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AgRISTARS

SM-L1-04091
JSC-17296

NASA-CR-161058

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**A Joint Program for
Agriculture and
Resources Inventory
Surveys Through
Aerospace
Remote Sensing**

Soil Moisture

June 1981

GROUND REGISTRATION OF DATA FROM AN AIRBORNE SCATTEROMETER

E82-1008
CR-161058

John C. Richter

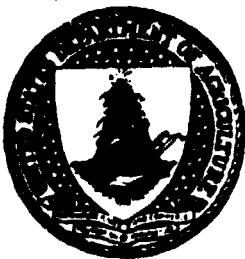
(E82-10084) GROUND REGISTRATION OF DATA
FROM AN AIRBORNE SCATTEROMETER (Lockheed
Engineering and Management) 27 p
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Lockheed Engineering and Management Services Company, Inc.
1830 NASA Road 1, Houston, Texas 77058



**Lyndon B. Johnson Space Center
Houston, Texas 77058**

SM-L1-04091
JSC-17296

GROUND REGISTRATION OF DATA FROM
AN AIRBORNE SCATTEROMETER

Job Order 71-323

This report describes activities of the Soil Moisture project
of the AgRISTARS program.

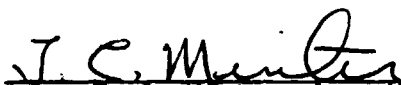
PREPARED BY

John C. Richter

APPROVED BY



J. G. Carnes, Supervisor
Agricultural Technology Section



T. C. Mintzer, Jr., Manager
Development and Evaluation Department

LOCKHEED ENGINEERING AND MANAGEMENT SERVICES COMPANY, INC.

Under Contract NAS 9-15800

For

Earth Resources Research Division
Space and Life Sciences Directorate
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

June 1981

LEMSCO-16340

PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is an 8-year program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources, which began in fiscal year 1980. This program is a cooperative effort of the National Aeronautics and Space Administration; the U.S. Agency for International Development; and the U.S. Departments of Agriculture, Commerce, and the Interior.

The work which is the subject of this document was performed within the Earth Resources Research Division, Space and Life Sciences Directorate, at the Lyndon B. Johnson Space Center, National Aeronautics and Space Administration. Under Contract NAS 9-15800, personnel of Lockheed Engineering and Management Services Company, Inc., performed the tasks which contributed to the completion of this research.

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CONTENTS

Section	Page
1. INTRODUCTION.....	1
2. REQUIRED INPUT DATA.....	1
3. PROGRAM EXPLANATION.....	6
3.1 <u>SCAT</u>	6
3.2 <u>PLOT</u>	8
3.3 <u>GRID</u>	10
Appendix	
PROGRAM LISTINGS AND EXECUTE FILES.....	A-1

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FIGURES

Figure		Page
1	Bottom view of the NASA C-130 aircraft.....	2
2	A sample listing of the file containing the aircraft flight parameters.....	4
3	A sample listing of the file containing the scatterometer data.....	5
4	A sample plot illustrating how and where to measure the variables AMISS and YUP.	7
5	A portion of the plot depicting the aircraft's ground track.....	9
6	Illustration of the plot of the aircraft's ground track with overlays indicating the photographic position and field boundaries.....	11
A-1	Computer listing for program SCAT.....	A-2
A-2	Execute file for program SCAT.....	A-5
A-3	Computer listing for program PLOT.....	A-6
A-4	Computer listing for program GRID.....	A-7
A-5	Execute file for program GRID.....	A-9

1. INTRODUCTION

Radar scatterometer measurements were taken by the National Aeronautics and Space Administration (NASA) C-130 aircraft at 1500 feet above ground level as part of the Agricultural Soil Moisture Experiment (ASME) near Colby, Kansas, on July 18, 20, 21, and 22 and on August 8, 9, and 11, 1978. These data are a measure of the efficiency of surface backscattering as seen from the sensor. Four radar scatterometers were mounted on the aircraft: 0.4, 1.6, 4.75, and 13.3 GHz. Their location on the aircraft is illustrated in figure 1. Each sensor collected data by looking aft with incidence angles between 5° and 50°. All angles were sensed simultaneously.

Soil samples from several layers were collected from preselected fields of approximately 40 acres on each of the 7 flight days. These samples were weighed, oven dried, and weighed again so that the moisture content of the layers could be calculated. They will be used for comparison with the scatterometer data.

The purpose of this report is to document a method of converting the scatterometer computer-compatible tape (CCT) data into disk files, wherein each file contains the date, the scatterometer data, and the ground reference position of the data within the sampled field. This conversion is accomplished by executing three programs on the National Advanced Systems AS/3000 computer, located in the Earth Observations Division Laboratory (EODL) in Building 17 at the NASA Lyndon B. Johnson Space Center (JSC). A listing and discussion of each program are given in this document.

2. REQUIRED INPUT DATA

As the plane flew down the flight line, the scatterometer data were recorded on tape in analog form. The tapes were sent to the Sensor Analysis Laboratory (SAL) in JSC Building 15. At the SAL, the analog data were subjected to a Doppler frequency shift filtering which separated the data by incidence angle. Then, the data were digitized and manipulated so that all incidence angles representing approximately the same target area were grouped together.

