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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

Plotter Subroutine for Meteorological Flight Path (PATH) (Revised)

HEINZ H. GROTE

BOULDER, COLO.
MARCH 1971

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Plotter Subroutine for Meteorological Flight Path (PATH) (Revised)

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FOREWORD

This Technical Report is a revision of ESSA Technical Report ERL 139-APCL 9, December 1969, "Plotter Subroutine for Meteorological Flight Path (PATH).

TABLE OF CONTENTS

1.	INTRODUCTION	1
2.	VARIABLES	9
3.	FURTHER DETAILS ON SUBROUTINE PATH	12
4.	PROGRAM TESTPATH	17
5.	PROGRAM TESTGRID	17
6.	SUBROUTINE COGRID	18
7.	ACKNOWLEDGEMENT	25
8.	REFERENCES	25
APPENDIX A.	PATH Lettering	26
APPENDIX B.	Time Scale for PATH Lettering	27
APPENDIX C.	TESTPATH Printout	28
APPENDIX D.	PATH Printout	30
APPENDIX E.	TESTGRID Printout	35
APPENDIX F.	COGRID Printout	36

PLOTTER SUBROUTINE FOR METEOROLOGICAL FLIGHT PATH (PATH)

Heinz H. Grote

This paper describes a subroutine PATH that works in connection with the plotter subroutine CRTPLT to provide a two-dimensional plot of a meteorological flight path with wind vectors, time notations, and a legend. A coordinate network can be added with subroutine COGRID.

1. INTRODUCTION

The subroutine PATH works in connection with the plotter subroutine (CRTPLT (Tucker, 1968) to provide a two-dimensional plot of a meteorological flight path with wind vectors, time notations, and a legend. By proper choice of a flag, a coordinate network is superimposed. This is achieved by subroutine COGRID.

Figures 1, 2 and 3 show examples of a plot. The legend of the plot without the coordinate network provides the following reference information:

(1) The flight number LID is expressed as a six-digit number and an index letter according to the convention used by NOAA's Research Flight Facility. The first two digits represent the year, the next two the month, and the last two the day of the flight. The letter stands for the particular airplane.

(2) The altitude ALT in kilometers is a reference value brought in from the main program.

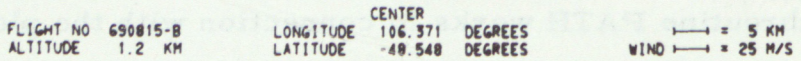


Figure 1a. Plot generated by TESTPATH (M=0) (N=0)

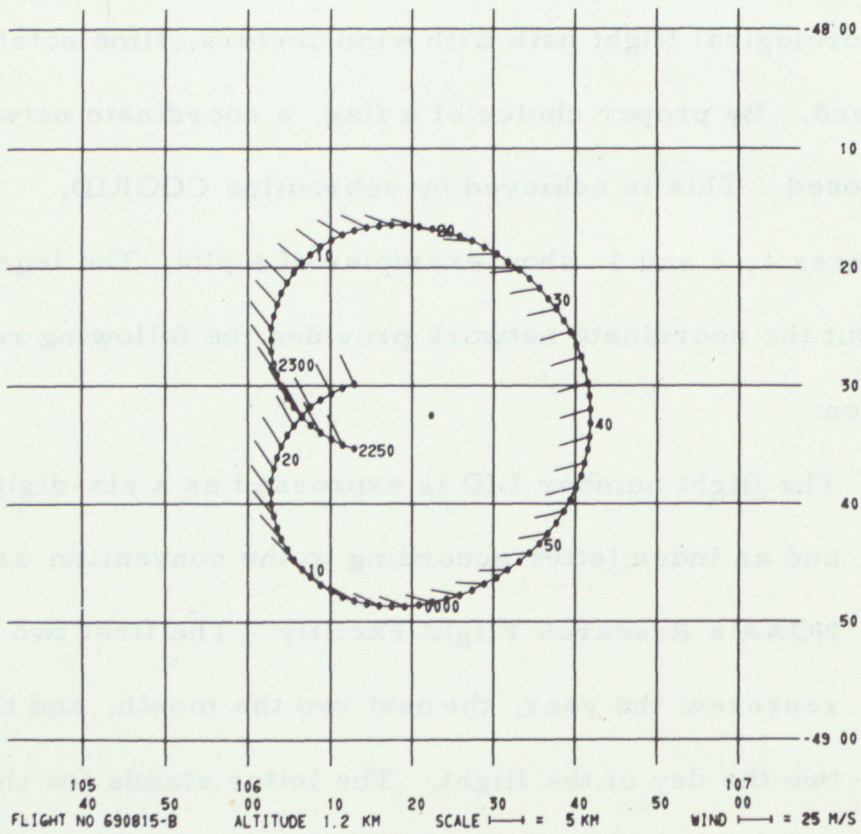


Figure 1b. Plot generated by TESTPATH (M=0) (N=1)

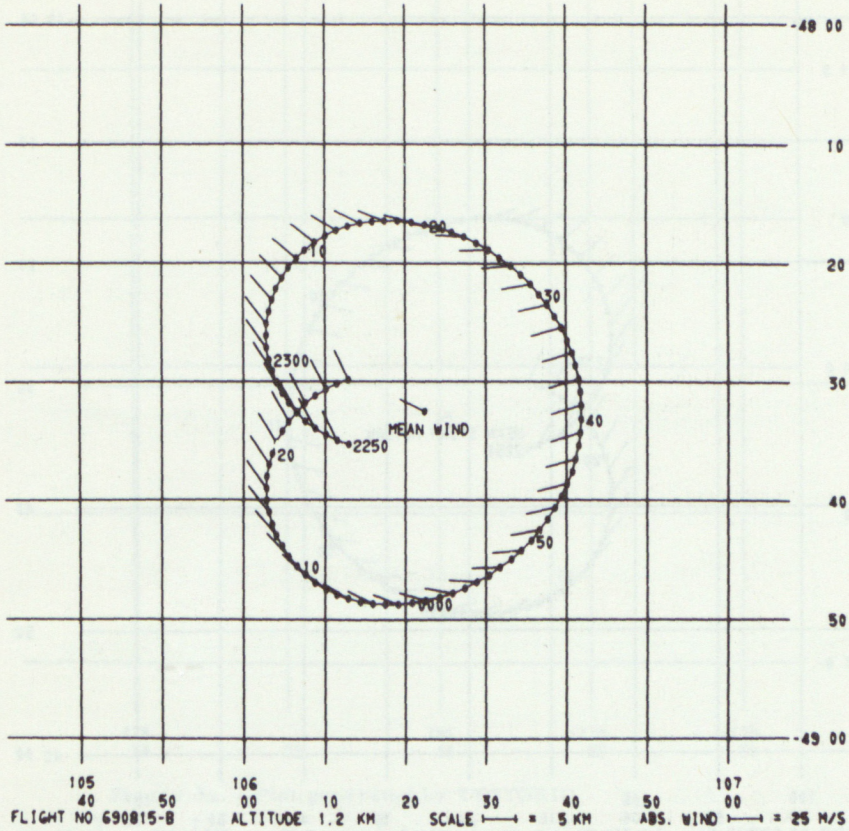


Figure 1c. Plot generated by TESTPATH (M=1) (N=1)

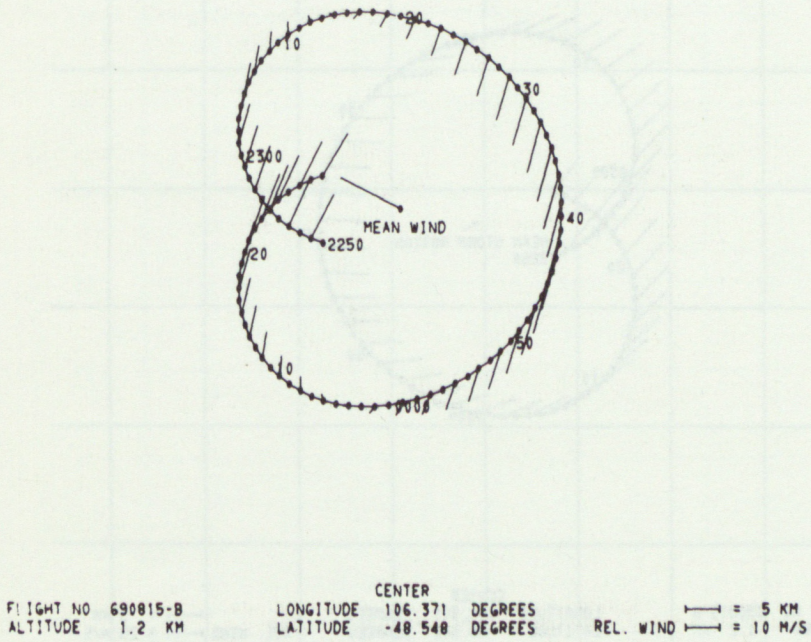


Figure 1d. Plot generated by TESTPATH (M=2) (M=0)

