SCALARS

FLC	361	JA	362	J	363	NEL	16	LOC	0
X	364	X1	354	Y	365	Y1	355	R	366
Z	356	PHI	10	PSI	13	IET	3	CON3	367
AK	41	F	370	JC	372	JB	373	FRQ	4

WAMDA	5	PI	6	RADD	7	XTH	17	SLP	20
TGS	35	BT	36	SIG	37	DB	40		

ARRAYS

C	137	S	303	ARAD	0	AFPP	62	AGPP	144
BRAD	226	BFPP	310	BGPP	372	LC	0	P	11
TT	14	XXA	21	YA	24	HA	27	RA	32
FPP	1	GPP	5	F	11	CWA	51	AS	53
D	55	ET	447	ND	517	GC	521	TH	0
BH	6	CJA	14	CJB	110	RH	374		

AFPP	9 40
AGPP	9 40
AK	10 52
ANT	12
ANTP	40
ARAD	9 40
AS	12 66 71
ATAN2	36 37
BFPP	9
BGPP	9
BH	14 49
BRAD	9
BT	10
C	8 12 41
CD	9
CEXP	58
CJA	8 14
CJB	8 14
CLEAR	22
CMPLX	58
CONJ	52 58
CSP	39
CWA	12 71
D	12 41
DB	10
E	8 12 72 73
ET	12 41
F	8 58 72 73
FLC	7
FPP	8 12 22 40 41 49 71 73
FRO	10
GC	12 51
GPP	8 12 40 41 40 66 72
GSA	51
GWG	49
HA	10 33 37 47
IET	10 51
J	21 27 31 32 33 34 37 38 40 41 47 49 51 72 73
JA	16 38 40
JB	60 72 73
JC	59 60 66 71 72 73
LC	10 27
LNAM	41
LOC	12 27 35 39 40 41 48 51
ND	12 41
NEL	10 21
P	10
PHI	10 36 41
PI	10
PSI	10 37
R	33 34 45 46 47 52 58
RA	10 34
RADD	10
RH	15 45 46 47 49 51
S	8 12 41
SIG	10
SLP	10
SQRT	33
SUB	10
TGS	10
TH	14 49
TT	10
WAMDA	10
WG	14
X	31 33 36 37 45
X1	7 31
XTH	10
XXA	10 31
Y	32 33 36 46
Y1	7 32
YA	10 32
Z	7 33 37 47
2P	35 44
3P	48 51
13P	43 50 52
11P	21 59 73

```
C
C  THIS IS THE WAVEGUIDE FAR FIELD ANGULAR PATTERN ROUTINE.
C  UNIT VECTORS ARE USED TO DENOTE THE SIGNIFICANT DIRECTIONS :
C       R  =  DIRECTION OF OBSERVATION
C       B  =  BROADSIDE DIRECTION
C       T  =  TANGENT  DIRECTION
      SUBROUTINE GWG( FPP, GPP, R, T, B )
      COMPLEX FPP,GPP, C(50),S(50), FP,GP, E
      COMMON /ANT/ LOC,FP(2),GP(2),E(4,4),CWA(2),AS(2),D(50),C,S,
     2             ET(20,2),NDD(2),GC(4,3,4)
      DIMENSION R(3), B(3), T(3)
      ND = 20
      SIPH = SP( R,T )
      EPP = SP( R,B )
      IF ( T(3) .LT. 0.0 ) EPP = -EPP
      FPP = (0.0,0.0)
      GPP=(0.0,0.0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END

CONSTANTS

0       000000002020    1       200020000000

GLOBAL DUMMIES

FPP     151             GPP     153             R       155             T       156             B       157

COMMON

LOC     /ANT    /+0     FP      /ANT    /+1     GP      /ANT    /+5     E       /ANT    /+11    CWA     /ANT    /+51
AS      /ANT    /+53    D       /ANT    /+55    C       /ANT    /+137   S       /ANT    /+303   ET      /ANT    /+447
NDD     /ANT    /+517   GC      /ANT    /+521

SUBPROGRAMS

SP      CEXP    CMPLX   CFM.2   CFMM.2

SCALARS

GWG     163             ND      164             SIPH    165             EPP     166             FPP     151
GPP     153             J       167             LOC     0

ARRAYS

C       137             S       303             FP      1               GP      5               E       11
CWA     51              AS      53              D       55              ET      447             NDD     517
GC      521             R       155             B       157             T       156
```