2

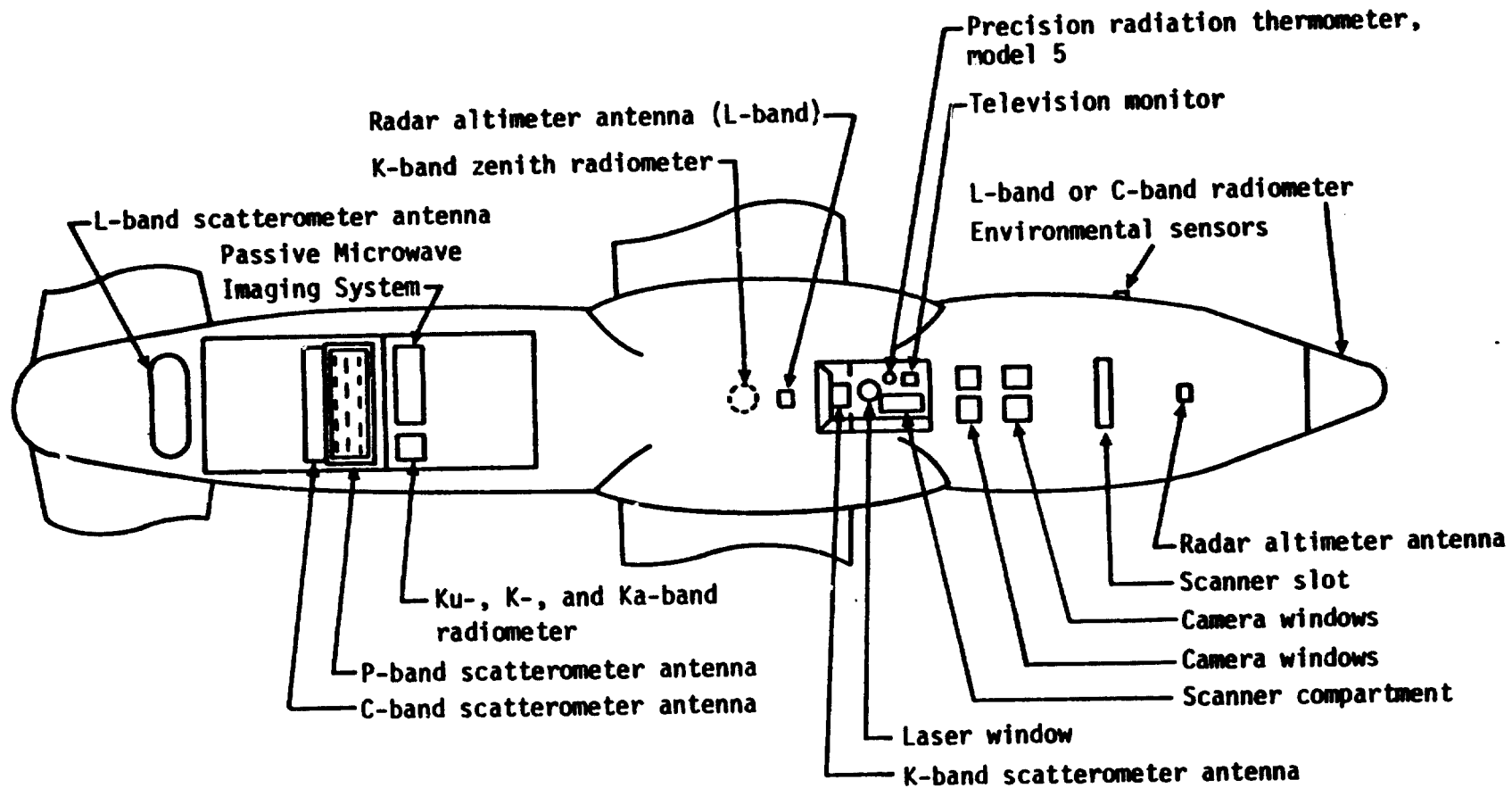


Figure 1.- Bottom view of the NASA C-130 aircraft.

In the case of the Colby ASME, the output CCT's from the SAL contain four files for each sensor on each run over a flight line. Only files 1 and 4 are required by the programs described in this document. The two files containing sensor calibration and bandwidth information (files 2 and 3, respectively) are not used.

File 1 contains the aircraft's flight parameters. Each record in the file contains the roll angle, pitch angle, drift angle, altitude, ground speed, and true heading angle of the aircraft referenced by the Auxiliary Data Annotation System (ADAS) time of measurement. New aircraft flight parameters were measured approximately every six-tenths of a second. A listing of a sample file is shown in figure 2.

File 4 on the CCT contains the scatterometer data. Figure 3 is a sample listing of this file. Each record in the file contains the backscatter coefficients, in decibels, for approximately the same area as viewed from 10 different incidence angles. They are referenced by the ADAS time when the aircraft passed over or closest to the target area. If the drift angle is nonzero, the areas viewed at various angles are unregistered and decorrelated.

A great deal of aerial photography was collected at the Colby test site. Photographs taken at an altitude of 8000 feet were used to construct controlled strip mosaics of each flight line. Additional aerial photography was acquired as the aircraft collected scatterometer data at altitudes of 1000 and 1500 feet. The acquisition time and the frame number of every photograph were recorded on the analog data system. This made it possible to determine the aircraft's position at the frame times. The camera positions and frame numbers were plotted on transparent overlays by the JSC Cartographic Technology Laboratory. Additional overlays were made showing the location of the sampled fields in each flight line. All overlays were made at the same scale as the strip mosaics.