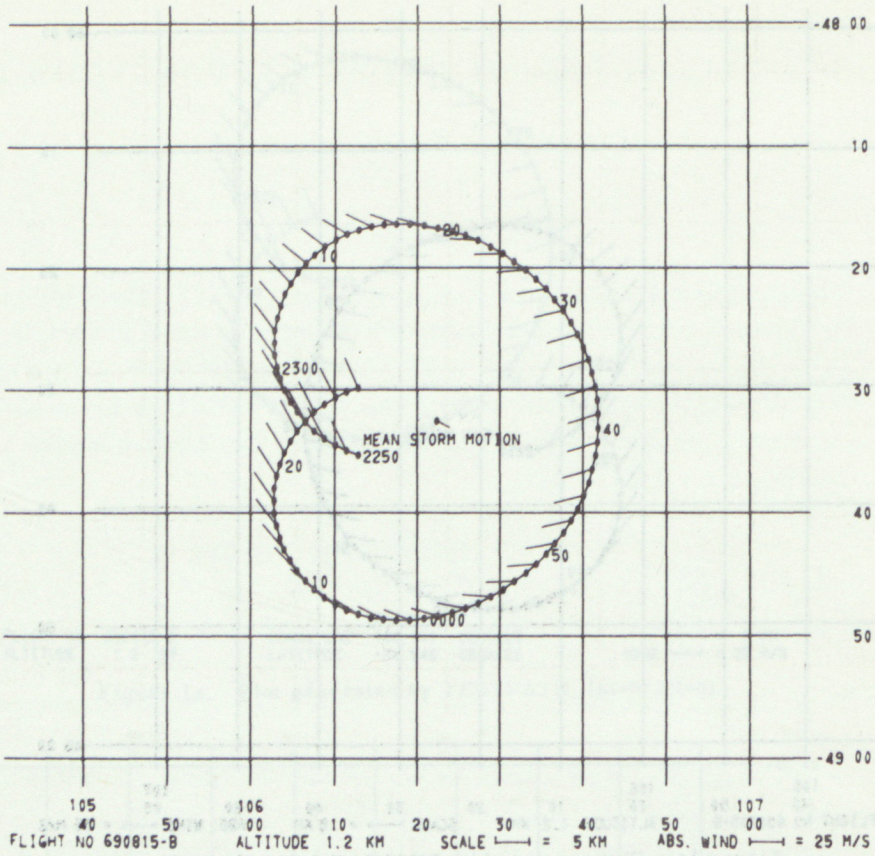
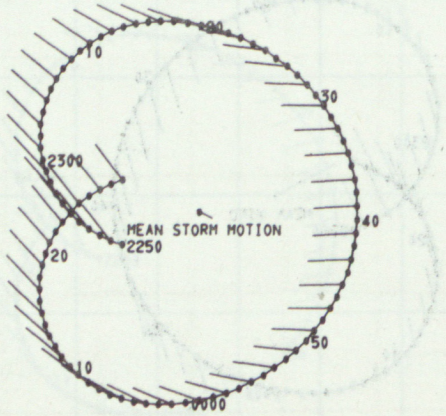


Figure 2a. Plot generated by TESTPATH (M=3) (N=1)



CENTER

FLIGHT NO 690815-B LONGITUDE 106.371 DEGREES = 5 KM
ALTITUDE 1.2 KM LATITUDE -48.548 DEGREES REL. WIND = 25 M/S

Figure 2b. Plot generated by TESTPATH (M=4) (N=0)