ANT	9				
AS	9				
B	7	11	14		
C	8	9	19		
CEXP	19	20			
CMPLX	19	20			
CNA	9				
D	9	19	20		
E	8	9			
EPP	14	15	21	22	
ET	9				
FP	8	9			
FPP	7	8	16	20	22
GC	9				
GP	8	9			
GPP	7	8	17	19	21
GNG	7				
J	18	19	20		
LOC	9				
ND	12	18			
NOD	9				
R	7	11	13	14	
S	8	9	20		
SIPM	13	19	20		
SP	13	14			
T	7	11	13	15	
1P	18	20			

```
      C
      C  THIS SUBROUTINE CALCULATES THE FAR FIELD AMPLITUDES EMANATING FROM
      C  INDIVIDUAL GLIDE SLOPE ELEMENTS.THE RELATIVE AMPLITUDES FOR THE VAR.
      C  IOUS SIDEBAND COMPONENTS ARE TRANSMITTED TO THE SUBROUTINE BY THE
      C  ARRAY G, THE ELEMENT PATTERN IS SELECTED BY THE INDEX IE
      C
            SUBROUTINE GSA ( G, R, IE )
            COMPLEX FPP,GPP, C(50),S(50), GP, E
            COMMON /ANT/ LOC,GP(4),E(4,4),CWA(2),AS(2),D(50),C,S,
           2             ET(20,2),ND(2),GC(4,3,4)
            DIMENSION G(4), R(3)
            IF ( IE .EQ. 0 ) F = SQRT( 1. - R(2)**2 )
            IF(IE .EQ. 1 ) F=(SINC(4.*ATAN2(R(2),SQRT(R(1)**2+R(3)**2))))**1.5
            DO 1 I = 1,4
          1 GP(I) = F*G(I)
      C      GP(1) = CWA(1)*GP(1)
            RETURN
            END

      GLOBAL DUMMIES

      G      76           R      77           IE     100

      COMMON

      LOC    /ANT    /+0     GP     /ANT   /+1     E      /ANT   /+11    CWA    /ANT   /+51    AS     /ANT   /+53
      D      /ANT    /+55    C      /ANT   /+137   S      /ANT   /+303   ET     /ANT   /+447   ND     /ANT   /+517
      GC     /ANT    /+521

      SUBPROGRAMS

      SQRT   SINC    ATAN2   EXP3.0

      SCALARS

      GSA    104             IE     100            F      105            I      106            LOC    0

      ARRAYS

      C      137             S      303            GP     1              E      11             CWA    51
      AS     53              D      55             ET     447            ND     517            GC     521
      G      76              R      77
 ANT         9
 AS          9
 ATAN2       13
 C           8       9
 CWA         9
 D           9
 E           8       9
 ET          9
 F           12      13      15
 FPP         8
 G           7       11      15
 GC          9
 GP          8       9       15
 GPP         8
 GSA         7
 I           14      15
 IE          7       12      13
 LOC         9
 ND          9
 R           7       11      12      13
 S           8       9
 SINC        13
 SQRT        12      13
     1P      14      15
```

```
C
C THIS SUBROUTINE GIVES FPP AND GPP AT ANGLE PHI BY SUMMING THE SIGNALS
C FROM THE ND ELEMENTS IN THE ARRAY.  THE PATTERN FOR THE
C ELEMENTS IS IN ET.  THE RELATIVE CARRIER PLUS SIDEBANDS AND
C SIDEBAND ONLY SIGNALS FED TO THE ELEMENTS ARE IN C AND S.
C
      SUBROUTINE LNAR (FPP,GPP,PHI,D,C,S,ET,ND)
      COMPLEX  FPP,GPP,C,S
       DIMENSION D(1),C(1),S(1),ET(1)
      SIPH=SIN(PHI)
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      R=TEMP-A
      EPP=R*(ET(I+1)-ET(I))+ET(I)
      FPP=(0.0,0.0)
      GPP=(0.0,0.0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END

CONSTANTS

0      176545343005    1      000000000000    2      000000000000

GLOBAL DUMMIES

FPP    173             GPP    175             PHI    177             D      200      C      201
S      202             ET     203             ND     204

SUBPROGRAMS

SIN    ABS    IFIX   FLOAT  CEXP   CMPLX  CFM,7  CFMM,2

SCALARS

LNAR   210             SIPH   211             PHI    177             TEMP   212      I      213
A      214             R      215             EPP    216             FPP    173      GPP    175
J      217             ND     204

ARRAYS

D      200             C      201             S      202             ET     203

A        14    15
ABS      12
C         8     9    10    20
CEXP     20    21
CMPLX    20    21
D         8    10    20    21
EPP      16    22    23
ET        8    10    16
FPP       8     9    17    21    23
GPP       8     9    18    20    22
I        13    14    16
J        19    20    21
LNAR      8
ND        8    19
PHI       8    11    12
R        15    16
S         8     9    10    21
SIN      11
SIPH     11    20    21
TEMP     12    13    15
   1P    19    21
```

```
      C
      C
      C THIS ANTENNA SUBROUTINE GIVES FPP AND GPP FOR ANGLE PHI BY
      C INTERPOLATION IN TABLES ANT AND ACP.  ANGLE PHI IS IN
      C RADIANS.  THE SUBROUTINE WILL INTERPOLATE BETWEEN VALUES
      C BRACKETTING TPHI.  IF PHI IS OUTSIDE THE RANGE OF THE TABLE
      C THEN EXTRAPOLATION FROM THE LAST TWO VALUES WILL BE USED.
      C
            SUBROUTINE ANTP (FPP,GPP,ANG,ANT,ACP)
            DIMENSION ANG(50), ANT(50), ACP(50)
            COMMON /SUB/ LC(4),FRQ,WAMDA,PI,RADO,PHI,P(2),PSI,T(2),NAR,XTH,
           1 XXA(3),YA,HA(3),RA(3)
            DO 1 I=2,50
            K=I
            IF(ANG(I) .GE. 6.3) GO TO 5
            IF(ANG(I)-PHI) 1,3,2
          1 CONTINUE
          2 FPP=ANT(K-1)+(ANT(K)-ANT(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
            GPP=ACP(K-1)+(ACP(K)-ACP(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
            GO TO 4
          3 FPP=ANT(K)
            GPP=ACP(K)
          4 RETURN
          5 K=K-1
            GO TO 2
            END

   CONSTANTS

   0    203623146314

   GLOBAL DUMMIES

   FPP    116          GPP    117          ANG    120          ANT    121          ACP    122

   COMMON

   LC     /SUB   /+0   FRQ    /SUB   /+4   WAMDA  /SUB   /+5   PI     /SUB   /+6   RADO   /SUB   /+7
   PHI    /SUB   /+10  P      /SUB   /+11  PSI    /SUB   /+13  T      /SUB   /+14  NAR    /SUB   /+16
   XTH    /SUB   /+17  XXA    /SUB   /+20  YA     /SUB   /+23  HA     /SUB   /+24  RA     /SUB   /+27

   SCALARS

   ANTP   123          I      124          K      125          PHI    10           FPP    116
   GPP    117          FRQ    4            WAMDA  5            PI     6            RADO   7
   PSI    13           NAR    16           XTH    17           YA     23

   ARRAYS

   ANG    120          ANT    121          ACP    122          LC     0            P      11
   T      14           XXA    20           HA     24           RA     27

 ACP        9     10     19     22
 ANG        9     10     15     16     18     19
 ANT        9     10     10     21
 ANTP       9
 FPP        9     18     21
 FRQ       11
 GPP        9     19     22
 HA        11
 I         13     14     15     16
 K         14     18     19     21     22     24
 LC        11                                                   1P     13     16     17
 NAR       11                                                   2P     16     18     25
 P         11                                                   3P     16     21
 PHI       11     16     18     19                              4P     20     23
 PI        11                                                   5P     15     24
 PSI       11
 RA        11
 RADO      11
 SUB       11
 T         11
 WAMDA     11
 XTH       11
 XXA       11
 YA        11
```

```
C
C
C THIS ANTENA SUBROUTINE WILL EVALUATE FPP AND GPP FOR THE
C STANDARD ANTENNAE.  THE VALUE OF LOC WILL DETERMINE THE TYPE
C OF ANTENNA USED.  THE SIGNALS WILL BE CALCULATED AT ANGLE PHI.
C
      SUBROUTINE CSP
      REAL LAMDA
      COMMON /SUB/ LC(4),FRQ,WAMDA,PI,RADD,PHI,P(2),PSI,T(2),NAR,XTH
      COMMON /ANT/ LOC,FPP,XF,FPM,YF,GPP,XG,GPM,YG,E(4,4)
      DIMENSION C(10),S(10),D(10),ET(20)
      SIPH=SIN(PHI)
       GO TO (1,4,6),LOC
C
C
C THIS IS THE V-RING ANTENNA
C
    1 C0=2.221
      C(1)=1.880
      C(2)=0.546
      C(3)=0.385
      C(4)=0.275
      C(5)=0.214
      C(6)=0.175
      C(7)=0.148
      D(1)=186.9
      D(2)=497.4
      D(3)=786.0
      D(4)=1120.
      D(5)=1440.
      D(6)=1760.
      D(7)=2080.
      DO 2 J=1,7
    2 D(J)=D(J)*RADD
      ET(1)=1.00
      ET(2)=0.99
      ET(3)=0.97
      ET(4)=0.92
      ET(5)=0.84
      ET(6)=0.73
      ET(7)=0.62
      ET(8)=0.48