SCATTERMETER 13-3 MISSION 303 FLT 0 SITE 76 LINE 4 RUN 5 FLIGHT DATE: 7/21/78 POLARIZATION VV
 PRN: 052731

GMT TIME	ROLL	PITCH	DRIFT	ALTITUDE	GROUND SPEED	HEADING
0.00	0.10	2.20	1.70	900.00	44.00	771.80
0.10	0.10	2.00	1.10	900.00	44.00	771.90
0.20	0.10	2.00	0.00	910.00	44.30	770.60
0.30	0.10	2.00	0.00	910.00	44.00	770.60
0.40	0.10	2.00	0.00	910.00	44.00	770.60
0.50	0.10	2.00	0.00	910.00	44.00	770.60
0.60	0.10	2.00	0.00	910.00	44.00	770.60
0.70	0.10	2.00	0.00	910.00	44.00	770.60
0.80	0.10	2.00	0.00	910.00	44.00	770.60
0.90	0.10	2.00	0.00	910.00	44.00	770.60
1.00	0.10	2.00	0.00	910.00	44.00	770.60
1.10	0.10	2.00	0.00	910.00	44.00	770.60
1.20	0.10	2.00	0.00	910.00	44.00	770.60
1.30	0.10	2.00	0.00	910.00	44.00	770.60
1.40	0.10	2.00	0.00	910.00	44.00	770.60
1.50	0.10	2.00	0.00	910.00	44.00	770.60
1.60	0.10	2.00	0.00	910.00	44.00	770.60
1.70	0.10	2.00	0.00	910.00	44.00	770.60
1.80	0.10	2.00	0.00	910.00	44.00	770.60
1.90	0.10	2.00	0.00	910.00	44.00	770.60
2.00	0.10	2.00	0.00	910.00	44.00	770.60
2.10	0.10	2.00	0.00	910.00	44.00	770.60
2.20	0.10	2.00	0.00	910.00	44.00	770.60
2.30	0.10	2.00	0.00	910.00	44.00	770.60
2.40	0.10	2.00	0.00	910.00	44.00	770.60
2.50	0.10	2.00	0.00	910.00	44.00	770.60
2.60	0.10	2.00	0.00	910.00	44.00	770.60
2.70	0.10	2.00	0.00	910.00	44.00	770.60
2.80	0.10	2.00	0.00	910.00	44.00	770.60
2.90	0.10	2.00	0.00	910.00	44.00	770.60
3.00	0.10	2.00	0.00	910.00	44.00	770.60
3.10	0.10	2.00	0.00	910.00	44.00	770.60
3.20	0.10	2.00	0.00	910.00	44.00	770.60
3.30	0.10	2.00	0.00	910.00	44.00	770.60
3.40	0.10	2.00	0.00	910.00	44.00	770.60
3.50	0.10	2.00	0.00	910.00	44.00	770.60
3.60	0.10	2.00	0.00	910.00	44.00	770.60
3.70	0.10	2.00	0.00	910.00	44.00	770.60
3.80	0.10	2.00	0.00	910.00	44.00	770.60
3.90	0.10	2.00	0.00	910.00	44.00	770.60
4.00	0.10	2.00	0.00	910.00	44.00	770.60
4.10	0.10	2.00	0.00	910.00	44.00	770.60
4.20	0.10	2.00	0.00	910.00	44.00	770.60
4.30	0.10	2.00	0.00	910.00	44.00	770.60
4.40	0.10	2.00	0.00	910.00	44.00	770.60
4.50	0.10	2.00	0.00	910.00	44.00	770.60
4.60	0.10	2.00	0.00	910.00	44.00	770.60
4.70	0.10	2.00	0.00	910.00	44.00	770.60
4.80	0.10	2.00	0.00	910.00	44.00	770.60
4.90	0.10	2.00	0.00	910.00	44.00	770.60
5.00	0.10	2.00	0.00	910.00	44.00	770.60
5.10	0.10	2.00	0.00	910.00	44.00	770.60
5.20	0.10	2.00	0.00	910.00	44.00	770.60
5.30	0.10	2.00	0.00	910.00	44.00	770.60
5.40	0.10	2.00	0.00	910.00	44.00	770.60
5.50	0.10	2.00	0.00	910.00	44.00	770.60
5.60	0.10	2.00	0.00	910.00	44.00	770.60
5.70	0.10	2.00	0.00	910.00	44.00	770.60
5.80	0.10	2.00	0.00	910.00	44.00	770.60
5.90	0.10	2.00	0.00	910.00	44.00	770.60
6.00	0.10	2.00	0.00	910.00	44.00	770.60
6.10	0.10	2.00	0.00	910.00	44.00	770.60
6.20	0.10	2.00	0.00	910.00	44.00	770.60
6.30	0.10	2.00	0.00	910.00	44.00	770.60
6.40	0.10	2.00	0.00	910.00	44.00	770.60
6.50	0.10	2.00	0.00	910.00	44.00	770.60
6.60	0.10	2.00	0.00	910.00	44.00	770.60
6.70	0.10	2.00	0.00	910.00	44.00	770.60
6.80	0.10	2.00	0.00	910.00	44.00	770.60
6.90	0.10	2.00	0.00	910.00	44.00	770.60
7.00	0.10	2.00	0.00	910.00	44.00	770.60
7.10	0.10	2.00	0.00	910.00	44.00	770.60
7.20	0.10	2.00	0.00	910.00	44.00	770.60
7.30	0.10	2.00	0.00	910.00	44.00	770.60
7.40	0.10	2.00	0.00	910.00	44.00	770.60
7.50	0.10	2.00	0.00	910.00	44.00	770.60
7.60	0.10	2.00	0.00	910.00	44.00	770.60
7.70	0.10	2.00	0.00	910.00	44.00	770.60
7.80	0.10	2.00	0.00	910.00	44.00	770.60
7.90	0.10	2.00	0.00	910.00	44.00	770.60
8.00	0.10	2.00	0.00	910.00	44.00	770.60
8.10	0.10	2.00	0.00	910.00	44.00	770.60
8.20	0.10	2.00	0.00	910.00	44.00	770.60
8.30	0.10	2.00	0.00	910.00	44.00	770.60
8.40	0.10	2.00	0.00	910.00	44.00	770.60
8.50	0.10	2.00	0.00	910.00	44.00	770.60
8.60	0.10	2.00	0.00	910.00	44.00	770.60
8.70	0.10	2.00	0.00	910.00	44.00	770.60
8.80	0.10	2.00	0.00	910.00	44.00	770.60
8.90	0.10	2.00	0.00	910.00	44.00	770.60
9.00	0.10	2.00	0.00	910.00	44.00	770.60

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Figure 2.- A sample listing of the file containing the aircraft's flight parameters.

3. PROGRAM EXPLANATION

3.1 SCAT

The first program used to process the scatterometer data is a Fortran program called SCAT. A listing of the program and its execute file are given in the appendix. This program reads files 1 and 4 after they have been transferred from the CCT to a disk. The program uses these data to compute the intersection of the aircraft's negative z-axis with the ground in a scene-based coordinate system.