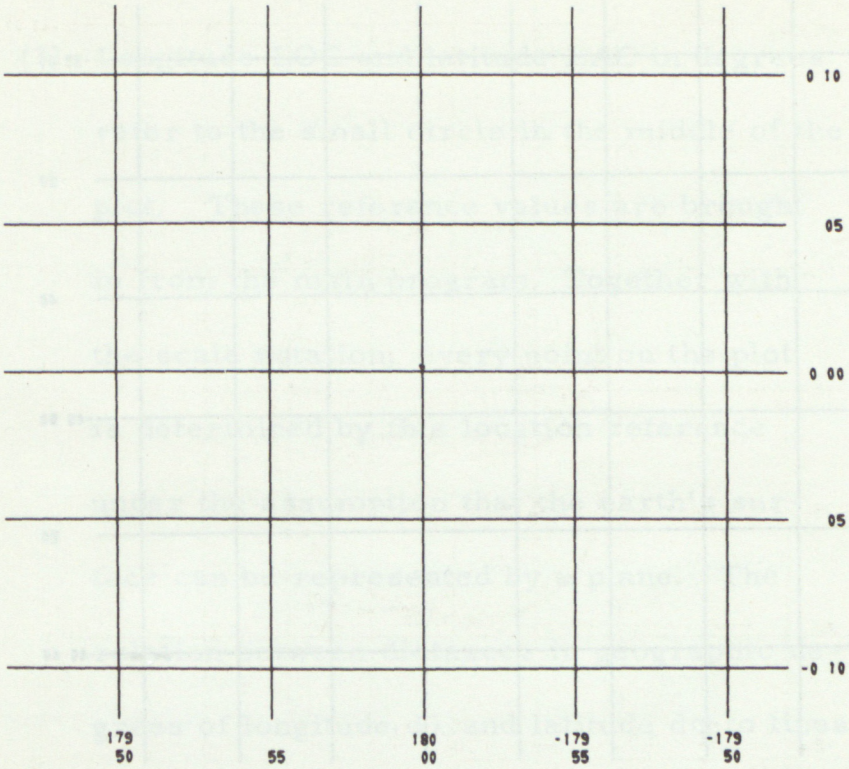


Figure 3a. Plot generated by TESTGRID

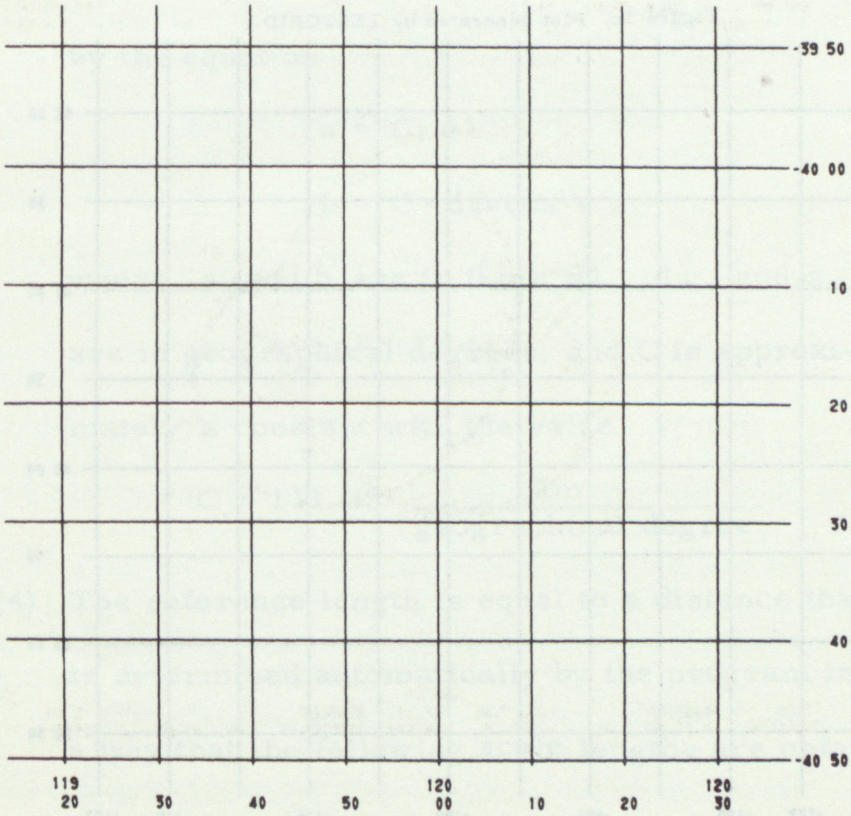


Figure 3b. Plot generated by TESTGRID

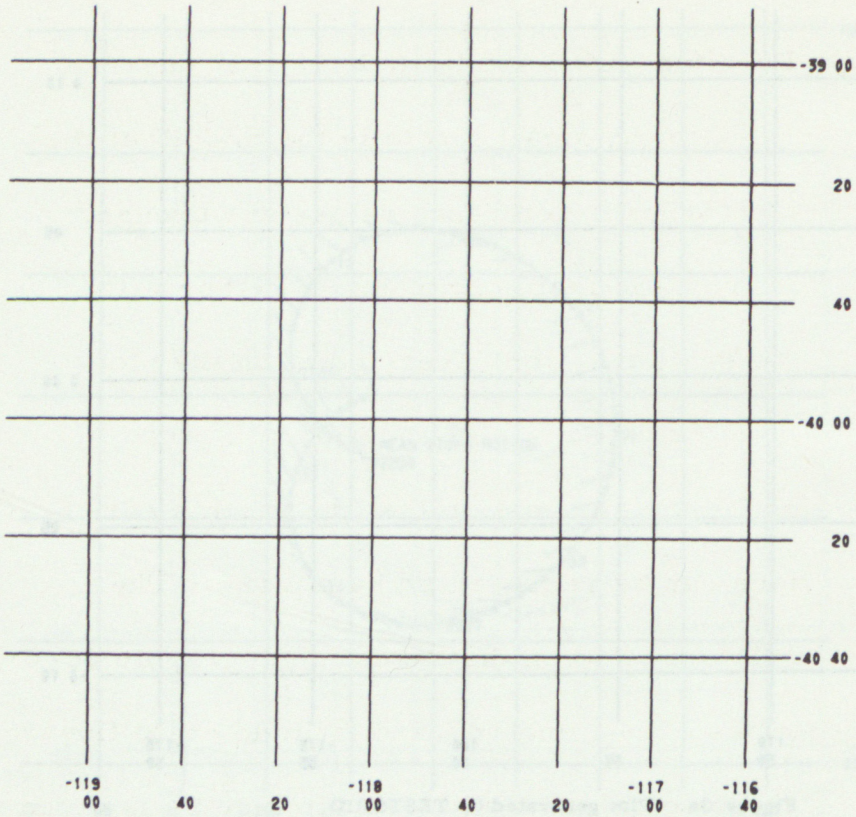


Figure 3c. Plot generated by TESTGRID

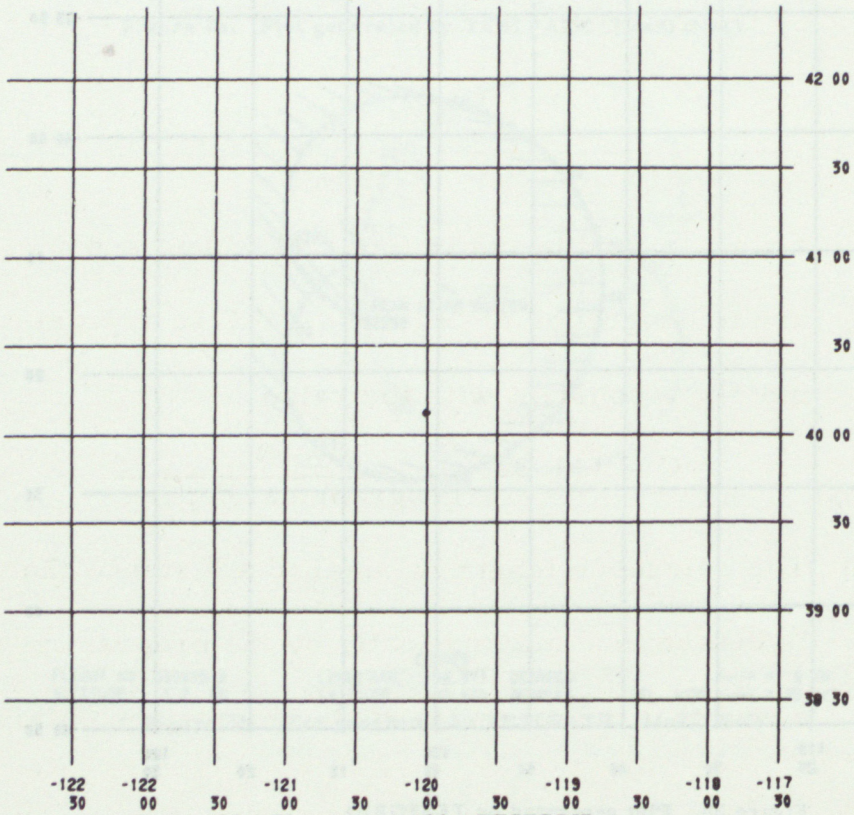


Figure 3d. Plot generated by TESTGRID

(3) Longitude LOC and latitude LAC in degrees refer to the small circle in the middle of the plot. These reference values are brought in from the main program. Together with the scale notation, every point on the plot is determined by this location reference under the assumption that the earth's surface can be represented by a plane. The relation between distances in geographic degrees of longitude, $d\lambda$, and latitude, $d\varphi$, to linear distance values a and b in kilometers is given by the equation

$$a = C \cdot d\lambda$$

$$b = C \cdot d\varphi \cdot \cos \varphi ,$$

where a and b are in (km); $d\lambda$, $d\varphi$, and φ are in geographical degrees; and C is approximately a constant with the value

$$C = 111.32 \frac{\text{km}}{\text{geographical degree}}$$

(4) The reference length is equal to a distance that is determined automatically by the program in such a way that the following scale lengths are obtained

for a corresponding span (SPAN introduced from the main program) of the flight path in its largest dimension.

Dimension	Scale Length
51.2 km	2 km
128.0 km	5 km
256.0 km	10 km
above 256 km	20 km

(5) The wind reference length is equal to a wind speed that is determined automatically by the program. Scale lengths for a maximum wind speed (WM introduced from the main program) are:

Wind Speed	Scale Length
10 m/sec	5 m/sec
20 m/sec	10 m/sec
50 m/sec	25 m/sec
above 50 m/sec	50 m/sec

(6) A wind reference vector is provided with its origin at the reference coordinate point. Scaled according to the wind reference length, its value is brought in from the main program as WXA, WYA. There are five possibilities to represent the wind

reference vector. They are contained in the following table:

M	legend close to center	in front of "Wind"
0	-	-
1	MEAN WIND	ABS
2	MEAN WIND	REL
3	MEAN STORM MOTION	ABS
4	MEAN STORM MOTION	REL

If the plot contains a coordinate network, longitude and latitude are omitted from the legend since the network is labeled in degrees and minutes of longitude and latitude.

2. VARIABLES

The variables, listed in alphabetical order, that enter the subroutine are as follows:

ALT a representative flight altitude (km) printed under legend (2) with one digit after the decimal point, so that hundreds of meters can be represented.

IFS a six-digit number that determines the scaling. The center two digits are without significance and serve

only as a separator. The first two digits are the numbers inserted under legend (4) as the plotting scale values. The last two are the numbers inserted under legend (5) as the wind scale values. If IFS is zero, automatic scaling is used, as explained under (5) and (6).

IN the number of coordinate points X, Y.

INCW determining the spacing of the wind vectors on the plot.

INCW= 1 means that a wind vector is drawn for every coordinate point.

INCW = 2 indicates that a wind vector is drawn for every second coordinate point.

JT The time array, consisting of six digits. The first two stand for the hours (in 24-hour notation), the second two digits for the minutes, and the last two for the seconds. The capacity of the array is 500.

LID the identification array, containing eight places.

LID(1) consists of two digits and represents the most significant digits of the year of the flight.

LID(2) is the number of the month incremented by 1000 in order to maintain leading zeroes in printing.

LID(3) is the number of the day incremented by 1000 in order to maintain leading zeroes in printing.

LID(4) is the airplane identifier in Hollerith notation. (The airplane identifier B thus has to be expressed as 1 HB.)

N selector for grid net. N = 0: no net

N = 1: grid net

SPAN the largest extension of the flight path in kilometers in either longitudinal or latitudinal direction. This value is used for the automatic scaling as explained under legend (5).