      ET(9)=0.33
      ET(10)=0.22
      ET(11)=0.13
      ET(12)=0.13
      ET(13)=0.18
      ET(14)=0.23
      ET(15)=0.30
      ET(16)=0.36
      ET(17)=0.38
      ET(18)=0.39
      ET(19)=0.40
```

```
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      R=TEMP-A
      EPP=R*(ET(I+1)-ET(I))+ET(I)
      FPP=0.0
      GPP=C0*EPP
      DO 3 J=1,7
      CSPH=COS(D(J)*SIPH)
      SNPH=SIN(D(J)*SIPH)
      GPP = GPP + 2.*EPP*C(J)*CSPH
    3 FPP = FPP + 2.*EPP*C(J)*SNPH
      GO TO 8
C
C
C THIS IS THE 8-LOOP ANTENNA
C
    4 C(1)=1.29
      C(2)=1.00
      C(3)=0.50
      C(4)=0.30
      D(1)=55.0
      D(2)=190.0
      D(3)=500.0
      D(4)=800.0
      FPP=0.
      CSPH=2.*COS(RADD*D(1)*SIPH)
      GPP=C(1)*CSPH
      DO 5 J=2,4
      SNPH=2.*SIN(RADD*D(J)*SIPH)
    5 FPP=FPP+C(J)*SNPH
      GO TO 8
C
C
C
C THIS IS THE WAVEGUIDE ANTENNA
C
    6 C(1)=3.210
      C(2)=2.950
      C(3)=2.560
      C(4)=2.020
      C(5)=1.410
      C(6)=0.865
      C(7)=0.545
      C(8)=0.064
      C(9)=-0.16
      S(1)=0.179
      S(2)=0.513
      S(3)=0.776
      S(4)=0.994
      S(5)=1.000
      S(6)=0.962
      S(7)=0.853
```

```
      S(8)=0.720
      S(9)=0.543
      D(1)=117.
      D(2)=352.
      D(3)=597.
      D(4)=822.
      D(5)=1060.
      D(6)=1295.
      D(7)=1530.
      D(8)=1765.
      D(9)=2000.
      FPP=0.0
      GPP=0.0
      DO 7 J=1,9
      CSPH=2.*COS(RADD*D(J)*SIPH)
      SNPH=2.*SIN(RADD*D(J)*SIPH)
      GPP=GPP+C(J)*CSPH
    7 FPP=FPP+S(J)*SNPH
    8 RETURN
      END

CONSTANTS

0    202434223351   1    200427432477   2    177612172702   3    177431463146   4    176660213207
5    176546314631   6    176457065176   7    210565631463   10   211761314631   11   212611314631
12   200772702436   13   200760507534   14   200727024365   15   200656050753   16   200565605075
17   200475341217   20   177753412172   21   177521727024   22   176702436560   23   176412172702
24   176560507534   25   176727024365   26   177463146314   27   177560507534   30   177605075341
31   177617270243   32   177631463146   33   176545343005   34   201512172702   35   202632702436
36   202571463146   37   202507534121   40   202402436560   41   201550753412   42   200672702436
43   200427024365   44   175406111564   45   176507534121   46   176556457065   47   200406517676
50   200615237574   51   200774733105   52   200754426416   53   200664570651   54   200546314631
55   200426010142   56   212445400000   57   213503600000   60   213576400000   61   213671200000

COMMON

LC    /SUB  /+0    FRO   /SUB  /+4    WAMDA /SUB  /+5    PI    /SUB  /+6    RADD  /SUB  /+7
PHI   /SUB  /+10   P     /SUB  /+11   PSI   /SUB  /+13   T     /SUB  /+14   NAR   /SUB  /+16
XTH   /SUB  /+17   LOC   /ANT  /+0    FPP   /ANT  /+1    XF    /ANT  /+2    FPM   /ANT  /+3
YF    /ANT  /+4    GPP   /ANT  /+5    XG    /ANT  /+6    GPM   /ANT  /+7    YG    /ANT  /+10
E     /ANT  /+11

SUBPROGRAMS

SIN   ABS   IFIX   FLOAT   COS

SCALARS

CSP    506      SIPH   507      PHI    10       LOC    0        CB     510
J      511      RADD   7        TEMP   512      I      513      A      514
R      515      EPP    516      FPP    1        GPP    5        CSPH   517
SNPH   520      FRQ    4        WAMDA  5        PI     6        PSI    13
NAR    16       XTH    17       XF     2        FPM    3        YF     4
```

```
      XG      6          GPM     7          YG      10

      ARRAYS

      LC      J          P       11         T       14              E       11            C       521
      S       533        D       545        ET      597
   A          56     57
   ABS        54
   ANT        10
   C          11     19     20     21     22     23     24     25     64     65     71     72     73     74
              81     84     91     92     93     94     95     96     97     98     99     123
   CB         10     60
   COS        62     80     121
   CSP        7
   CSPH       62     64     80     81     121    123
   D          11     26     27     28     29     30     31     32     34     62     63     75     76     77
              78     80     83     109    110    111    112    113    114    115    116    117    121    122
   E          10
   EPP        58     60     64     65
   ET         11     35     36     37     38     39     40     41     42     43     44     45     46     47
              48     49     50     51     52     53     58
   FPH        10
   FPP        10     59     65     79     84     110    124
   FRQ        9
   GPH        10
   GPP        10     60     64     81     119    123
   I          55     56     58
   J          33     34     61     62     63     64     65     82     83     84     120    121    122    123
              124
   LAMDA      8
   LC         9
   LOC        10     13
   NAR        9
   P          9
   PHI        9      12     54
   PI         9
   PSI        9
   R          57     58
   RADU       9      34     80     83     121    122
   S          11     100    101    102    103    104    105    106    107    108    124
   SIN        12     63     83     122
   SIPH       12     62     63     80     83     121    122
   SNPH       63     65     83     84     122    124
   SUR        9
   T          9
   TEMP       54     55     57
   WAMDA      9
   XF         10
   XG         10
   XTH        9
   YF         10
   YG         10
        1P    13     10
        2P    33     34
        3P    61     65
        4P    13     71
        5P    82     84
        6P    13     91
        7P    120    124
        8P    66     85     125
```

```
C
C
C THIS FUNCTION EVALUATES THE WEIGHTED SUM OF A SERIES OF
C BESSEL FUNCTIONS.  IT IS USED TO CALCULATE THE SCATTERING
C FROM A CYLINDER.
C
      COMPLEX FUNCTION BESF(AKA,XCB,XSB)
      COMPLEX SUM
      DATA PI,EE/3.14159265,2.71828183/
      CB=XCB
      SUM=(-2.,0.,0.)
      IF(CB .LT. -.99996) GO TO 6
      SB=ABS(XSB)
      CB2=SQRT((1.+CB)/2.)
      V=2.*AKA*CB2
      VI=2./V
      SER=7.
      FN=IFIX(9.+.67*V)*2+10
      OJ=1./FN
      EJ=((1.-1./FN)**(FN-.5))*EE*V*.5*OJ*OJ
      FN=FN-1.
      DO 3 KK=1,5
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
    3 CONTINUE
      B=ATAN2(SB,CB)
      S1=SIN((FN+2.)*B/2.)
      C1=COS((FN+2.)*B/2.)
      S2=S1*CB-C1*SB
      C2=C1*CB+S1*SB
    4 YI=FN
      ZI=FN+2.
      SER=SER+EJ*(C2/YI-C1/ZI)
      IF(FN .LT. 2.) GO TO 5
      C1=C2
      S1=S2
      TEMP=C2*CB+S2*SB
      S2=S2*CB-C2*SB
      C2=TEMP
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
      AM=2./(ABS(EJ)+ABS(OJ))
      EJ=EJ*AM
      OJ=OJ*AM
      SER=SER*AM
      GO TO 4
    5 AJ=-EJ+FN*VI*OJ
      ZZJ=AJ
      XXJ=OJ
```

```
      IF(ABS(AJ) .GE. ABS(OJ)) GO TO 7
      IF(V .LT. 3.) GO TO 9
      XI=3./V
      FO=.79788456+XI*(.00000156+XI*(.01659667+XI*(
     1.00017105-XI*(.00249511-XI*(.00113653-XI*.00020033)))))
      PHI=V-2.35619449+XI*(.12499612+XI*(.0000565-XI*
     1(.00637879-XI*(.00074348+XI*(.00079824-XI*.00029166)))))
      BJ=FO*COS(PHI)/SQRT(V)
      GO TO 10
    9 XI=V*V/9.
      BJ=V*(.5-XI*(.56249985-XI*(.21093573-XI*
     1(.03954289-XI*(.00443319-XI*(.00031761-XI*.00001109))))))
   10 SCAL=BJ/OJ
      OJ=BJ
      BJ=AJ*SCAL
      GO TO 8
    7  XI=3./V
      IF(V .LT. 3.) GO TO 1
      PHI=V-.78539816-XI*(.04166397+XI*(.00003954-XI*(
     ..00262573-XI*(.00054125+XI*(.00029333-XI*.00013558)))))
      FO=.79788456-XI*(.00000077+XI*(.00552740+XI*(
     ..00009512-XI*(.00137237-XI*(.00072805-XI*.00014476)))))
       BJ=FO*COS(PHI)/SQRT(V)
      GO TO 2
    1 XI=V*V/9.
      BJ=1.-XI*(2.2499997-XI*(1.2656208-XI*(.3163866-XI*(
     ..0444479-XI*(.0039444-XI*(.00021))))))
    2 SCAL=BJ/AJ
      OJ=OJ*SCAL
    8 RI=-SB*SIN(AKA*SB)/(AKA*(1.+CB))+2.*CB2*CB2*BJ
      SER=SER*SCAL
      RI=RI-2.*CB2*SER
      CI=-PI*CB2*OJ
      SUM=CMPLX(RI,CI)
    6 CONTINUE
      BESF=SUM
      RETURN
      END
```