Three inputs from the terminal are requested by the program. The first input, AMISS, is the northward distance (in feet) of the plane from the southern field boundaries, if the flight line runs east-west, or westward from the eastern field boundaries for north-south flight lines, at the beginning of the flight line. The second input, YUP, is the crosstrack distance (in feet) that the airplane's position is from the reference field boundary at the end of the flight line. Figure 4 is a diagram of a flight line and shows the distances represented by AMISS and YUP. Both distances are measured (in millimeters) with the overlay on the strip mosaic. The final input requested is called CODE. It is a three-symbol numeric identifier for the day, sensor, and polarization of the data. The codes used for the Colby ASME are shown in table 1.

Program SCAT creates two output files. One file contains the downtrack and crosstrack locations of the airplane at each time that aircraft flight parameters were available. The second output file contains the scatterometer data and the location of the aircraft's negative z-axis intersection with the ground with respect to the beginning of the flight line. The file also contains the distance (in feet) of footprint decorrelation caused by aircraft drift. This distance represents the difference in crosstrack location of the 5° and 50° sensor footprints.

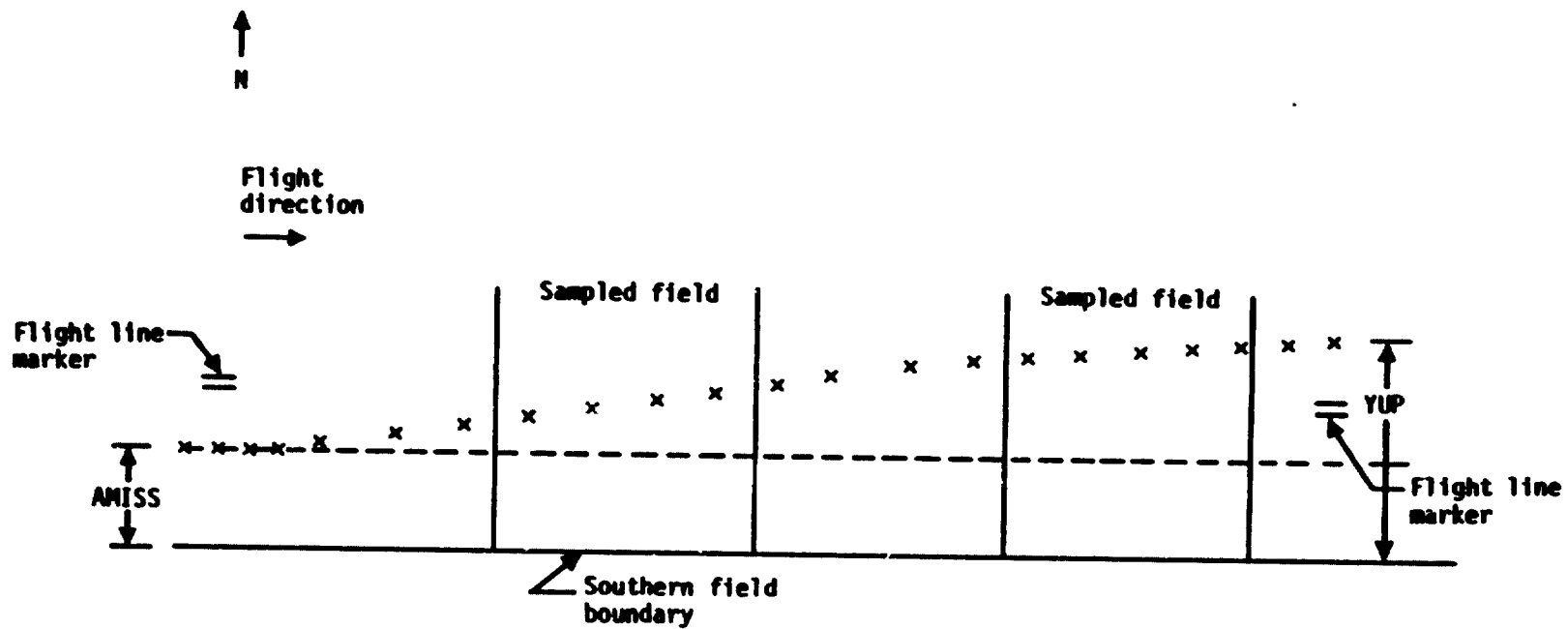


Figure 4.- A sample plot illustrating how and where to measure the variables AMISS and YUP.

TABLE 1.- CODES FOR THE COLBY SCATTEROMETER DATA

Code	Day, 1978	Sensor, GHz	Polarization ^a
1	199 - 7/18	13.3	VV
2	201 - 7/20	4.75	VH
3	202 - 7/21	1.6	HV
4	203 - 7/22	0.4	HH
5	220 - 8/08		
6	221 - 8/09		
7	223 - 8/11		

^aVV = vertical transmit and vertical receive,
 VH = vertical transmit and horizontal receive,
 HV = horizontal transmit and vertical receive, and
 HH = horizontal transmit and horizontal receive.

3.2 PLOT

The second program, PLOT, is a Statistical Analysis System (SAS) program. This program reads the two files output by program SCAT and produces a printer plot of the aircraft's ground track along with the corresponding 20° scatterometer data. The plot is at the same scale as the strip mosaics. The 20° incidence angle was chosen because it was judged to be most responsive to row direction effects. The advantage of this will be explained later in this paper. A portion of the plot is shown in figure 5, and a program listing is given in the appendix. At this point in the analysis, the scatterometer data are referenced by the distance (in feet) down track and the distance from the southern or eastern field boundaries, depending upon the direction of the flight line. It is necessary to know the ground reference position of the data within the sampled fields. This is accomplished by using the overlays in conjunction with the plot. Both overlays, one with photographic position and the other with field boundaries, are placed on the plot in the following manner. First, a time is found when the aircraft's flight parameters are available and when an aerial photograph was taken. The time represented by each asterisk in the flight path plot can be found by using the exclamation points plotted along side. The exclamation points are time marks when the aircraft clock was at the

