U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 257

Evaluation of the Maximum Wind Value and Level Finder Code

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This is an unreviewed manuscript, primarily intended for informal exchange of information among NMC staff members.

Introduction

During the past year, the International Civil Aviation Organization (ICAO) has continued to express an interest in adding maximum wind information to the Aviation Digital Forecast code (ADF). In early 1981, as part of NMC's services to the aviation community, we (in SEB) devised a method of calculating, from mandatory level winds, the value of the maximum wind speed and the pressure level at which the maximum wind was found. Documentation may be found in NMC Office Note 229 (Ref. 1). Recently, we tested this method and evaluated the data produced.

This report presents statistics obtained from comparisons between calculated maximum wind data and observed max wind data. This report also describes the results of comparisons (10 cases) between experimental charts of maximum wind fields produced at NMC and charts of maximum wind fields produced at the British Meteorological Office (Bracknell). However, because we did not receive Bracknell's charts that display the pressure levels of these max winds, comparisons were not attempted.

The numerical method used at Bracknell to produce the maximum wind data is briefly described in an article that was presented by W. L. Hughes (Ref. 1) before the ICAO, Area Forecast Panel in Montreal, Canada.

Maximum Wind Finder Method

Using only mandatory level wind data (i.e. 500-100 mb), the maximum wind value and its level are calculated by repeated applications of available mathematical codes. These codes, will (1) fit a 4th order polynomial to 5 points of data (2) calculate the derivative (3) find the real (and imaginary) roots of the derivative polynomial and (4) using the real roots, find the greatest of the maxima (or smallest of the minima) of the initial 5 point polynomial.

In use, the "data points" are winds as a function of pressure - thus the selected root is the level of max wind and the value of the polynomial is the maximum wind itself.

Comparisons Between NMC and Bracknell Charts

The charts collected for comparison are for the period 1200 GMT 4 January through 0000 GMT 9 January 1982. Figures 1-10 show examples of the experimental charts (gridpointed fields of the computed speeds) produced at NMC and Figures 1a-10a show examples of the charts prepared at Bracknell. Both sets of charts display the wind speed in knots, contoured in 20 knot intervals. The speeds displayed on NMC's charts are derived from the Hough Analysis and the speeds shown on Bracknell's charts are derived from Bracknell's operational ten-level model. Notice that Bracknell prints the max wind strength only when its value is greater than 60 knots.

In general, comparisons revealed that the charts are in reasonable agreement. In some areas, however, the wind speeds are markedly different. This is especially noticeable in regions of fairly well defined jets. In these regions, it appears (at least in these examples) that Bracknell's method produces slightly higher speeds. In areas where these differences were noted, we attempted to resolve the discrepancies by referencing soundings.

For example, at 1200 GMT 4 January, Figure 1 shows a maximum wind value of 120 knots in the broad area of high winds--greater than 90 knots--over the western United States. Figure 1a, on the other hand, shows a value of 142 knots in a similar isotach pattern. Examination of radiosonde data, in this case, suggested that the value shown in Figure 1a is more reasonable. Also, observations indicated that the speeds shown

in Figure 1 in the vicinity of Lake Huron (about 46°N latitude, 80°W longitude) are too weak.

Another example is observed in Figures 3 and 3a (1200 GMT 5 January). As seen in the previous example, the isotach patterns are similar, but there are areas where the wind speeds differ noticeably. For example, the wind speeds shown throughout the flow over the central United States in Figure 3a are in excess of 120 knots. In contrast, Figure 3 shows speeds below 110 knots. In this case, the referenced radiosonde data indicated that Figure 3 is in better agreement with the observations, except in the vicinity of 43°N latitude and 109°W longitude. In this area the values shown in Figure 3a are more reasonable.

Two other figures worth noting are Figures 4 and 4a (0000 GMT 6 January). Figure 4a shows a region of high wind speeds (above 120 knots) over the central United States, with a max of 129 knots located about 44°N latitude and 99°W longitude. In comparison, Figure 4 displays somewhat weaker winds throughout the region. Radiosonde data referenced in this vicinity indicated that the values shown in Figure 4 are more reasonable. In the area of strong winds (in excess of 110 knots) located over the eastern U. S., soundings suggested that the value (137 kts) shown on Figure 4a (about 39°N latitude, 76°W longitude) is somewhat higher than the observed value (120 kts) and the value shown on Figure 4 is slightly lower. In general, Figure 4 appears to be better correlated with the observations.

Further comparisons revealed that, in spite of the differences noted above, (and other differences that were observed) the data produced by Bracknell and NMC are generally comparable. (It should be mentioned here, that Figures 1-10 (NMC) agree quite well with the NMC's 250 mb height/isotach analysis charts.)