CONSTANTS

0	575400000000	1	200000000000	2	200777765407	3	200527024365	4	200400000000
5	201400000000	6	170476447137	7	167451736362	10	170507023776	11	164546557423
12	173417726752	13	155642604610	14	200630410514	15	202455457437	16	165461647612
17	166642403726	20	166605630311	21	171642024531	22	162731751515	23	175777767671
24	204440000000	25	163721113737	26	165515023444	27	171442421130	30	174503736715
31	176657776111	32	200437777753	33	200622877324	34	164434251725	35	165463450260
36	166433612541	37	170530121603	40	162513537003	41	174525237266	42	164457452673
43	166575552336	44	167547604304	45	163616754512	46	171552174610	47	154635307772
50	164670315620	51	171472400064	52	174554074002	53	177503765545	54	201503777546
55	202437777765								

GLOBAL DUMMIES

```
AKA      665               XCB      666               XSB      667

SUBPROGRAMS

ABS      SQRT     IFIX     FLOAT    EXP3.4   ATAN2    SIN      COS      CMPLX

SCALARS

BESF     672               PI       674               EE       675               CB       676               XCB      666
SUM      677               SB       701               XSB      667               CB2      702               V        703
AKA      665               VI       704               SER      705               FN       706               OJ       707
EJ       710               KK       711               9        712               S1       713               C1       714
S2       715               C2       716               YI       717               ZI       720               TEMP     721
AM       722               AJ       723               ZZJ      724               XXJ      725               XI       726
FO       727               PHI      730               BJ       731               SCAL     732               RI       733
CI       734

ABS       13      46      54
AJ        51      52      54      68      81
AKA        7      15      83
AM        46      47      48      49
ATAN2     28
B         28      29      30
BESF       7      89
BJ        61      64      66      67      68      76      79      81      83
C1        30      31      32      35      37
C2        32      35      37      39      40      41
CB        10      12      14      28      31      32      39      40      83
CB2       14      15      83      85      86
CI        86      87
CMPLX     87
COS       30      61      76
EE         9      20
EJ        20      23      25      35      42      44      46      47      51
FN        18      19      20      21      23      24      25      26      29      30      33      34      36      42
          43      44      45      51
FO        57      61      74      76
IFIX      18
KK        22
OJ        19      20      23      25      42      44      46      48      51      53      54      66      67      82
          86
PHI       59      61      72      76
PI         9      86
RI        83      85      97
S1        29      31      32      38
S2        31      38      39      40
SB        13      28      31      32      39      40      83
SCAL      66      68      51      82      84
SER       17      35      49      84      95
SIN       29      83
SQRT      14      61      76
SUM        8      11      87      89
TEMP      39      41
V         15      16      18      20      55      56      59      61      63      64      70      71      72      76
          78
VI        16      23      25      42      44      51
XCB        7      10
XI        56      57      59      63      64      70      72      74      78      79
XSB        7      13
XXJ       53
YI        33      35
ZI        34      35
ZZJ       52

   1P     71      78
   2P     77      81
   3P     22      27
   4P     33      50
   5P     36      51
   6P     12      88
   7P     54      70
   8P     69      83
   9P     55      63
  12P     62      66
```

```
 1   C
 2   C
 3   C
 4   C THIS IS THE SINC FUNCTION.  IT IS DEFINED AS THE SINE OF
 5   C X DIVIDED BY X.  SINC OF ZERO IS TAKEN TO BE ONE.
 6   C
 7         FUNCTION SINC(X)
 8         XX=ABS(X)
 9         IF(XX .LT. .000122070 3) XX=.0001
10         SINC=SIN(XX)/XX
11         RETURN
12         END

     CONSTANTS

     0       163777777762     1       163643334272

     GLOBAL DUMMIES

     X.      41

     SUBPROGRAMS

     ABS     SIN

     SCALARS

     SINC    42               XX      43              X       41
  ABS          8
  SIN         10
  SINC         7        10
  X            7         8
  XX           8         9       10
```

```
      BLOCK DATA
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON /SUB/DUMMY(6),PI,RADD
      COMMON /ANT/DUM(43),AS(2),DUMXX(292),GC(4,3,4)
      COMPLEX CJA(30),CJB(30)
      COMMON /WG/WGDUM(12),CJA,CJB
       DATA CJA( 2),CJB( 2)/( 0.994396E-01,-0.444252E+00),
     1( 0.732930E-01, 0.327656E+00)/
       DATA CJA( 3),CJB( 3)/( 0.153952E+00,-0.452091E+00),
     1( 0.114439E+00, 0.336059E+00)/
       DATA CJA( 4),CJB( 4)/( 0.221030E+00,-0.474087E+00),
     1( 0.165794E+00, 0.355604E+00)/
       DATA CJA( 5),CJB( 5)/( 0.304208E+00,-0.502587E+00),
     1( 0.230768E+00, 0.381238E+00)/
       DATA CJA( 6),CJB( 6)/( 0.403680E+00,-0.528400E+00),
     1( 0.310674E+00, 0.406687E+00)/
       DATA CJA( 7),CJB( 7)/( 0.515791E+00,-0.542297E+00),
     1( 0.404531E+00, 0.425217E+00)/
       DATA CJA( 8),CJB( 8)/( 0.634920E+00,-0.536363E+00),
     1( 0.510200E+00, 0.430537E+00)/
       DATA CJA( 9),CJB( 9)/( 0.748220E+00,-0.505310E+00),
     1( 0.618978E+00, 0.417856E+00)/
       DATA CJA(10),CJB(10)/( 0.850034E+00,-0.448100E+00),
     1( 0.728660E+00, 0.383874E+00)/
       DATA CJA(11),CJB(11)/( 0.924680E+00,-0.367463E+00),
     1( 0.824869E+00, 0.327759E+00)/
       DATA CJA(12),CJB(12)/( 0.972880E+00,-0.269360E+00),
     1( 0.907035E+00, 0.251112E+00)/
       DATA CJA(13),CJB(13)/( 0.986563E+00,-0.161654E+00),
     1( 0.963434E+00, 0.157879E+00)/
       DATA CJA(14),CJB(14)/( 0.973517E+00,-0.526250E-01),
     1( 0.996483E+00, 0.538674E-01)/
       DATA CJA(15),CJB(15)/( 0.931749E+00, 0.502681E-01),
     1( 0.998247E+00,-0.538717E-01)/
       DATA CJA(16),CJB(16)/( 0.863803E+00, 0.141137E+00),
     1( 0.966121E+00,-0.157881E+00)/
       DATA CJA(17),CJB(17)/( 0.781282E+00, 0.215820E+00),
     1( 0.908347E+00,-0.251213E+00)/
       DATA CJA(18),CJB(18)/( 0.684827E+00, 0.272410E+00),
     1( 0.824159E+00,-0.327751E+00)/
       DATA CJA(19),CJB(19)/( 0.584010E+00, 0.310151E+00),
     1( 0.723922E+00,-0.383734E+00)/
       DATA CJA(20),CJB(20)/( 0.487807E+00, 0.329516E+00),
     1( 0.610665E+00,-0.417957E+00)/
       DATA CJA(21),CJB(21)/( 0.393764E+00, 0.333237E+00),
     1( 0.508884E+00,-0.430658E+00)/
       DATA CJA(22),CJB(22)/( 0.308467E+00, 0.324260E+00),
     1( 0.404480E+00,-0.425227E+00)/
       DATA CJA(23),CJB(23)/( 0.234293E+00, 0.306669E+00),
     1( 0.310654E+00,-0.406686E+00)/
       DATA CJA(24),CJB(24)/( 0.172580E+00, 0.285123E+00),
     1( 0.237762E+00,-0.381212E+00)/
```

```
      DATA CJA(25),CJB(25)/( 0.123197E+00, 0.264256E+00),
     1( 0.165783E+00,-0.355592E+00)/
      DATA CJA(26),CJB(26)/( 0.846165E-01, 0.248495E+00),
     1( 0.114433E+00,-0.336041E+00)/
      DATA CJA(27),CJB(27)/( 0.539731E-01, 0.241264E+00),
     1( 0.733415E-01,-0.327657E+00)/
      DATA AS/1.0,1.2/
      DATA ZJM,ZJP,ZJPC,ZJMC /6*(0.,0.)/
      DATA PI,RADD/3.14159265,.017453292/
      DATA GC/2.,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     1-.12,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     2-.06,.006,.4,.006,.12,0.,-.2,0.,-.06,.006,0.,.006,
     30.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      END

 COMMON

 ZJM    /AB   /+0     ZJP    /AB   /+2    ZJPC   /AB   /+4    ZJMC   /AB   /+18   DUMMY  /SUB  /+0
 PI     /SUB  /+6     RADD   /SUB  /+7    DUM    /ANT  /+0    AS     /ANT  /+53   DUMXX  /ANT  /+55
 GC     /ANT  /+521   WGDUM  /WG   /+0    CJA    /WG   /+14   CJB    /WG   /+118

 SUBPROGRAMS

 .JBFF

 SCALARS

 ZJM    0             ZJP    2            PI     6            RADD   7

 ARRAYS

 ZJPC   4             ZJMC   10           DUMMY  0            DUM    0            AS     53
 DUMXX  55            GC     521          CJA    14           CJB    118          WGDUM  0

AB       3
ANT      5
AS       5    60
CJA      6     7     8    10    12    14    16    18    20    22    24    26    28    30
        32    34    36    38    40    42    44    46    48    50    52    54    56    58
CJB      6     7     8    10    12    14    16    18    20    22    24    26    28    30
        32    34    36    38    40    42    44    46    48    50    52    54    56    58
DUM      5
DUMMY    4
DUMXX    5
GC       5    63
PI       4    62
RADD     4    62
SUB      4
WG       7
WGDUM    7
ZJM      2     3    61
ZJMC     2     3    61
ZJP      2     3    61
ZJPC     2     3    61
```

APPENDIX B

DYNAMIC SIMULATION

PROGRAM DYNM LISTING

The ILSLOC program calculates the CDI at each point in space; this CDI includes the Doppler effects from the velocity of the aircraft. In the simulation, the receiver system is assumed to generate the CDI value instantaneously. In the real case, the inertia of the electrical and mechanical portions of the system limit the rate of change of the CDI. Thus the real observed CDI appears to have been low-pass filtered from the instantaneous CDI.

The program DYNM takes the output tape generated by program ILSLOC and converts it to observed CDI by simulating the effect of a low-pass filter. The variable TAU is the time constant of the effective filter.*

Note: When a flight path has been segmented, the low-pass filter will operate continuously over the entire flight path.

```
C THIS PROGRAM SIMULATES THE EFFECT OF THE  MECHANICAL AND ELECTRICAL
C INERTIA OF THE ILS RECEIVER ON THE CDI.  THIS EFFECT IS EQUIVALENT
C TO A SIMPLE R-C LOW PASS FILTER.  THE VARIABLE TAU IS THE TIME
C CONSTANT OF THE EFFECTIVE FILTER.  A TYPICAL VALUE IS .4 SECONDS.
C THE INPUT TAPE IS ON UNIT 11, THE OUTPUT ON UNIT 12.
C
C
      DIMENSION XY(10),DEF(501),MEMO(14)
      LOGICAL EOF
      DATA ILBL/4HDYNM/
      DATA TAU/0.4/
      IF(EOF(11)) GO TO 4
    1 IT=0
      DELC=0.
    2 READ(11,1000) MEMO,XY,ID,NC,ICF
      WRITE(6,1003) MEMO,XY,ID,NC,ICF
      DEFK=ABS(XY(9)/XY(5)/TAU)
      IR=IFIX(XY(10)+.1)
      READ(11,1001) (DEF(I),I=1,IR)
      IF(IT .EQ. 0) CEF2=DEF(1)
      IT=1
      DO 3 I=1,IR
      CEF2=CEF2+DELC
      DELC=(DEF(I)-CEF2)*DEFK
    3 DEF(I)=CEF2
      MEMO(13)=ILBL
      WRITE(12,1000) MEMO,XY,ID,NC,ICF
      WRITE(12,1001) (DEF(I),I=1,IR)
      IF(ID .GT. 13) GO TO 1
      IF( ID .EQ. 0) GO TO 1
      GO TO 2
    4 REWIND 11
      END FILE 12
      REWIND 12
      CALL EXIT
 1000 FORMAT(13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
 1001 FORMAT(7E15.8)
 1003 FORMAT(1X,13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
      STOP
      END
```

APPENDIX C

ILSPLT PLOTTING ROUTINE

This program has been written to generate graphs of the static and dynamic CDI's. It was written on the IBM 7094 using the CALCOMP plotting subroutines.