WM the largest wind speed (m/sec). This value is used for the automatic scaling as explained under legend (6).

WX an array of 500 words that contains the x-component of the presented wind, either absolute or relative to the mean wind as explained under legend (7).

WXA the x-component of the reference wind as explained under legend (7).

WY an array of 500 words that contains the y-component of the presented wind.

WYA the y-component of the reference wind as explained under legend (7).

X is an array of 500 words that contains the x-coordinates of the points of the flight path in a plane coordinate system with distances from the reference point in kilometers.

Y an array of 500 words that contains the y-coordinates of the points of the flight path in a plane coordinate system with distances from the reference point in kilometers.

3. FURTHER DETAILS ON SUBROUTINE PATH

ID — the identification printed on the microfilm. It contains the name of the user and his telephone number in Hollerith notation.

IKL — $= 2^{42}$. This factor is used to shift an integer number for conversion to a Hollerith character by 7 BCD orders of magnitude. Each BCD word contains 6 binary characters. (Control Data Corporation, 1967, 1,1, "Word Structure")

IMX — = IN+1. The number of the reference point X(IMX) = Y(IMX) = 0.0 .

JC — the first time value to be printed. It has to be an integer of MU.

JF — the number of the reference vector. Since a wind vector is printed for every INCWth flight path point:

JF = IN/INCW * INCW + INCW

M — for M = 0 no reference wind shall be printed. Then WX(JF) and WY(JF) are set equal to zero

M = 2 or M = 4 provide for the presentation of relative winds. The ground coordinate system can not be used in this case since the reference system is moving with respect to ground. Thus the printing of a grid net is prevented, even if by accident N = 1 should have been specified.

A grid net can be printed only if, for M = 0; also N = 1 was specified or for M = 1 or M = 3. In the latter cases the absolute wind, as measured, is plotted. In the first case no relative wind is specified; and therefore a grid net can be inserted. (See also the table in I, 6.)

SC the multiplication factor for presenting the wind vector on the flight path plot. The scale reference length is KS kilometers; the wind scale reference length is KW meters/second. Thus the value of a wind has to be divided by KW and multiplied by KS to prepresent a length that is referenced by the wind scale reference length.

SCC the scale factor that links letter printing units to flight path scaling.

The full width of a frame will accept 94 letters. The span SP also covers the full width. Thereby, the nth letter appears at a location that is equivalent to N * SP/94.0 km from the left. Since the zero point of the flight path display is in the center, the position of the nth letter is

$$(-47.5) * SSC$$

Thereby the first letter is at -46.5 * SSC.

XK(I) = SPH. The corner coordinates equal in absolute value half the quantized span SPAN. See Table, Section 4, paragraph 1.

Different methods have been used to shift an integer number to a specific location.

a. Multiplication with IKL. This was explained under IKL.

b. Multiplication with 8 H xxxxxxxx .

Care has to be taken that zeroes appear at all locations except the desired one; 1 has to be placed at this location. Blank spaces or decimal points have to be added later.

Examples:

+ 8H00.0

+ 2H00

c. Encoding. In this way, separate Hollerith and integer characters can be compressed in one expression. To obtain, alternatively, a blank or an integer, a Hollerith character is defined in the encoding format, and the integer is converted to Hollerith by multiplying with 2^{42} , which means shifting left by 7 binary coded decimal locations.

For the printing of the flight path points, an L = 1 command (Tucker, 1968) is used in connection with an L = 5 command. NCC = 3H + 0C provides a circle with a centerpoint ⊙ for each point.

AN L = 8 command connects the data points by lines.

AN L = 9 command prints the wind vector and the reference lengths.

AN L = 10 command provides tabular plotting for the legends

AN L = 2 command leaves one frame blank.

The L = 20 command terminates the plotting of a frame.

The variables used for plotting are:

X, Y, IN	the coordinates of the points representing the flight path and their number.
3H+0C; X, Y, IMX	circle marks denoting points on the flight path and in the center.
XA, YA, NL, KL	flight number
XB, YB, NQ, KQ	mean flight altitude
XC, YC, NU, KU	plot scale
XD, YD, NV, KV	wind scale
YE, YE, NE, KE	legend : "MEAN STORM MOTION"
XF, YF, NF, KF	legend : "MEAN WIND"
XG, YG, NG, KG	legend : "CENTER"
XH, YH, NH, KH	legend : "FLIGHT NO LONGITUDE DEGREES"
XI, YI, NI, KI	legend : "ALTITUDE LATITUDE DEGREES WIND"

XJ, YJ, NJ, KJ	legend for plot with grid net ; "FLIGHT NO ALTITUDE KM SCALE"
XK, YK, ID	limits of the plot and identification of the programmer
XL, YL, NL, KL	flight number in plot without grid
XM, YM, NM, KM	legend : "ABS" to identify the wind as absolute used in plot without grid
YM, YM NN, KN	legend : "REL" to identify the wind as relative used in plot without grid
XN, YN NN, KN	legend : "ABS" in plot with grid net
XP, YP, NP, KP	reference longitude in plot without grid
XQ, YQ NR, KR	mean flight altitude in plot without grid
XR, YR, NR, KR	reference latitude in plot without grid
3H+0L XS, YS	plot scale end marks
3H+-L XT, YT	wind scale end marks
XU, YU NU, KU	plot scale label in plot without grid
XV, YV, NV, KV	wind scale label in plot without grid
XW, YW	wind vectors
XX, YY	blank frame
XZ, YZ NZ, KZ	time numerals

4. PROGRAM TESTPATH

The same path is presented in six different ways:

M=N=0	does not provide a mean wind and accordingly no legend. No grid.
M=0 N=1	no mean wind vector, but a grid is printed.
M=N=1	the mean wind is presented at the coordinate reference point with a corresponding legend. The wind vector values are absolute (as measured). A grid net is superimposed.
M=2	the wind vectors are presented relative to the mean wind, that means, only the difference against the mean wind is drawn. No grid.
M=3	the mean storm motion is presented at the coordinate reference point with a corresponding legend. The wind vector values are absolute (as measured). A grid net is superimposed.
M=4 N=0	the wind vectors are presented relative to the mean storm motion. No grid.

5. PROGRAM TESTGRID

A special program TESTGRID was written to ensure that the subroutine COGRID is working properly.

Positive and negative values for longitude and latitude are provided as well as different spans to obtain four different grid nets. (Figures Appendix E.)

6. SUBROUTINE COGRID

This subroutine provides for the printing of a grid net in steps of 2, 5, 10, 20, 30 geographical minutes. These steps are selected according to the span SP. The following table shows the spacing NC of the grid lines

SPAN	GRID LINE SPACING
< 51.2 km	2 minutes
51.2 - 127.9 km	5 minutes
128.0 - 255.9 km	10 minutes
256.0 - 511.9 km	20 minutes
>520 km	30 minutes

The spacing in degrees is ZA.

Minute labels are printed for every grid line, while degrees are labeled at the ends, and when the number of degrees is changing. The degree labels contain the sign, while minute labels are not signed.

In the following, the steps to obtain the grid net and the labels can be followed from the explanation of the variables:

SSC spacing of letters expressed in 1/94 of span in km.
CX center point in munutes
CY

R is used for rounding, and is equal to half the grid line spacing in minutes.

SIGN(R, CX) provides the right sign for rounding.

MX MY	point in minute coordinates, whose coordinates can be expressed in multiple integers of the grid spacing
ZX ZY	point MX, MY in degrees
XD	spacing of longitudinal net in km
XM	lower limit for the grid net in km
XMP	upper limit for the grid net in km
NK	count of grid lines. The fact, that the initial value of NK is -3 will be explained later
XA XB	deviation of the longitude of the center point ALO from the longitude of the quantized center CZ in km
ZB	starting with the quantized center ZX the longitude is decreased in steps of ZA degrees. At the same time XA is decreased in steps of XD km while NK is increased by 2 until XM is passed. This value for XA is preserved as XP while XA and ZB are increased back to the last value that was within limits. These values are called XA (km) and ZC (degrees)
MAS	the integer value of the leftmost longitudinal gridline is the value of the full degrees
NAZ	is the remainder of the longitudinal gridline value in minutes. It has to be rounded by SIGN (0.5, ZC) to represent the quantized value for proper grid spacing.