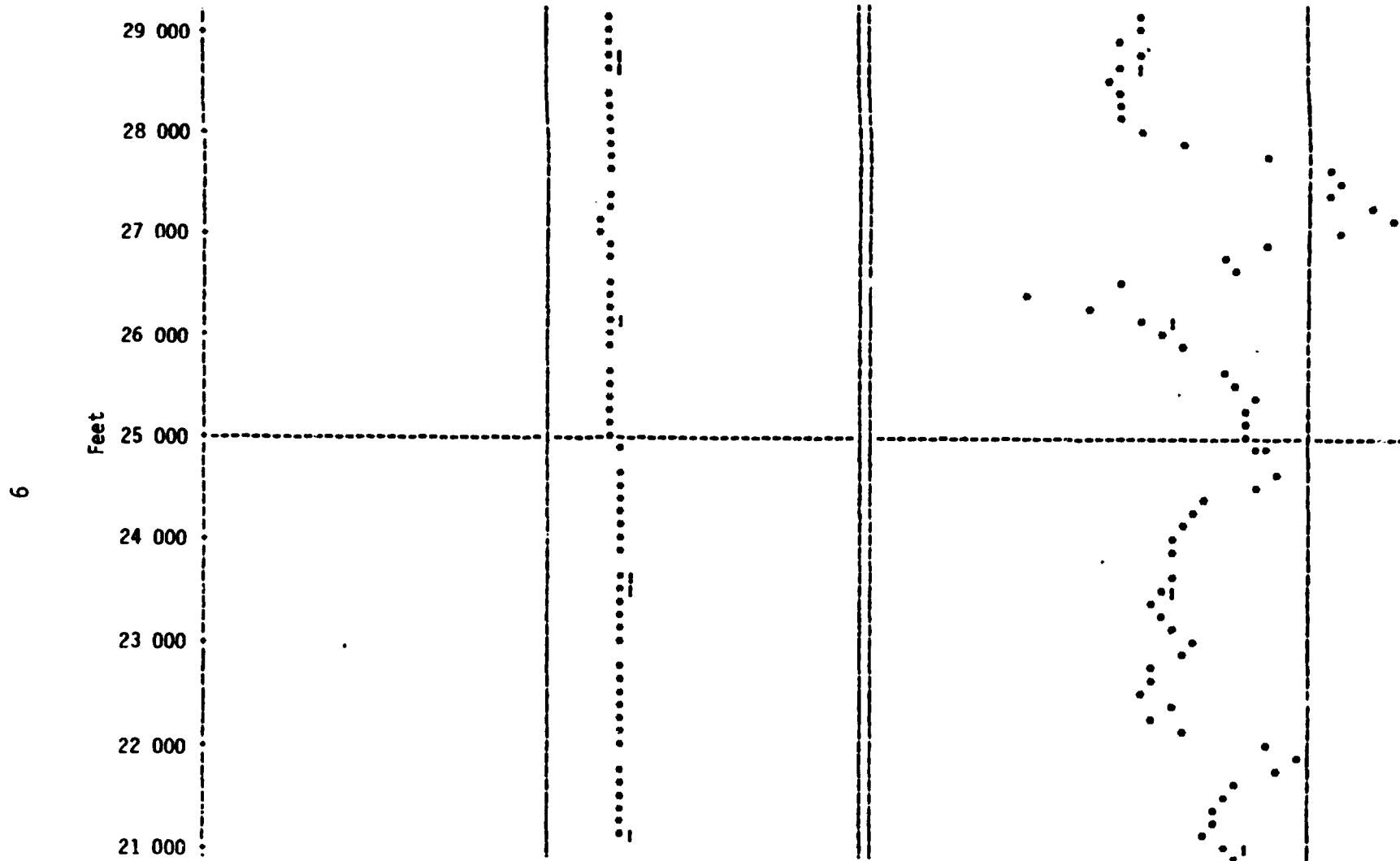


Figure 5.- A portion of the plot depicting the aircraft's ground track.

minute or a multiple of 10 seconds after the minute. Next, the overlays are placed on the plot so that the photographic position from the overlay is on top of the asterisk representing the same time. The solid line paralleling the plot of the flight path should be even with the southern field boundaries for an east-west flight or with the eastern field boundaries for a north-south flight. Figure 6 is an illustration of the plot with the overlays in place. The downtrack distance (in feet) of each field's closest boundary to the beginning of the flight line is read from the plot. These distances, along with the dimensions of the corresponding fields, are written in a separate file. This file is used as an input to the next program.

When the procedure is carried out in the manner described above, a discrepancy may become apparent. If the overlay and plot were registered at an extreme end of the flight line, the overlay and plot positions will not necessarily correspond at the opposite end. This is due to a lack of sufficient accuracy in recording the airplane's flight parameters. Therefore, it is recommended that the overlay and plot be registered at several points along the flight line. The plot of the 20° scatterometer values is useful for a final, small adjustment in the alongtrack direction.

The row direction of the fields can be determined from the aerial photography. Since the 20° scatterometer angle is highly responsive to row direction effects, knowledge of how the row direction changes from field to field can aid in determining exactly which points fall in the sampled field.

3.3 GRID

The GRID program reads in the boundary data file, along with the file containing the scatterometer data that was created by program SCAT. A listing of this Fortran program and its execute file are given in the appendix. A separate output file is generated for each sampled field within the flight line. Each record in the file contains the distance (in feet) from the 30° footprint to the northern and the western field boundaries, along with the corresponding scatterometer data and decorrelation distance. The output files can then be combined in the manner which best suits the analysis techniques that will be used.