The first input card has the following format:

Col.	Symbol	Use
1-2	NL	Number of lines per graph
3-4	NGRFS	Number of graphs
5-7	NTAPE (1)	Input logical unit no. for first line
8-10	NTAPE (2)	Input logical unit no. for second line
11-13	NTAPE (3)	Input logical unit no. for third line.

NL permits the overlaying of two or more CDI or signal strength graphs for comparison purposes. The scaling will be set by the first graph, and the successive overlays will be plotted to the same scale. A maximum of three lines per graph will be allowed.

NGRFS sets the maximum number of graphs to be drawn. Each graph will have the same number of overlays.

NTAPE (i) gives the logical unit number used for the input of the ith line on each graph. If the value of NTAPE is negative then its absolute value will be used as its logical unit number and the tape will be rewound before input.

The second input card defines the scaling used for the graph (or graphs) described above. It has the following format:

Col.	Symbol	Use
1-10	XSC	Horizontal scale in ft/in. or deg/in.
11-20	DELX	Tick mark spacing in ft. or deg.
21-30	YMAX	Maximum y-value on vertical scale
31-40	YMIN	Minimum y-value on vertical scale
41-50	DELY	Tick mark spacing on vertical spacing in microamps for CDI or relative units.

The horizontal axis is drawn in either feet or degrees per inch as specified by XSC. The tick mark spacing along the axis is determined by DELX. The length of the axis will be adjusted to the shortest length with an integral number of tick marks that will cover the domain required by the input data. When a flight path has been segmented it is treated as a single line on the graph.

YMAX, YMIN define the range of the plotted variable: CDI or relative signal strength. The y-axis has a fixed length of seven inches. If DELY does not integrally divide the range, DELY will be adjusted to yield an integer. When the range (YMAX-YMIN) is zero, the program will automatically scale the range to the largest scale that will include the data in the length of the axis.

When multiple graphs are plotted, each graph is scaled independently.

After all NGRFS graphs have been drawn, the program will loop back to the beginning and attempt to read in a new NL card. This allows many graphs to be drawn. If the user wishes to replot data using different scales or overlaid with different sets of data, he may use the negative NTAPE to rewind the input tape.

The program will terminate after reaching an end-of-file on the card input unit.

The vertical scale on the graph is always labeled "microamperes." This is valid only for CDI graphs. All others are in relative units and this labeling should be ignored.

```
      COMMCN/TEST/XMIN,DXR,NTOT,NP
      LOGICAL EOF
      DIMENSION IBUF(1000)
      DIMENSION NTAPE(3),MEMO(14),M(14)
      EQUIVALENCE (M(1),MEMO(1))
      COMMCN /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMON /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      CALL PLOTS(IBUF,1000)
      CALL PLOT(0.0,-12.,-3)
      CALL FACTOR (0.4)
      ILBL=1
   60  CONTINUE
      IF(EOF(5)) GO TO 55
      READ(5,100) NL,NGRFS,NTAPE
      WRITE(6,100) NL,NGRFS,NTAPE
      IF(NGRFS.LE.C) NGRFS=3
100   FORMAT(2I2,3I3)
      DO 401 I=1,NL
      IF(NTAPE(I).GE.0) GO TO 401
      NTAPE(I)=-NTAPE(I)
      NU=NTAPE(I)
       REWIND NU
401   CONTINUE
      READ(5,101) XSC,DELX,YMAX,YMIN,DELY
      WRITE(6,101) XSC,DELX,YMAX,YMIN,DELY
  101 FORMAT(8F10.0)
      TEMP=AMIN1(YMIN,YMAX)
      YMAX=AMAX1(YMIN,YMAX)
      YMIN=TEMP
      TEMP=YMAX-YMIN
       IF(TEMP .NE. 0.) DELY=TEMP/(FLOAT(IFIX(TEMP/DELY+.5)))
      NPLT = 1
      NP = 1
      I = 1
      N1 = 1
      NTOT = 0
   10 NU = NTAPE(NP)
      IF(EOF(NU)) GO TO 50
      READ(NU,500) M,XO,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ICF .NE. 0) ICF=1
      WRITE(6,600) MEMO,XO,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ILBL .NE. 1) GO TO 70
      ILBL=0
      CALL SYMBOL(0.,0.,.14,MEMO,90.,80)
      CALL PLOT(3.,0.,-3)
70      CONTINUE
      IR =IFIX( XY+.1)
      NTOT = NTOT + IR
      IF(I.EQ.1) XMIN = XO
  500 FORMAT(13A6,A2,/,/,3F18.9,4I10)
  600 FORMAT(2X,13A6,A2,/,3F18.9,4I10)
501      FORMAT(7E15.8)
502      FORMAT(1X,7E15.8)
      READ(NU,501)(DF(J),J=N1,NTOT)
      WRITE(6,502) (DF(J),J=N1,NTOT)
```

```
      WRITE(6,1000) XMIN,IR,N1,NTOT,NP,I
 1000 FORMAT(F10.0,5I10)
      NPTS(I) = IR
      DX(I) = DXR
      IF( ID .GT. 13 ) GO TO 40
       IF(ID .EQ. 0) GO TO 40
      N1 = N1 + IR
      I = I + 1
      GO TO 10
   11 NL = NP
   40 CONTINUE
      NSTEPS = I
      IF(NP.GT.1) GO TO 41
      CALL GRAPH2(0)
      GO TO 42
41      CALL GRAPH2(1)
   42 CONTINUE
      N1 = 1
      I = 1
      NTOT = 0
      IF(NP.EQ.NL) GO TO 45
      NP = NP + 1
      GO TO 10
   45 NP = 1
      CALL PLOT(XLEN+7.,-12.,-3)
      NPLT = NPLT + 1
      ILBL=1
      IF(NPLT.GT.NGRFS) GO TO 60
      GO TO 10
   50 CONTINUE
      IF(NTOT.GT.0) GO TO 11
      CALL PLOT (XLEN+7.,-12.,-3)
      GO TO 60
   55 CONTINUE
      CALL PLOT(0.,0.,999)
      DO 400 I=1,NL
      NU=NTAPE(I)
400    REWIND NU
      STOP
      END
```

```
      SUBROUTINE GRAPH2(ITL)
      DIMENSICN XLAB(4)
      COMMON/TEST/X0,DELTAX,NDELTA,NP
      DATA XLAB/24HDISTANCE,FT.  DEGREES      /
      DIMENSICN TYPE(8)
      DIMENSION X(3),NC(3)
      COMMCN /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMCN /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      DATA X /-5.,5.,5./
      DATA NC /1,5,4/
      IF(ITL .NE. 0) GO TO 1
      ELX=DELX
      IF(DELTAX.LT.0.) ELX = -ABS(DELX)
       RANGE=0.
      DO 11 I=1,NSTEPS
11     RANGE=RANGE+FLOAT(NPTS(I))*DX(I)
      TIX=IFIX(RANGE/ELX+.9)
7     XLEN = ABS(ELX/XSC*TIX)
      IF(XLEN .GT. 40.) GO TO 9
      IF(XLEN .GT. 5.) GO TO 6
    9 XSC=ABS(RANGE/20.)
      XLEN=ABS(ELX/XSC*TIX)
      WRITE(6,8) XSC
8      FORMAT(25H AXIS OUT OF RANGE SCALE=,E12.5,8H FT./IN.  /)
6     CONTINUE
      XMAX=TIX*ELX+X0
      XMIN = AMIN1(X0,XMAX)
      XMAX = AMAX1(X0,XMAX)
      ND = 2
      PWR = 0.
      CALL PLOT(0.,1.5,-3)
      AMIN=YMIN
      AMAX=YMAX
      IF(YMAX .EQ. YMIN) CALL SCLAX(7.,DF,NDELTA,AMAX,AMIN,DELY,ND,PWR)
      CALL AXIS3(0.,0.,AMAX,AMIN,DELY,7.,12HMICROAMPERES,12,ND,PWR,DELN)
      YSC = DELN
      IXLAB=2*ICF+1
      IXSC=-1
      IF(ABS(ELX) .LT. 10.) IXSC=1
      CALL AXIS3(0.,0.,XMAX,XMIN,ELX,-XLEN,XLAB(IXLAB),12 ,IXSC,0.
     .,DELN)
      XSC = DELN
      XT = XLEN/2. - 2.
      IF(AMIN*AMAX.GT.0.) GO TO 2
      IF( AMIN .EQ. 0.) GO TO 2
      ZERO=(0.-AMIN/10.**PWR)/YSC
      CALL PLOT (0.,ZERO,3)
      CALL PLOT(XLEN,ZERO,2)
2     CONTINUE
1      CONTINUE
      XI=0.
      IF(DELTAX .LT. 0.) XI=XMAX-XMIN
      J=1
      DO 5 I=1,NSTEPS
      DELTAX = DX(I)
```

```
      NX=NPTS(I)
      IF(I .LT. NSTEPS) NX=NX+1
       YM=AMIN/10.**PWR
      CALL XCLINE(XI,DELTAX,DF(J),NX,0.,XSC,YM,YSC,NC(NP))
      J=J+NPTS(I)
      XI=XI+DX(I)*FLOAT(NPTS(I))
    5 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE XCLINE(XI,DX,Y,N,XM,DELX,YM,DELY,NC)
      DIMENSION Y(1),IPEN(4)
      REAL L(4,4),LL(4)
      DATA IPEN/2,3,2,3/
      DATA L/.3,.1,.3,.1,.5,3*.05,.3,3*.1,.1,.05,.1,.05/
      X = XI
    2 IC = NC - 1
      XP1 = (X-XM)/DELX
      YP1=(Y(1)-YM)/DELY
      CALL PLOT(XP1,YP1,3)
      IF(IC.LE.0) GO TO 1000
      IF(IC.GT.4) IC = 4
      K=1
      I=2
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(2)-YM)/DELY
    1 LL(K)=L(K,IC)
   10 DIFFX=XP2-XP1
      DIFFY=YP2-YP1
      DIS=SQRT(DIFFX*DIFFX+DIFFY*DIFFY)
      IF(DIS.GT.LL(K))GO TO 100
      CALL PLOT(XP2,YP2,IPEN(K))
      XP1=XP2
      YP1=YP2
      I=I+1
      IF(I.GT.N)RETURN
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(I)-YM)/DELY
      LL(K)=LL(K)-DIS
      GO TO 10
  100 RATIO=DIS/LL(K)
      XP1=XP1+DIFFX/RATIO
      YP1=YP1+DIFFY/RATIO
      CALL PLOT(XP1,YP1,IPEN(K))
      K=K+1
      IF(K.EQ.5)K=1
      GO TO 1
 1000 DO 50 I=2,N
      X = X + DX
      XP1 = (X-XM)/DELX
      YP1=(Y(I)-YM)/DELY
   50 CALL PLOT(XP1,YP1,2)
      RETURN
      END
```