For longitudes west of Greenwich the longitude is expressed in minutes to conserve the proper direction of decreasing or increasing minute values. For example: If NC is 20 minutes and if the leftmost longitudinal point is -120.666 degrees, then MAS = -120 and NAZ was originally 40 minutes. The next grid lines to the right have then to be labeled 20, 00, 40, 20, 00 etc., for the minute column. By starting with NAZ= -7240, adding of 20 provides -7220.

NAA	is the absolute value of NAZ (in the example NAA=7240)	
NAP	is the value of NAA expressed as integer multiple of 60	(NAP=7240)
NAB	is the difference between NAA and NAP	(NAB=40)
18	is the starting point of an undeclared subroutine that prepares the digits for the labeling of the grid net	
MAA	is the absolute value of MAS	(MAA=120)
MAB	is the first digit of MAA	(MAB=1)
MAD	is the second digit of MAA	(MAD=2)
MAE	is the third digit of MAA	(MAE=0)
MA	if the first or the first and the second digits are zero, MA has to contain blanks. If MAS is negative, a minus sign has to inserted in the proper location in front of the first digit that is not a zero or blank	
XMA	the location of the first degree digit is 2 spaces left of the leftmost grid line	
YMA	= -42.5 * SSC	
NAC	is the first character of the longitudinal minute lettering NAB	
NAD	is the second letter of NAB	
NA	each integer letter has to be shifted left by 2^{30} or 5 BCD letters for presentation in the CRTPLT subroutine. There a letter X is presented by 3H+0X.	
XNA	the first minute letter is located at the corresponding grid line	
YNA	= -42.5 * SSC	

XGA is the x-location of the grid line

YGA are the vertical limits of the grid line at -40.5 * SSC and +46.5 * SSC

Location 20-1 is the end of the undeclared grid labeling subroutine.

After the leftmost gridline and its labeling is defined, control goes back to location 12 to compute the values for the next gridline to the right. First, the total number of gridlines is determined.

NK was initialized with -3. It was incremented by 2 for each grid line. The following table shows, how NK is counted.

7	5	3	1	-1	-3	9	11	13	15	17
lower limit										upper limit

Thus, for 9 gridlines NK was determined to be 17. Since one gridline was already defined, loop 20 starts with N=3 in steps of 2 up to N=NK.

NAZ each loop NAZ is incremented by NZ. In our example avove NZ was -7240 for the first gridline; thus it becomes -7220 for the second gridline.

NAA is the absolute value of NAZ (NAA=7220)

NAQ is the value of NAA expressed in integer multiples of 60 (NAQ=7200)

NAB is the difference between NAA and NAQ (NAB=20)

If NAQ becomes greater than NAP, a jump in the minute value occurs.
MAS is increased by one, and NAP is set equal to NAQ. This can only occur for longitudes east of

Greenwich (ZC positive). Then a new degree value has to be printed. The procedure is somewhat different for longitudes west of Greenwich (ZC negative). In this case, MAS is printed when NAB becomes zero, but it is not incremented. MAS is incremented when NAQ becomes less than NAP.

The following table shows two examples, both with NC=20; but one with positive ZC and the other with negative ZC

Postiive ZC

NAZ	NAA	NAP	NAQ	NAB	MAS	
40	40	0	0	40	119	
60	60	0/60	60	0	120	PRINT
80	80	60	60	20	120	
100	100	60	60	40	120	
120	120	60/120	120	0	121	PRINT
140	140	120	120	20	121	

Negative ZC

-9600	7140	7140	7140	0	-119	PRINT
-9580	7120	7140/7080	7080	40	-118	
-9560	7100	7080	7080	20	-118	
-9540	7080	7080	7080	0	-118	PRINT
-9520	7060	7080/7020	7020	40	-117	
-9500	7040	7020	7020	20	-117	

The procedure for obtaining the location and the labeling for the horizontal grid lines is quite similar.

For the vertical lines the x-values vary, while the y-values are constant at -40.5 * SSC and +46.5 * SSC for the end points of the grid lines and -42.5 * SSC for the degree values and -44.5 * SSC for the minute values.

For the horizontal lines the x-values are constant at 46.5 * SSC and +40.5 * SSC for the endpoints of the grid lines and 41.5 * SSC, 42.5 * SSC and 43.5 * SSC for the degree legend and 45.5 * SSC and 46.5 * SSC for the minute legend.

The vertical lines are labeled with up to four letters (including the minus sign) for the degrees above two letters for the minutes. For the horizontal lines up to three letters (including the minus sign) are in the same line with two letters for the minutes, separated by a space.

The variables used for the presentation of the horizontal lines are:

YD	spacing of latitudinal grid lines in kilometers
YM	lower limit for the grid lines in km
YMP	upper limit for the grid lines in km
NL	count of latitudinal grid lines

YA	deviation of the latitude ALA of the center
YB	point from the quantized latitude ZY in km
ZF	latitude of grid lines in degrees
ZG	latitude of lowest grid line in degrees
YA	ordinate value of grid lines in km
YP	ordinate value of label for lowest grid line
MBS	degree value of latitudinal grid line
NBZ	minute reference value
NBA	absolute value of NBZ
NBP	the value of NBA expressed as integer multiple of 60
NBB	= NBA - NBP
ZH	value of latitudinal grid line in degrees
YB	ordinate value of latitudinal grid line in km
NBZ	count value for grid lines in minutes
NBA	absolute value of NBZ
NBQ	NBA expressed in integer multiples of 60
NBB	= NBA - NBQ
MB	value of the degree digits
NB	value of the minute digits
XMB	abscissa values of degree lettering
YMB	ordinate values of degree lettering

XNB	abscissa values of minute lettering
YNB	ordinate values of minute lettering
XGB, YGB	end points of latitudinal grid lines in km
KX	number of end points for longitudinal grid lines
KY	number of end points for latitudinal grid lines

7. ACKNOWLEDGMENT

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8. REFERENCES

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155 448

APPENDIX A

PATH Lettering

```
                    MEAN   WIND                          -2.0
                    70

                MEAN STORM  MOTION                       -2.0
                66

                        CENTER                           -42.5
                        72

....FLIGHT.NO..690815.B..........LONGITUDE..-10          -44.5
    5           16                34          45

....ALTITUDE...1.2..KM.........LATITUDE....-4            -46.5


6.371..DEGREES.....................=.10.KM......        -44.5
       55            69    73          85

8.216..DEGREES......REL.WIND......=.25.M/S.....          -46.5

 FLIGHT ..NO.701216.B....ALTITUDE...1.2.KM.....          -46.5
 2          12          26          35
            →           →

SCALE.......=.25.KM....REL.WIND........=.25.M/S.         -46.5
48          61          72  76          88
```

APPENDIX B

Time Scale for PATH Lettering

```
MU     MV                                                                    [Sec]
       1600                01                  02                            MT
500    100   1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1   [1605]   5
             41 min of data | 2 digits every minute | 4 digits every  5 min
-------------------------------------------------------------------------------------
       1600        01        02        03        04        05
1000   100   1 . . . . . 1 . . . . . 1 . . . . . 1 . . . . . 1 . . . . . 1   [1610]  10
             1 hour, 23 min of data | 2 digits every minute | 4 digits every 10 min
-------------------------------------------------------------------------------------
       1600        02        04        06        08        10
2000   200   1 . . 1 . . 1 . . 1 . . 1 . . 1 . . 1 . . 1 . . 1 . . 1 . . 1   [1620]  20
             2 hours,46 min of data | 2 digits every 2 min | 4 digits every 20 min
-------------------------------------------------------------------------------------
       1600                05                  10                  15
3000   500   1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1 . 1   [1630]  30
             4 hours,10 min of data | 2 digits every 5 min | 4 digits every 30 min
-------------------------------------------------------------------------------------
       1600                10                  20                  30
10000  1000  1 . . . . 1 . . . . 1 . . . . 1 . . . . 1 . . . . . . . . . 1   [1700]  60
             8 hours, 20 min of data | 2 digits every 10 min | 4 digits every hour
-------------------------------------------------------------------------------------
       1600                20                  40                  1700
10000  2000  1 . . . . 1 . . . . 1 . . . . 1 . . . . 1 . . . . 1 . . . . 1   120
             16 hours, 40 min of data | 2 digits every 20 min | 4 digits every hour
-------------------------------------------------------------------------------------
```