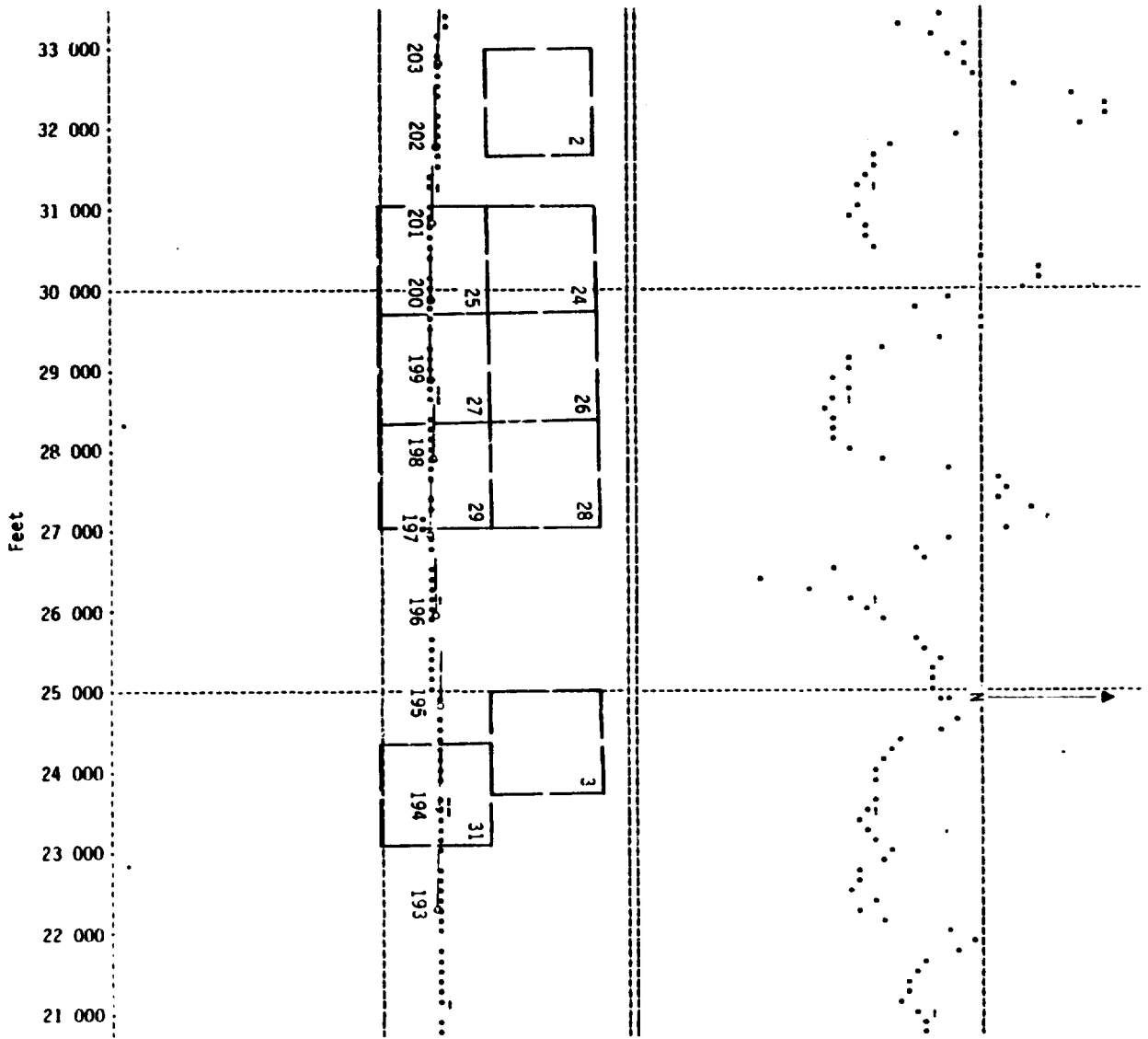


Figure 6.- Illustration of the plot of the aircraft's ground track with overlays indicating the photographic position and field boundaries.

APPENDIX
PROGRAM LISTINGS AND EXECUTE FILES

APPENDIX

PROGRAM LISTINGS AND EXECUTE FILES

A listing for program SCAT and its execute file are provided in figures A-1 and A-2, respectively. The listing for program PLOT is given in figure A-3. Figures A-4 and A-5 are respectively the listing and execute file for program GRID.


```

C
106 READ(10,106)F1,F2,ILINE,IRUN,IDAY,POLAR
      FORMAT(T17,A4,A2,T65,I2,T72,I2,T90,I2,T110,A2)
      IF(IILINE.EQ.1)CHGSN=-1.0
      IF(IILINE.EQ.4)CHGSN=-1.0
      IF(IILINE.EQ.5)CHGSN=-1.0
DO 15 M=1,2
105 READ(10,105)DUMMY
      FORMAT(A4)
      IFLAG=0
DO 1 I=1,510
      READ(10,101,END=201)ET,IMIN,SEC,ROLL,PITCH,DRIFT(I),ALT,SPEED(I),
6 HEAD
101 6 FORMAT(T2,F5.2,T12,I2,T15,F4.1,T26,F6.2,T36,F6.2,T46,F6.2,
      T55,F7.2,T66,F6.2,T76,F6.2)
      MIN=FLOAT(IMIN)
      ACSEC(I)=(MIN*60.0)*SEC
      DTOR=(ROLL*3.141593)/180.0
      YOFF(I)=ALT*TAN(DTOR)
      NUMBAC=I-1
      IMIN=IMIN*1000
      ISEC=IFIX(SEC*10.0)
      ITIME(I)=IMIN*ISEC
      SPEED(I)=SPEED(I)*1.6878
      IF(HEAD.LT.40.0)HEAD=HEAD+360.0
      ICHK=ITIME(I)-ITIME(I-1)
      IF(ICHK.GT.30)IFLAG=1
      IF(ICHK.LT.-50000)IFLAG=2
      IF(IFLAG.EQ.1)ITIME(I)=ITIME(I)-400
      IF(IFLAG.EQ.2)ITIME(I)=ITIME(I)+60000
      IF(IFLAG.EQ.2)ACSEC(I)=ACSEC(I)+3600.0
1  TRACK(I)=DRIFT(I)+HEAD
201 CONTINUE
      YUP=YUP/(ET*SPEED(NUMBAC))
      NN=NUMBAC+1
C
C THESE STATEMENTS COMPUTE THE AVERAGE FLIGHT DIRECTION
      NN=FLOAT(NN)
DO 14 K=1,NN
14 HTOT=HTOT+TRACK(K)
      HAVG=HTOT/ANN
C
C THIS SECTION COMPUTES THE LOCATION OF THE AIRCRAFT
DO 11 I=1,NUMBAC
      TOTD=0.0
DO 18 KJ=1,10
      JJ=KJ+I-1
18 TOTD=TOTD+DRIFT(JJ)
      AVGD=((TOTD/10.0)*3.141593)/180.0
      DECURR(I)=(TAN(AVGD)*1350.0)*CHGSN
      ELPTME=FLOAT(ITIME(I+1)-ITIME(I))/10.0
      ANGLE=((HAVG-TRACK(I))*3.141593)/180.0
      DISP=ELPTME*SPEED(I)
      XDISP=DISP*COS(ANGLE)
      YDISP=DISP*SIN(ANGLE)*CHGSN
      L=I+1
      IF(L.EQ.1)GO TO 12
      YDIFF=(YOFF(I)-YOFF(I-1))*CHGSN
      TOTX(L)=TOTX(L-1)+XDISP
      TOTY(L)=TOTY(L-1)+YDISP+YDIFF+(YUP*TOTX(L)-YUP*TOTX(L-1))
      GO TO 11
12 TOTX(L)=XDISP
      TOTY(L)=YDISP+YOFF(I)*AMISS
11 CONTINUE
C
C THIS SECTION DETERMINES WHICH AIRCRAFT DATA IS AT 10 SECONDS
DO 9 I=2,NUMBAC
      L=I-1
      ITEN(I)=0.0
      ITEMP=ITIME(I)/100
      IDIFF=ITIME(I)-(ITEMP*100)
      IF(IDIFF.LE.3)ITEN(I)=TOTY(L)+100.0
      IF(IDIFF.GT.96)ITEN(I)=TOTY(L)+100.0
9 CONTINUE
C
C THIS SECTION READS IN THE SIGMA ZERO'S