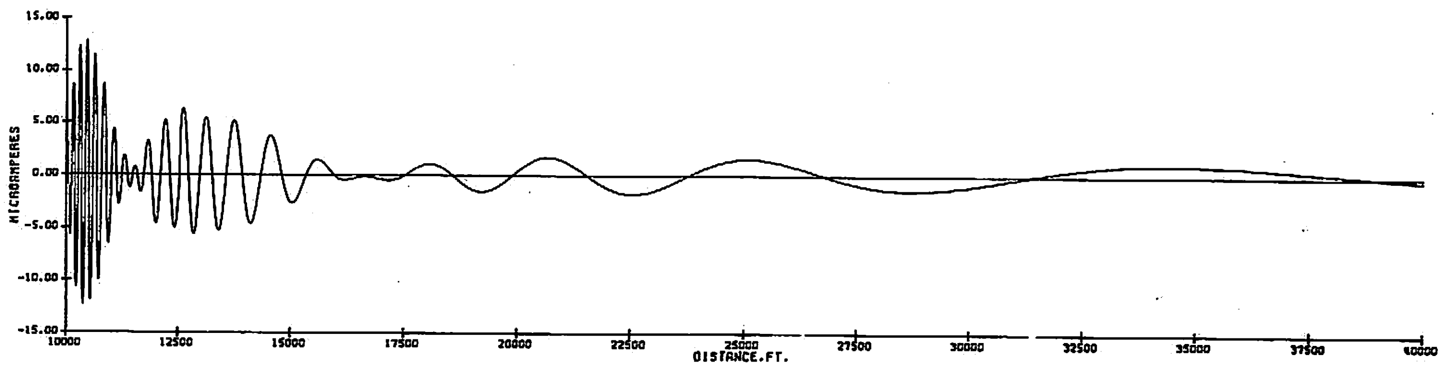
```
      SUBROUTINE SCLAX(AINCH,VAR,N,VMAX,VMIN,DELTA,ND,EXP)
      DIMENSION VAR(1)
C
      AXLEN = AINCH
      VMAX = VAR(1)
      VMIN = VAR(1)
      DO 40 I=2,N
      VMAX = AMAX1(VMAX,VAR(I))
   40 VMIN = AMIN1(VMIN,VAR(I))
      ND = 0
      NE = 0
      M = 2
      TOTAL = VMAX - VMIN
C                                DETERMINE EXPONENT AND INCREMENT/INCH
      VM = AMAX1(ABS(VMAX),ABS(VMIN))
      IF(VMAX*VMIN) 6,5,7
    7 VAV = ABS(VMAX+VMIN)/2.
      DELTA = TOTAL/AXLEN
      IF(TOTAL.GT.0..AND.TOTAL/VM.LT..75) GO TO 4
      IF(VMAX.EQ.VM) VMIN=0.
      IF(VMIN.EQ.-VM) VMAX=0.
      GO TO 5
    6 AXLEN = AXLEN*VM/TOTAL
    5 DELTA = VM/AXLEN
      VAV = VM/2.
C                                TEST FOR VAV BETWEEN .01 AND 1000.
    4 IF(VAV.LE.1.E-11) GO TO 21
      IF(VAV - .01) 3,10,1
   41 IF(VAV - 1.) 3,10,10
    1 IF(VAV - 1000.) 10,2,2
C                                VAV GE 1000.
    2 IF(NE.EQ.0) VAV = VM
      VAV = VAV/1000.
      NE = NE - 3
      GO TO 1
C                                VAV LT 1.
    3 VAV = VAV*1000.
      NE = NE + 3
      GO TO 41
C                                DETERMINE DECIMAL PLACES IN DELTA
   10 IF(DELTA.LT.VM/1.E4) GO TO 21
      DELTA = DELTA*10.**NE
   11 IF(DELTA - 1.) 12,19,13
   12 DELTA = DELTA*10.
      ND = ND + 1
      GO TO 11
   13 IF(DELTA - 10.) 15,8,14
   14 DELTA = DELTA/10.
      ND = ND - 1
      GO TO 13
C                                DELTA NOW BETWEEN 1 AND 10
   15 IF(DELTA - 5.) 16,17,17
   16 IF(DELTA - 2.) 19,18,18
   17 DELTA = 5./10.**(ND+NE)
      GO TO 20
```

```
   18 DELTA = 2./10.**(ND+NE)
      M = 5
      GO TO 20
    8 ND = ND - 1
   19 DELTA = 1./10.**(ND+NE)
C                                  RESET VMIN (FIRSTV) FOR AXIS
   20 AK = VMIN/DELTA + .01
      K = (IFIX(AK)/M)*M
      IF(VMIN.LT.0.) K=K-M
      VMIN = DELTA*FLOAT(K)
      NDIV = (VMAX - VMIN)/DELTA + .9
      IF(FLOAT(NDIV).GT.AINCH*2.) DELTA=DELTA*AMAX1(2.,FLOAT(M)/2.)
      IF(ND.LE.0) ND = -1
   21 EXP = NE
      WRITE(6,1002) VMAX,VMIN,DELTA,ND,NE
      RETURN
 1002 FORMAT(1H0,3E13.3,3I7//)
      END
```

```
      SUBROUTINE AXIS3(XO,YO,VMAX,VMIN,DELV,AINCH,BCD,NCR,NDEC,PWR,VSC)
      FACTOR = 10.**PWR
      AMIN = VMIN*FACTOR
      AMAX = VMAX*FACTOR
      DELX = ABS(DELV)*FACTOR
      DIMENSICN BCD(1)
      HT = .15
      W1=0.
      W2=0.
      W3 = 0.
      NEXP = 0
      NCH=IABS(NCR)
      IF(PWR.NE.0.) NEXP = 6
      CINCH=ABS(AINCH)
      IF((VMAX-VMIN)/AMAX1(VMAX,-VMIN).LT.1.E-6) GO TO 50
      IF((AMAX-AMIN)/(DELX+1.E-8).GT.3.*CINCH) DELX = (AMAX-AMIN)/CINCH
      IF(DELX.GT.AMAX-AMIN) DELX = AMAX - AMIN
      IF(NCR.LT.0) W3 = 1.
      NUM=(AMAX-AMIN)/DELX+1.9
      ANC=CINCH/FLOAT(NUM-1)
      IF(AINCH.LT.C.)GO TO 5
      W2=1.
      GO TO 10
    5 W1=1.
   10 CALL PLCT(XO,YO,3)
      VSC = DELX/FACTOR/ANC
      ANUM=AMIN-DELX
      X=0.
      Y=0.
      XM=0.
      OFF = .05
      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.C.)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))
      HL = AMAX1(.12,1.2*HT)
      CENTER = FLOAT(II)*HT/(1.+W1)
      XC = X - CENTER - W2*.15
      IF(XC.LT.XM) XM = XC
      IF(W2*W3.GT.C.) XC = .15
      IF(ABS(XC).GT.ABS(XM)) XM = XC
      YC = Y - W1*(HT + .15 - W3*(HT+.3)) - W2*OFF
      CALL PLOT(XO+X,YO+Y,2)
      CALL PLOT(XO+X+.1*W2,YO+Y+.1*W1,3)
      CALL PLOT(XO+X-.1*W2,YO+Y-.1*W1,2)
      CALL NUMBER(XO+XC,YO+YC,HT,ANUM,0.,NDEC)
      CALL PLCT(XO+X,YO+Y,3)
      X=X+ANC*W1
```