MT	5	10	20	30	60	120
MU	500	1000	2000	3000	10000	10000
MV	100	100	200	500	1000	2000

APPENDIX C

```
      PROGRAM TESTPATH
      DIMENSION LID(8),JJ(500),OX(500),OY(500),OWX(500),OWY(500)
    1 FORMAT (1H1,8X *REFERENCE WIND 9   WXA=*F7.2* M/S   WYA=*
     1 F7.2 * M/S*/// )
    2 FORMAT (10X *TIME* 5X *LONGITUDE* 4X *LATITUDE* 4X *WIND X* 5X
     1 *WIND Y* / 11X *GMT* 9X *KM* 10X *KM* 9X *M/S* 8X *M/S* // )
    3 FORMAT (9X,I6,2F12.3,2F11.2)
      DATA (ALA=-48.548),(ALO=106.372),(ALT=1.234),(IFS=0),(IW=2),
     1(LID=69,1008,1015,1HB,15,6HAUGUST,2HH  ,69),(LT=60),
     2(NM=100),(SPAN=60.0),(WMAX=23.0),(ZDR=0.01745329253)
      DO 11  I=1,10
      JJ(I)=(2249+I)*100
   11 CONTINUE
      DO 12  I=11,70
      JJ(I)=(2289+I)*100
   12 CONTINUE
      DO 13  I=71,100
      JJ(I)=(-71+I)*100
   13 CONTINUE
      DO 14  I=1,27
      A=(258-6*I)*ZDR
      OX(I)=18.0*COS(A)-6.0
      OY(I)=18.0*SIN(A)+12.0
   14 CONTINUE
      DO 15  I=28,73
      A=(202-4*I)*ZDR
      OX(I)=30.0*COS(A)-6.0
      OY(I)=30.0*SIN(A)
   15 CONTINUE
      DO 16  I=74,100
      A=(708-6*I)*ZDR
      OX(I)=18.0*COS(A)-6.0
      OY(I)=18.0*SIN(A)-12.0
   16 CONTINUE
      SWX=SWY=0.0
      DO 17  J=1,100
      OWX(J)=10.0*COS((280-2*J)*ZDR)-12.0
      OWY(J)=15.0*SIN((470-4*J)*ZDR)+ 8.0
      SWX=SWX+OWX(J)
      SWY=SWY+OWY(J)
   17 CONTINUE
      WMX=WXA=SWX/100.0
      WMY=WYA=SWY/100.0
      DO 29  L=1,6
      GOTO (18,19,20,21,22,23)  L
   18 M=N=0
      GOTO 26
   19 M=0
      N=1
      GOTO 28
   20 M=N=1
      GOTO 28
   21 M=2
      WMAX=18.0
```

```
      GOTO 24
   22 M=3
      N=1
      WXA=10.0
      WYA=-5.0
      WMX=-WMX
      WMY=-WMY
      WMAX=23.0
      GOTO 24
   23 M=4
      N=0
      WMX=WXA
      WMY=WYA
      WMAX=18.0
   24 DO 25  J=1,100
      OWX(J)=OWX(J)-WMX
      OWY(J)=OWY(J)-WMY
   25 CONTINUE
   26 PRINT 1, WXA,WYA
      PRINT 2
      DO 27  I=1,100
      PRINT 3, JJ(I),OX(I),OY(I),OWX(I),OWY(I)
   27 CONTINUE
   28 CALL PATH (LID,ALT,IW,NM,JJ,LT,SPAN,
     1WMAX,WXA,WYA,OX,OY,OWX,OWY,ALO,ALA,IFS,M,N)
   29 CONTINUE
      END
```