```

CA00800
CA00810
CA00820
CA00830
CA00840
CA00850
CA00860
CA00870
CA00880
CA00890
CA00900
CA00910
CA00920
CA00930
CA00940
CA00950
CA00960
CA00970
CA00980
CA00990
CA01000
CA01010
CA01020
CA01030
CA01040
CA01050
CA01060
CA01070
CA01080
CA01090
CA01100
CA01110
CA01120
CA01130
CA01140
CA01150
CA01160
CA01170
CA01180
CA01190
CA01200
CA01210
CA01220
CA01230
CA01240
CA01250
CA01260
CA01270
CA01280
CA01290
CA01300
CA01310
CA01320
CA01330
CA01340
CA01350
CA01360
CA01370
CA01380
CA01390
CA01400
CA01410
CA01420
CA01430
CA01440
CA01450
CA01460
CA01470
CA01480
CA01490
CA01500
CA01510
CA01520
CA01530
CA01540
CA01550
CA01560
CA01570
CA01580

Figure A-1.- Continued.

FILE: SCAT FORTRAN A

CONVERSATIONAL MONITOR SYSTEM

```

C
16 DO 16 M=1,3
107 READ(11,107) DUMMY
      FORMAT(A4)
      KFLAG=0
      DO 2 K=1,510
102 READ(11,102,END=202) KMIN,SEC,(SIGZ(M),M=1,10)
      FORMAT(1S,12,78,F4.1,T16,10F11.5)
17 DO 17 N=1,10
      ISIGZ(K,N)=IFIX(SIGZ(N)*10.0)
      NUMBSO=K
      MIN=FLOAT(KMIN)
      SCATS(K)=(MIN*60.0)+SEC
      KMIN=KMIN*1000
      KSEC=IFIX(SEC*10.0)
      KTIME(K)=KMIN+KSEC
      KC=K-KTIME(I)-KTIME(I-1)
      IF(KCHK.GT.30) KFLAG=1
      IF(KCHK.LT.-50000) KFLAG=2
      IF(KFLAG.EQ.1) KTIME(K)=KTIME(K)-400
      IF(KFLAG.EQ.2) KTIME(K)=KTIME(K)+60000
      IF(KFLAG.EQ.2) SCATS(K)=SCATS(K)+3600.0
2 CONTINUE
202 CONTINUE

C
C THESE STATEMENTS COMPUTE WHICH SCATTEROMETER DATA IS AT 10 SECONDS
C
DO 9 K=1,NUMBSO
  KTEN(K)=0.0
  KTEMP=KTIME(K)/100
  KDIFF=KTIME(K)-(KTEMP*100)
  MM=ISIGZ(K,4)
  IF(KDIFF.LE.3) KTEN(K)=FLOAT(MM)/10.0+0.5
  IF(KDIFF.GT.96) KTEN(K)=FLOAT(MM)/10.0+0.5
  IF(KTEN(K).GT.5.0) KTEN(K)=KTEN(K)-1.0
9 CONTINUE

C
C THESE STATEMENTS FIND DOWNTRACK LOCATION OF THE SIGMA ZERO'S
C
I=1
DO 3 K=1,NUMBSO
  SCATY(K)=0.0
  SCATX(K)=0.0
32 IF (SCATS(K).LT.ACSEC(I)) GO TO 3
   IF (SCATS(K).LT.ACSEC(I+1)) GO TO 33
   I=I+1
   IF (I.GT.NUMBAC) GO TO 203
   GO TO 32
33 RANGE1=ACSEC(I+1)-ACSEC(I)
   RANGE2=SCATS(K)-ACSEC(I)
   RATIO=RANGE2/RANGE1
   L=I+1
   IF (I.FO.1) GO TO 13
   ALOFF=TOTX(L)-TOTX(L-1)
   YYOFF=TOTY(L)-TOTY(L-1)
   DCOFF=DECORR(L)-DECORR(L-1)
   SCATY(K)=(YYOFF*RATIO)+TOTY(L-1)
   SCATX(K)=(ALOFF*RATIO)+TOTX(L-1)
   SMEAR(K)=(DCOFF*RATIO)+DECORR(L-1)
   GO TO 3
13 SCATX(K)=TOTX(L)*RATIO
3 CONTINUE

C
C THESE STATEMENTS WRITE OUT THE FILES TO DISK
C
203 CONTINUE
DO 4 I=1,NUMBAC
4 WRITE(12,103) TOTX(I),TOTY(I),ITEN(I)
103 FORMAT(' ',3F10.2)
DO 5 K=1,NUMBSO
5 WRITE(13,104) C1,C2,C3,ILINE,IRUN,SMEAR(K),SCATX(K),SCATY(K),
1 KTEN(K),(ISIGZ(K,ML),ML=1,10)
104 FORMAT(' ',3I1,1X,11,'/',11,1X,F4.0,1X,F6.0,1X,F5.0,
1 1X,F4.0,1X,1014)
STOP
END

```

Figure A-1.- Concluded.