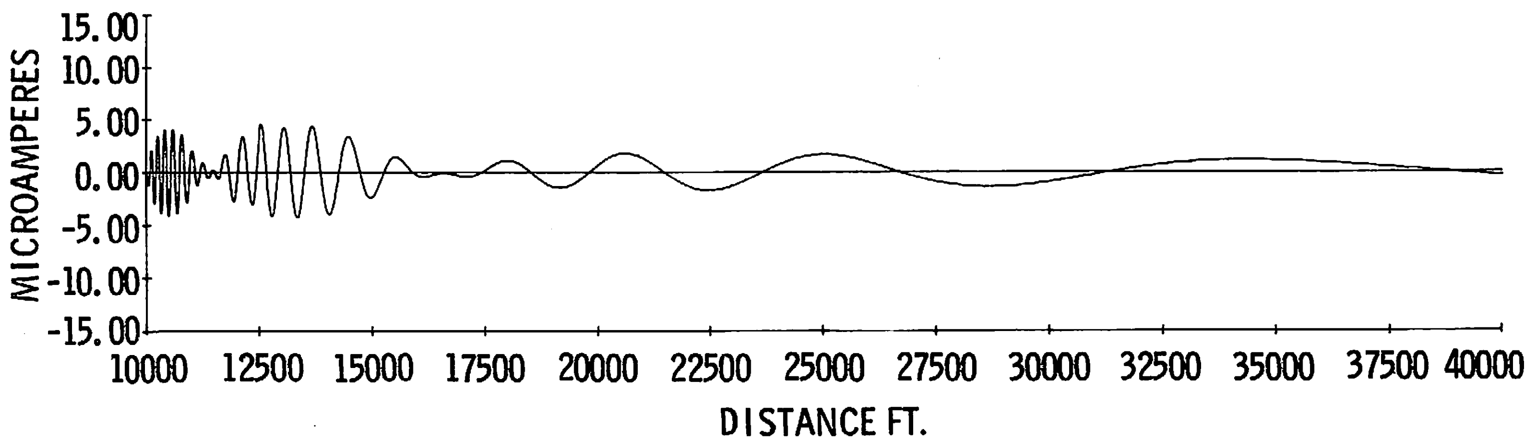
```
      Y=Y+ANC*W2
   40 CONTINUE
      BST = (CINCH - FLOAT(NCH+NEXP)*HL)/2.
      IF(W3.EQ.1.) XM = -XM
      XXC = W1*(XO + BST) + W2*(XO + XM - OFF + W3*(2.*OFF+HL))
      YYC = W1*(YO + YC - 1.5*HL + W3*(HT + 2.*HL)) + W2*(YO+BST)
      CALL SYMBOL(XXC,YYC,HL,BCD,90.*W2,NCH)
      IF(PWR.EQ.0.) RETURN
      CALL SYMBOL(999.,999.,HL,5H * 10,90.*W2,5)
      X = 999. + (XXC-.66*HL-999.)*W2
      Y = 999. + (YYC+.66*HL-999.)*W1
      CALL NUMBER(X,Y,.75*HL,PWR,90.*W2,-1)
      RETURN
   50 VSC = (VMAX-VMIN+1.E-6/FACTOR)/CINCH
      WRITE(6,1000)
 1000 FORMAT(1H0,27HINSUFFICIENT RANGE FOR AXIS )
      RETURN
      END
```

SIMULATED CERTIFICATION FLIGHT for
TEST CASE AIRPORT - GIVING
INSTANTANEOUS CDI - USING MEASURED
ALFORD ANTENNA

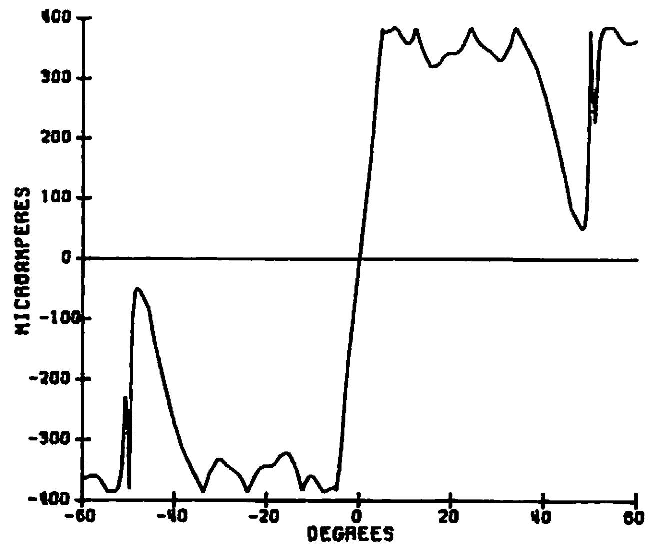


THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT

SIMULATED TEST FLIGHT SHOWING EFFECTS OF DYNAMIC SIMULATION - ASSUMED TIME CONSTANT OF 0.4 SECOND



SIMULATED CLEARANCE RUN for MEASURED PATTERN
ALFORD 14 AND 6

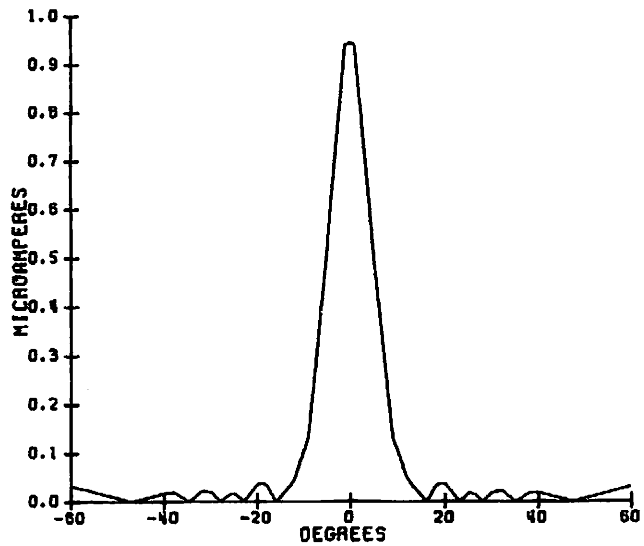


THIS IS THE CLEARANCE RUN WITHOUT SCATTERERS

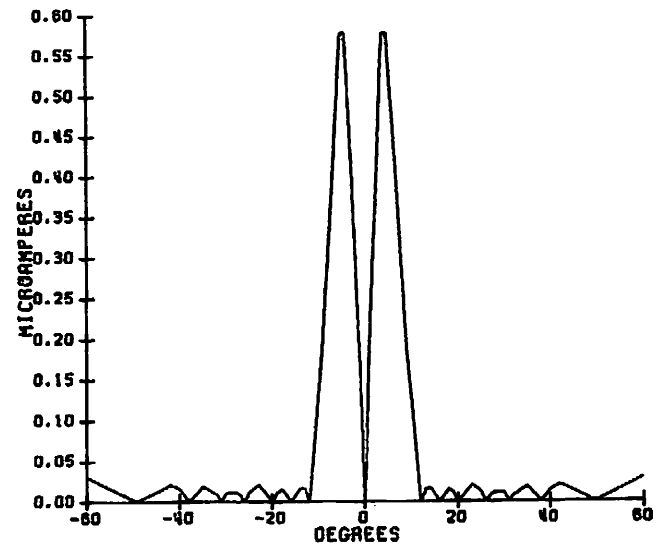
MEASURED ANTENNA PATTERN -
CARRIER and SIDEBAND for
ALFORD 14, SCALE in
RELATIVE UNITS