APPENDIX D

```
      SUBROUTINE PATH (LID,ALT,INCW,IN,JT,MT,
     1SPAN,WM,WXA,WYA,X,Y,WX,WY,ALO,ALA,IFS,M,N)
      DIMENSION JT(500),KE(3),KF(2),KG(2),KH(12),KI(12),KJ(12),LID(8),
     1 MUT(6),MVT(6),NE(6),NF(6),NG(6),NH(6),NI(6),NJ(6),NL(6),NM(6),
     2 NN(6),NP(6),NQ(6),NR(6),NU(6),NV(6),NZ(6),WX(500),WY(500),
     3 X(500),XK(2),XS(2),XT(2),XW(2),XX(2),
     4 Y(500),YK(2),YS(2),YT(2),YW(2),YY(2)
    1 FORMAT (6I1,2A1)
    2 FORMAT (3A1,I1,A1,3I1)
      DATA (ID=19HH.GROTE   EXT. 6270)
      DATA (IKL=4398046511104)
      DATA (KE=21H$1MEAN STORM MOTION'.   )
      DATA (KF=13H$1MEAN WIND'.   )
      DATA (KG=10H$1CENTER'. )
      DATA (KH=89H$1FLIGHT NO                          LONGITUDE                DE
     1GREES                          =     KM'.   )
      DATA (KI=90H$1ALTITUDE          KM            LATITUDE                 DE
     1GREES              WIND        =     M/S'.   )
      DATA (KJ=96H$1FLIGHT NO                    ALTITUDE      KM      SCALE
     1       =     KM              WIND        =     M/S'. )
      DATA (KM=8H$1ABS.'. )
      DATA (KN=8H$1REL.'. )
      DATA (MUT=100,100,200,500,1000,2000)
      DATA (MVT=500,1000,2000,3000,10000,10000)
      DATA (NE=3,1,0,0,0,1)
      DATA (NF=2,1,0,0,0,1)
      DATA (NG=2,1,0,0,0,1)
      DATA (NH=12,1,0,0,0,1)
      DATA (NI=12,1,0,0,0,1)
      DATA (NJ=12,1,0,0,0,1)
      DATA (NL=1,1,0,0,0,1)
      DATA (NM=1,1,0,0,0,1)
      DATA (NN=1,1,0,0,0,1)
      DATA (NP=1,1,0,0,0,1)
      DATA (NQ=1,1,0,0,0,1)
      DATA (NR=1,1,0,0,0,1)
      DATA (NU=1,1,0,0,0,1)
      DATA (NV=1,1,0,0,0,1)
      DATA (NZ=1,1,0,0,0,1)
      DATA (XX=0.0,1.0),(YY=0.0,1.0)
      IF (IFS.NE.0)  11,12
   11 KS=IFS/10000
      KW=IFS-KS*10000
      GOTO 14
   12 KS=20
      IF (SPAN .LE. 256.0)  KS=10
      IF (SPAN .LE. 128.0)  KS= 5
      IF (SPAN .LE.  51.2)  KS= 2
      SPH=12.8*KS
      SP=SPH+SPH
   13 KW=50
      IF (WM .LE. 50)  KW=25
      IF (WM .LE. 20)  KW=10
      IF (WM .LE. 10)  KW= 5
```

```
14 XK(1)= SPH
   XK(2)=-SPH
   YK(1)= SPH
   YK(2)=-SPH
   IMX=IN+1
   X(IMX)=0.0
   Y(IMX)=0.0
   CALL CRTPLT (XK,YK,4,ID,2)
   CALL CRTPLT (0,0,3H+0(,4,5)
   CALL CRTPLT (X,Y,IMX,1,1)
   CALL CRTPLT (X,Y,IN,0,8)
15 JF=IN/INCW*INCW+INCW
   X(JF)=Y(JF)=0.0
   WX(JF)=WXA
   WY(JF)=WYA
   IF (M .EQ. 0)  WX(JF)=WY(JF)=0.0
   SSC=SP/94.0
   SC=FLOAT(KS)/FLOAT(KW)
   DO 16  J=INCW,JF,INCW
   XW(1)=X(J)
   XW(2)=X(J)+WX(J)*SC
   YW(1)=Y(J)
   YW(2)=Y(J)+WY(J)*SC
   CALL CRTPLT (XW,YW,2,0,9)
16 CONTINUE
   IT=MT/10+1
   IF(MT .LT.  10)  IT=1
   IF(MT .GE.  60)  IT=5
   IF(MT .GE. 120)  IT=6
   MU=MUT(IT)
   MV=MVT(IT)
   JC=(JT(1)-1)/MU*MU+MU
   IA=1
   DO 23  I=1,IN
   GOTO (17,18)  I
17 IF (JT(I) .GE. JC)  19,23
18 IF(MOD(JT(I),MU) .EQ. 0)  19,23
19 JX=JT(I)/10000
   JY=(JT(I)-JX*10000)/100
   IKA=JX/10
   IKB=JX-IKA*10
   IKC=JY/10
   IKD=JY-IKC*10
   KZ=IKA*8H10000000+IKB*8H01000000+IKC*8H00100000+IKD*8H00010000
  1 +8H0000
   GOTO (22,20)  IA
20 IF(MOD(JT(I),MV) .EQ. 0)  22,21
21 KZ=IKC*8H10000000+IKD*8H01000000+8H00
22 XZ=X(I)+SSC
   YZ=Y(I)-0.15*SSC
   IA=IA+1
   CALL CRTPLT (XZ,YZ,NZ,KZ,10)
23 CONTINUE
   LFA=LID(1)/10
```

```
      LFB=LID(1)-LFA*10
      LFC=LID(2)-1000
      LFD=LFC/10
      LFE=LFC-LFD*10
      LFF=LID(3)-1000
      LFG=LFF/10
      LFH=LFF-LFG*10
      LFI=1H-
      ENCODE (8,1,KL) LFA,LFB,LFD,LFE,LFG,LFH,LFI,LID(4)
      LHA=INT(ALT)
      LHB=LHA/10
      LHC=LHA-LHB*10
      LHD=(ALT-LHA)*10.0
      KQ=LHB*8H10000000+LHC*8H01000000+8H00.0     +LHD*8H00010000
      IF (LHB .NE. 0)  GOTO 35
      KQ=KQ+8H 0000000
   35 LSA=KS/10
      LSB=KS-LSA*10
      KU=LSA*8H10000000+LSB*8H01000000+2H00
      IF (LSA .EQ. 0)  36,37
   36 KU=KU+8H 0000000
   37 LWA=KW/10
      LWB=KW-LWA*10
      KV=LWA*8H10000000+LWB*8H01000000+2H00
      IF (LWA .EQ. 0)  38,39
   38 KV=KV+8H 0000000
   39 IF ((M+1)/2-1)  42,41,40
   40 XE= -7.5*SSC
      YE= -2.0*SSC
      CALL CRTPLT (XE,YE,NE,KE,10)
      GOTO 42
   41 XF= -3.5*SSC
      YF= -2.0*SSC
      CALL CRTPLT (XF,YF,NF,KF,10)
   42 IF ((N .EQ. 0) .OR. (M .EQ. 2) .OR. (M .EQ. 4))  43,60
   43 XG= -2.5*SSC
      YG=-42.5*SSC
      CALL CRTPLT (XG,YG,NG,KG,10)
      XH=-42.5*SSC
      YH=-44.5*SSC
      CALL CRTPLT (XH,YH,NH,KH,10)
      XI=-42.5*SSC
      YI=-46.5*SSC
      CALL CRTPLT (XI,YI,NI,KI,10)
      XL=-31.5*SSC
      YL=-44.5*SSC
      CALL CRTPLT (XL,YL,NL,KL,10)
   44 XP= -2.5*SSC
      YP=-44.5*SSC
      LOA=1H
      IF (ALO .LT. 0.0)  LOA=1H-
      BLO=ABS(ALO)
      LOB=INT(BLO)
      LOC=LOB/100
```

```
      LOD=LOB-LOC*100
      LOE=LOD/10
      LOF=LOD-LOE*10
      LOJ=1H.
      LOG=(BLO-LOB)*1000.0
      LOH=LOG/100
      LOI=LOG-LOH*100
      LOK=LOI/10
      LOL=LOI-LOK*10
      LOM=LOC*IKL
      LON=LOE*IKL
      IF (LOC .EQ. 0)  LOM=1H
      IF ((LOC .EQ. 0) .AND. (LOE .EQ. 0))  LON=1H
      ENCODE (8,2,KP) LOA,LOM,LON,LOF,LOJ,LOH,LOK,LOL
      CALL CRTPLT (XP,YP,NP,KP,10)
   45 XQ=-31.5*SSC
      YQ=-46.5*SSC
      CALL CRTPLT (XQ,YQ,NQ,KQ,10)
      XR= -2.5*SSC
      YR=-46.5*SSC
   46 LAA=LAB=1H
      IF (ALA .LT. 0.0)  LAB=1H-
      BLA=ABS(ALA)
      LAC=INT(BLA)
      LAD=LAC/10
      LAE=LAC-LAD*10
      LAG=(BLA-LAC)*1000.0
      LAH=LAG/100
      LAI=LAG-LAH*100
      LAK=LAI/10
      LAL=LAI-LAK*10
      LAM=LAD*IKL
      IF (LAD .EQ. 0)  LAM=1H
      ENCODE (8,2,KR) LAA,LAB,LAM,LAE,LOJ,LAH,LAK,LAL
      CALL CRTPLT (XR,YR,NR,KR,10)
   47 XU= 38.5*SSC
      YU=-44.5*SSC
      CALL CRTPLT (XU,YU,NU,KU,10)
      XV= 38.5*SSC
      YV=-46.5*SSC
      CALL CRTPLT (XV,YV,NV,KV,10)
      XS(1)=XT(1)= 30.83*SSC
      XS(2)=XT(2)= 34.50*SSC
      YS(1)=YS(2)=-44.5*SSC
      YT(1)=YT(2)=-46.5*SSC
      XM= 21.5*SSC
      YM=-46.5*SSC
      IF ((M .EQ. 1) .OR. (M .EQ. 3))  48,49
   48 CALL CRTPLT (XM,YM,NM,KM,10)
      GOTO 70
   49 IF (M .EQ. 0)  70,50
   50 CALL CRTPLT (XM,YM,NN,KN,10)
      GOTO 70
   60 XJ=-45.5*SSC
```

```
      YJ=-46.5*SSC
      CALL CRTPLT (XJ,YJ,NJ,KJ,10)
      XA=-35.5*SSC
      YA=-46.5*SSC
      CALL CRTPLT (XA,YA,NL,KL,10)
      XB=-12.5*SSC
      YB=-46.5*SSC
      CALL CRTPLT (XB,YB,NQ,KQ,10)
      XC= 14.5*SSC
      YC=-46.5*SSC
      CALL CRTPLT (XC,YC,NU,KU,10)
      XD= 41.5*SSC
      YD=-46.5*SSC
      CALL CRTPLT (XD,YD,NV,KV,10)
      XS(1)= 6.53*SSC
      XS(2)=10.20*SSC
      XT(1)=34.00*SSC
      XT(2)=37.67*SSC
      YS(1)=YS(2)=YT(1)=YT(2)=-46.5*SSC
      XN= 24.5*SSC
      YN=-46.5*SSC
      IF (M .EQ. 0)  62,61
   61 CALL CRTPLT (XN,YN,NM,KM,10)
      GOTO 62
   62 CALL COGRID (ALO,ALA,SP)
   70 CALL CRTPLT (0,0,3H+0L,4,5)
      CALL CRTPLT (XS,YS,2,1,1)
      CALL CRTPLT (XT,YT,2,1,1)
      CALL CRTPLT (XS,YS,2,0,9)
      CALL CRTPLT (XT,YT,2,0,9)
      CALL CRTPLT (XX,YY,0,0,2)
      CALL CRTPLT (0,0,0,0,20)
      RETURN
      END
```

APPENDIX E

```
      PROGRAM TESTGRID
      DIMENSION XD(2),YD(2)
      DATA (ID=18HH.GROTE    EXT.6270 )
      DO 16  K=1,4
      GOTO (11,12,13,14)  K
   11 ALO= 180.000
      ALA=   0.000
      SPH=25.6
      GOTO 15
   12 ALO= 119.976
      ALA=- 40.352
      SPH=64.0
      GOTO 15
   13 ALO=-117.812
      ALA=- 39.998
      SPH=128.0
      GOTO 15
   14 ALO=-120.012
      ALA=  40.098
      SPH=256.0
   15 SP=SPH+SPH
      XD(1)= SPH
      XD(2)=-SPH
      YD(1)= SPH
      YD(2)=-SPH
      CALL CRTPLT (XD,YD,4,ID,2)
      CALL CRTPLT (0,0,1,1,17)
      CALL CRTPLT (0,0,1,1,17)
      CALL COGRID (ALO,ALA,SP)
   16 CONTINUE
      CALL CRTPLT (0,0,0,0,20)
      END
```