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OF POOR QUALITY

ORIGINAL PAGE IS

FILE: SCAT EXEC A

CONVERSATIONAL MONITOR SYSTEM

```
GLOBAL TXTLIR CMSLIB FORTMOD2
FILEDEF 5 READER (PERM
FILEDEF 6 DISK SCAT LISTING D (PERM RECFM F
FILEDEF 7 PUNCH (PERM
FILEDEF 10 DISK 61 PDATA1 D (PERM RECFM F LRECL 132 BLKSIZE 132
FILEDEF 11 DISK 61 PDATA4 D (PERM RECFM F LRECL 132 BLKSIZE 132
FILEDEF 12 DISK 61 YDATA1 D (PERM RECFM F LRECL 80
FILEDEF 13 DISK 61 YDATA4 D (PERM RECFM F LRECL 80
FILEDEF 15 TERMINAL (PERM
FILEDEF 16 TERMINAL (PERM
LOAD SCAT
START
```

Figure A-2.- Execute file for program SCAT.

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OF POOR QUALITY

FILE: PLOT

SAS A

CONVERSATIONAL MONITOR SYSTEM

```

CMS FILEDEF FILE1 DISK FILE1 YDATA1 D;
CMS FILEDEF FILE4 DISK FILE4 YDATA4 D;
DATA PART1 PART2;
  INFILE FILE1;
  INPUT X Y TIC;
  IF TIC = 0.0 THEN TIC=.1;
  YTIC=1.0*TIC;
  IF X LE 40000 THEN OUTPUT PART1;
  IF X GE 20000 THEN OUTPUT PART2;
DATA PART3 PART4;
  INFILE FILE4;
  INPUT #15 X 6.0 #28 TTIC 4.0 #45 YI 4.1;
  AA=((YI+10.0)/3.0)*1000.0;
  IF TTIC = 0.0 THEN TTIC=.1;
  Y2=AA+4000.0;
  YYTIC=TTIC+10;
  YTIC2=(YYTIC/3.0)*1000.0+4000.0;
  DROP YYTIC AA;
  IF X LE 40000 THEN OUTPUT PART3;
  IF X GE 20000 THEN OUTPUT PART4;
DATA PLOT1;
  MERGE PART1 PART3;
  BY X;
DATA PLOT2;
  MERGE PART2 PART4;
  BY X;
PROC PLOT DATA=PLOT1;
  PLOT X*Y=*, X*YTIC=*, X*Y2=*, X*YTIC2=*/OVERLAY
  HAXIS=-3000 TO 9000 BY 1000
  VAXIS=0 TO 40000 BY 1000
  HSPACE=10 VSPACE=8
  HREF=0 3000 3150 7333
  VREF=0 TO 40000 BY 5000
  VPOS=350 ;
PROC PLOT DATA=PLOT2;
  PLOT X*Y=*, X*YTIC=*, X*Y2=*, X*YTIC2=*/OVERLAY
  HAXIS=-3000 TO 9000 BY 1000
  VAXIS=20000 TO 62000 BY 1000
  HSPACE=10 VSPACE=8
  HREF=0 3000 3150 7333
  VREF=20000 TO 62000 BY 5000
  VPOS=350 ;

```

Figure A-3.- Computer listing for program PLOT.

FILE: GRID EXEC A

CONVERSATIONAL MONITOR SYSTEM

```
&CONTROL OFF
&ERROR &GOTO -ERR
&REMOTE E TO HOUSTON
&SPOOL E HOLD
&GLOBAL TXLIB CMSLIB FORTRAN
&FORTRAN GRID
&FILEDEF 5 READER (PERM
&LEDEF 6 DISK GRID LISTING A1 (PERM RECFM FA
&LEDEF 7 PUNCH (PERM
&LEDEF 8 TERMINAL (PERM
&LEDEF 9 DISK 61 YDATA A (PERM RECFM F LRECL 80
&LEDEF 10 DISK UNDRY4 ADATA A (PERM RECFM F LRECL 80
&LEDEF 11 DISK 63 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 1 &GOTO -DONE
&LEDEF 12 DISK 64 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 2 &GOTO -DONE
&LEDEF 13 DISK 65 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 3 &GOTO -DONE
&LEDEF 14 DISK 66 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 4 &GOTO -DONE
&LEDEF 15 DISK 67 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 5 &GOTO -DONE
&LEDEF 16 DISK 68 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 6 &GOTO -DONE
&LEDEF 17 DISK 69 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 7 &GOTO -DONE
&LEDEF 18 DISK 610 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 8 &GOTO -DONE
&LEDEF 19 DISK 611 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 9 &GOTO -DONE
&LEDEF 20 DISK 612 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 10 &GOTO -DONE
&LEDEF 21 DISK 613 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 11 &GOTO -DONE
&LEDEF 22 DISK 614 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 12 &GOTO -DONE
&LEDEF 23 DISK 615 ZDATA A (PERM RECFM F LRECL 64
&LEDEF E0 13 &GOTO -DONE
&TYPE NOT ENOUGH FILEDEF'S IN EXEC
&EXIT
&ERR &TYPE ERROR ENCOUNTERED IN DEFINING FILES
&EXIT
-DONE &TYPE 62 OUTPUT FILES HAVE BEEN DEFINED
LOAD GRID
START
```

Figure A-5.- Execute file for program GRID.