SIDEBAND ONLY for ALFORD 14

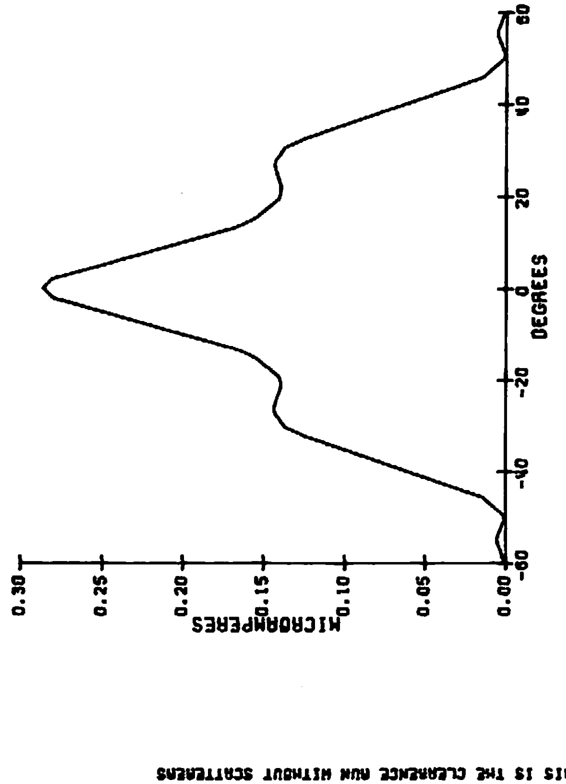
THIS IS THE CLEARANCE RUN WITHOUT SCATTERERS



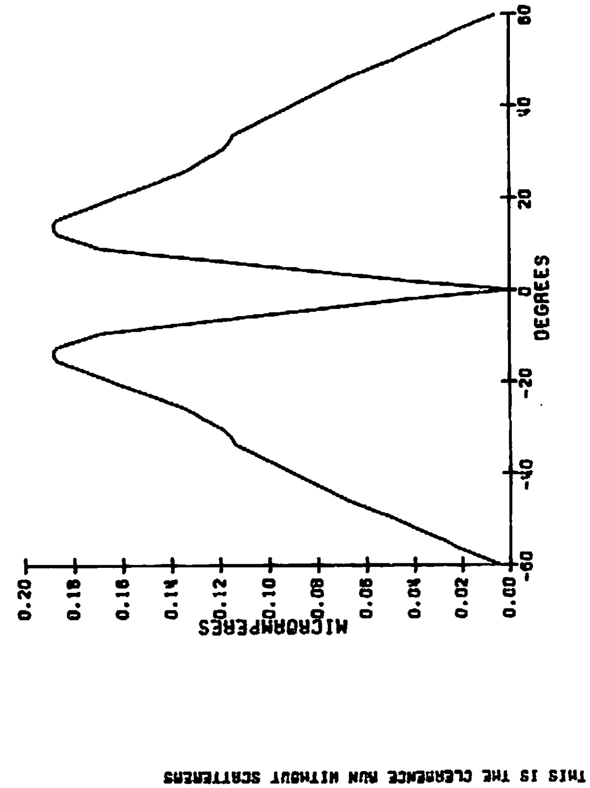
THIS IS THE CLEARANCE RUN WITHOUT SCATTERERS



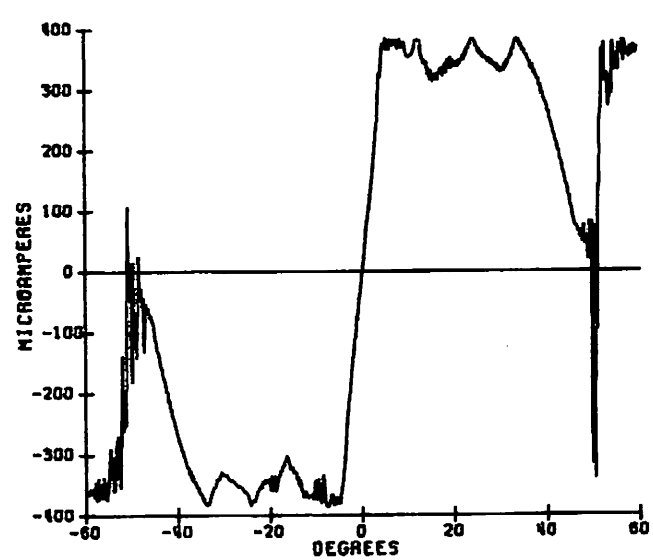
MEASURED ANTENNA PATTERN -
CARRIER and SIDEBAND for
ALFORD 6, SCALE in RELATIVE
UNITS



SIDEBAND ONLY for ALFORD 6



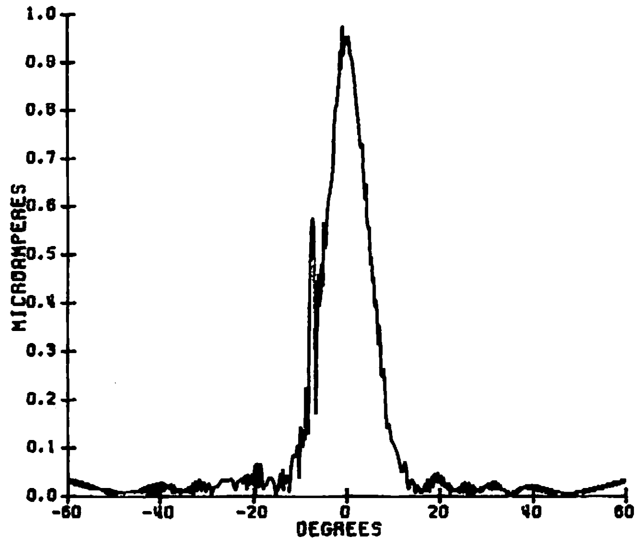
SIMULATED CLEARANCE RUN for TEST CASE AIRPORT SHOWING EFFECT of SCATTERERS ON CDI



This is Orbit Case with Scatterers

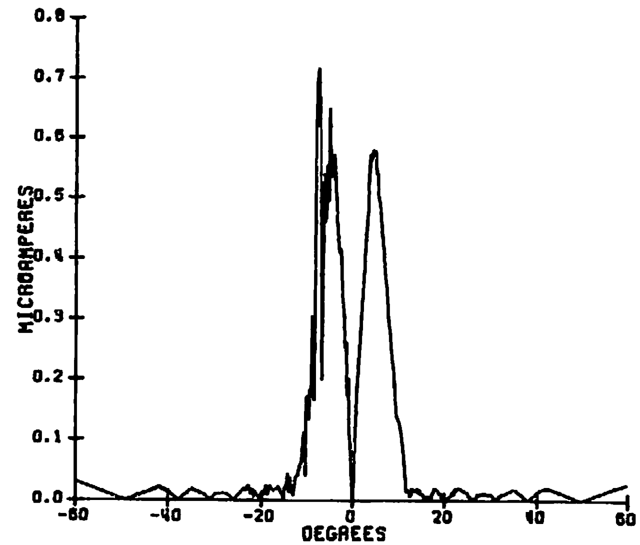
MEASURED ANTENNA PATTERN CARRIER
and SIDEBAND for ALFORD 14
SHOWING SCATTERERS, SCALE IN
RELATIVE UNITS

This is Orbit Case with Scatterers



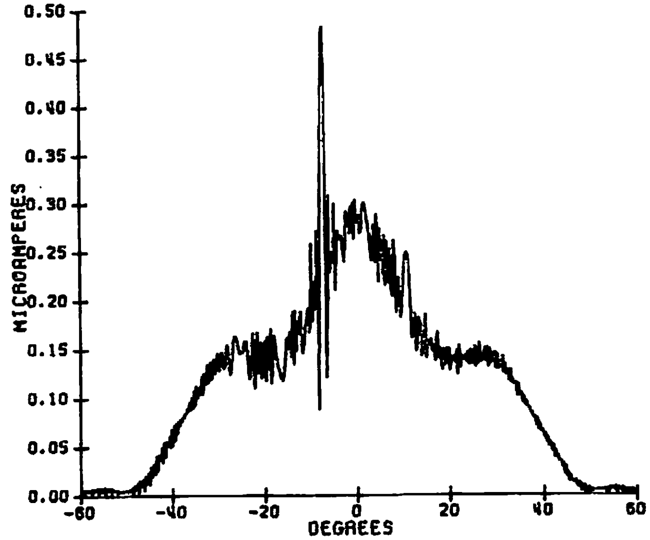
SIDEBAND ONLY - WITH SCATTERERS
for ALFORD 14

This is Orbit Case with Scatterers



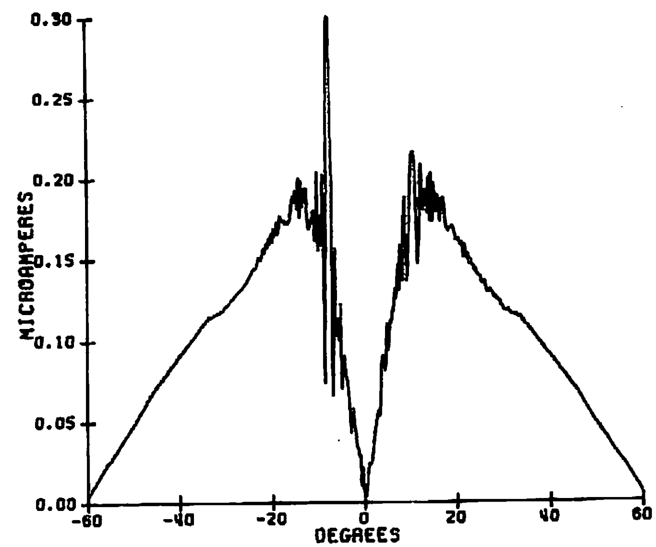
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND ONLY for ALFORD 6 SHOWING SCATTERERS, SCALE IN RELATIVE UNITS

This is Orbit Case with Scatterers



SIDEBAND ONLY SHOWING SCATTERERS for ALFORD 6

This is Orbit Case with Scatterers



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