APPENDIX F

```
      SUBROUTINE COGRID (ALO,ALA,SP)
      DIMENSION MA(50),MB(50),NA(50),NB(50),XGA(50),XGB(50),XMA(50),
     1 XMB(50),XNA(50),XNB(50),YGA(50),YGB(50),YMA(50),YMB(50),
     2 YNA(50),YNB(50)
      DATA (CLA=111.32)
      DATA (DTR=0.01745329253)
      DATA (IJK=1073741824)
      CLO=ABS(CLA*COS(DTR*ALA))
      SSC=SP/94.0
      ZA=2.0/60.0
      IF (SP .GE.  51.2)  ZA= 5.0/60.0
      IF (SP .GE. 128.0)  ZA=10.0/60.0
      IF (SP .GE. 256.0)  ZA=20.0/60.0
      IF (SP .GE. 512.0)  ZA=0.5
      NC=INT(ZA*60.0)
      CX=ALO*60.0
      CY=ALA*60.0
      R=NC/2.0
      MX=INT(CX+SIGN(R,CX))/NC*NC
      MY=INT(CY+SIGN(R,CY))/NC*NC
      ZX=MX/60.0
      ZY=MY/60.0
      XD=ZA*CLO
      XM = 44.5*SSC
      XMP= 40.5*SSC
      NK=-3
      XA=XB=(ZX-ALO)*CLO
      ZB=ZX
   11 NK=NK+2
      ZB=ZB-ZA
      XA=XA-XD
      IF (ABS(XA) .LT. XM)  GOTO 11
      XA=XA+XD
      XP=XA-XD
      ZC=ZB+ZA
      MAS=INT(ZC)
      NAZ=(ZC-MAS)*60.0+SIGN(0.5,ZC)
      IF (MAS .LT. 0)  NAZ=MAS*60+NAZ
      NAA=IABS(NAZ)
      NAP=NAA/60*60
      NAB=NAA-NAP
      K=-1
      L=1
      M=1
      N=1
      GOTO 18
   12 ZD=ZX
   13 NK=NK+2
      ZD=ZD+ZA
      XB=XB+XD
      IF (ABS(XB) .LT. XMP)  GOTO 13
      L=2
      DO 20  N=3,NK,2
      NAZ=NAZ+NC
```

```
      NAA=IABS(NAZ)
      NAQ=NAA/60*60
      NAB=NAA-NAQ
      IF (NAQ .GT. NAP)  14,15
   14 MAS=MAS+1
      NAP=NAQ
      GOTO 18
   15 IF (NAB .EQ. 0)  GOTO 18
      IF (NAQ .LT. NAP)  16,17
   16 MAS=MAS+1
      NAP=NAQ
   17 IF (N .EQ. NK)  18,19
   18 MAA=IABS(MAS)
      MAB=MAA/100
      MAC=MAA-MAB*100
      MAD=MAC/10
      MAE=MAC-MAD*10
      IF (NAZ .LT. 0)  181,186
  181 IF (MAA .EQ. 0)  182,185
  182 MA(M)   =1H
      IF (MAB .EQ. 0)  183,184
  183 MA(M+1)=1H
      MA(M+2)=3H+0-
      GOTO 189
  184 MA(M+1)=3H+0-
      GOTO 188
  185 MA(M)   =3H+0-
      GOTO 187
  186 MA(M)   =1H
  187 IF (MAA .EQ. 0)  188,190
  188 MA(M+1)=1H
      IF (MAB .EQ. 0)  189,191
  189 MA(M+2)=1H
      GOTO 192
  190 MA(M+1)=MAB*IJK
  191 MA(M+2)=MAD*IJK
  192 MA(M+3)=MAE*IJK
      XMA(M)   =XP+XD-SSC-SSC
      XMA(M+1)=XMA(M)   +SSC
      XMA(M+2)=XMA(M+1)+SSC
      XMA(M+3)=XMA(M+2)+SSC
      YMA(M)=YMA(M+1)=YMA(M+2)=YMA(M+3)=-42.5*SSC
      M=M+4
      IF (MAS .EQ. 180)  193,19
  193 MAS=-180
      NAP=NAZ=-10800
   19 NAC=NAB/10
      NAD=NAB-NAC*10
      NA(N)=NAC*IJK
      NA(N+1)=NAD*IJK
      XNA(N)=XP=XP+XD
      XNA(N+1)=XNA(N)+SSC
      YNA(N)=YNA(N+1)=-44.5*SSC
      K=K+2
```

```
      XGA(K)=XGA(K+1)=XNA(N)
      YGA(K)   =-40.5*SSC
      YGA(K+1)= 46.5*SSC
      GOTO (12,20)  L
   20 CONTINUE
   21 MK=M-1
      KX=K+1
      NK=NK+1
      YD=ZA*CLA
      YM = 40.5*SSC
      YMP= 46.5*SSC
      NL=-3
      YA=YB=(ZY-ALA)*CLA
      ZF=ZY
   22 NL=NL+2
      ZF=ZF-ZA
      YA=YA-YD
      IF (ABS(YA) .LT. YM)  GOTO 22
      YA=YA+YD
      YP=YA-YD-0.4*SSC
      ZG=ZF+ZA
      MBS=INT(ZG)
      NBZ=(ZG-MBS)*60.0+SIGN(0.5,ZG)
      IF (MBS .LT. 0)  NBZ=MBS*60+NBZ
      NBA=IABS(NBZ)
      NBP=NBA/60*60
      NBB=NBA-NBP
      K=-1
      L=1
      M=1
      N=1
      GOTO 29
   23 ZH=ZY
   24 NL=NL+2
      ZH=ZH+ZA
      YB=YB+YD
      IF (ABS(YB) .LT. YMP)  GOTO 24
      L=2
      DO 31  N=3,NL,2
      NBZ=NBZ+NC
      NBA=IABS(NBZ)
      NBQ=NBA/60*60
      NBB=NBA-NBQ
      IF (NBQ .GT. NBP)  25,26
   25 MBS=MBS+1
      NBP=NBQ
      GOTO 29
   26 IF (NBB .EQ. 0)  GOTO 29
      IF (NBQ .LT. NBP)  27,28
   27 MBS=MBS+1
      NBP=NBQ
   28 IF (N .EQ. NL)  29,30
   29 MBA=IABS(MBS)
      MBB=MBA/10
```

```
      MBC=MBA-MBB*10
      IF (NBZ .LT. 0)  291,294
  291 IF (MBB .EQ. 0)  292,293
  292 MB(M)   =1H
      MB(M+1)=3H+0-
      GOTO 297
  293 MB(M)   =3H+0-
      GOTO 296
  294 MB(M)   =1H
      IF (MBB .EQ. 0)  295,296
  295 MB(M+1)=1H
      GOTO 297
  296 MB(M+1)=MBB*IJK
  297 MB(M+2)=MBC*IJK
      XMB(M)   = 41.5*SSC
      XMB(M+1)= 42.5*SSC
      XMB(M+2)= 43.5*SSC
      YMB(M)=YMB(M+1)=YMB(M+2)=YP+YD
      M=M+3
   30 NBC=NBB/10
      NBD=NBB-NBC*10
      NB(N)=NBC*IJK
      NB(N+1)=NBD*IJK
      XNB(N)   = 45.5*SSC
      XNB(N+1)= 46.5*SSC
      YP=YNB(N)=YNB(N+1)=YP+YD
      K=K+2
      XGB(K)   =-46.5*SSC
      XGB(K+1)= 40.5*SSC
      YGB(K)=YGB(K+1)=YNB(N)
      GOTO (23,31)  L
   31 CONTINUE
   32 ML=M-1
      KY=K+1
      NL=NL+1
      CALL CRTPLT (XGA,YGA,KX,0,9)
      CALL CRTPLT (XGB,YGB,KY,0,9)
      DO 33  I=1,MK
      CALL CRTPLT (0,0,MA(I),1,5)
      CALL CRTPLT (XMA(I),YMA(I),1,1,1)
   33 CONTINUE
      DO 34  I=1,NK
      CALL CRTPLT (0,0,NA(I),1,5)
      CALL CRTPLT (XNA(I),YNA(I),1,1,1)
   34 CONTINUE
      DO 35  I=1,ML
      CALL CRTPLT (0,0,MB(I),1,5)
      CALL CRTPLT (XMB(I),YMB(I),1,1,1)
   35 CONTINUE
      DO 36  I=1,NL
      CALL CRTPLT (0,0,NB(I),1,5)
      CALL CRTPLT (XNB(I),YNB(I),1,1,1)
   36 CONTINUE
      RETURN
      END
```


GPO 834-168