Statistical Evaluation

Twice per day, programs were run to extract radiosonde station reports from NMC's 0000 GMT and 1200 GMT ADP files (observational data in O. N. 29 format). These reports were extracted from stations located within the area between 25°N to 60°N latitude and 50°W to 145°W longitude. To be useful, the report had to contain (1) seven levels of mandatory data (500-100 mb) in category 01 (mandatory constant-pressure data) and (2) maximum wind information in category 03 (wind at variable pressure). If category 03 contained information for more than one max wind (between 500-100 mb), the wind with the greatest speed was selected.

Provided that the above criteria were satisfied, the seven manadatory wind speeds were used as input to the max wind finder code and max wind data (speed and pressure level) were computed. Then the calculated wind data were compared to the observed wind data (cat. 03) and differences were formed (i.e. calculated minus observed). These differences composed the data base from which various statistics were derived, i.e., the mean algebraic difference and the root-mean-square (rms) difference. Only observed wind speeds or computed wind speeds 60 knots or greater were used in compiling the statistics.

Table 1 presents the mean and root-mean-square difference computed for the period January 4-9. Also shown (bottom of page) are the averages of the statistics presented in the table. As indicated, the calculated wind data is in good agreement with the observed wind data. Statistics compiled for other periods revealed similar results.

Variation of average pressure differences (Table 1 values) are shown in Figure 11. Mean pressure differences are negative only on 12Z the 4th and 00Z the 6th when a large number of negative values were observed. All other periods show positive pressure differences. This suggests that there is a tendency for the max wind finder code to produce lower pressures than observed. As illustrated in Figure 12, there is very little difference between computed and observed wind speeds.

Table 2 shows the averages of the RMS differences by wind speed categories. (Namely the averages were computed for all winds greater than 60 knots, then all winds greater than 70 knots, etc.) These statistics were computed in an attempt to determine a reasonable cut-off value for reporting and/or displaying max wind information. As noted in Table 2 and Figures 13 and 14 (graphs of table 2 values), there is little difference between the values. It is interesting to note, however, that as the wind speed increases, the speed differences increase while on the other hand, the pressure differences decrease. This suggests that the polynomial fitting method does a better job finding the maximum level for stronger winds, but underestimates the value of the wind.

Conclusion

Overall, it appears that the method devised at NMC of calculating maximum wind information generally produces reasonable and reliable data. This was evidenced not only in the recent evaluations, but also in previous evaluations. Evaluations of NMC's max wind level charts, however, indicate that 70 knots seems to be the boundary between the chaotic and coherent regions. Therefore, if this information is to be used in the output sections of a forecast model, only information from winds speeds greater than 70 knots should be used.

TABLE 1.

MEAN ALGEBRAIC DIFFERENCE AND ROOT-MEAN SQUARE (RMS) DIFFERENCE BETWEEN CALCULATED AND OBSERVED WIND DATA (CALCULATED-OBSERVED)

DATE	TIME	NO. REPORTS	MEAN PRESSURE DIFF (MB)	RMS (PRESSURE)	MEAN ABS WIND SPEED DIFF (KTS)	RMS (WIND SPEED)
4 JAN 82	12Z	44	-15.1	55.5	.6	7.8
5 JAN	00Z	40	12.6	56.9	1.1	6.3
5 JAN	12Z	49	13.2	59.7	1.2	8.8
6 JAN	00Z	42	-15.2	52.7	1.0	7.6
6 JAN	12Z	51	13.2	59.0	-.4	5.0
7 JAN	00Z	44	4.1	34.8	-.3	4.8
7 JAN	12Z	47	.7	36.8	-.6	7.3
JAN	00Z	51	1.5	41.5	-1.4	6.8
8 JAN	12Z	48	10.5	32.9	-.6	9.5
9 JAN	00Z	40	6.3	30.9	.2	9.2

**Averages of the above cases (10 observation periods)

(1) Mean of the Pressure Difference 3.2

(2) RMS (Pressure) 47.4

(3) Mean of the Wind Speed Difference .1

(4) RMS (wind speed) 7.5

TABLE 2.

AVERAGES OF THE RMS DIFFERENCE (FOR ALL WINDS) BY CATEGORIES

CRIT VALUE	RMS (PRESS)	RMS (WIND SPD)
> 60 KTS	47.4	7.5
> 70 KTS	44.9	7.7
> 80 KTS	43.3	8.0
> 90 KTS	41.9	8.3
> 100 KTS	38.9	8.4

REFERENCES

Stackpole, John, D.: "How to manufacture charts of the maximum wind speed and level of maximum wind," Office Note 229, March 1981.

Hughes, W. L.: 1981, "Numerical forecasts of tropopause and max wind", International Civil Aviation Organization, Area Forecast Panel Second Meeting, Montreal, 21st September to 9th October 1981.

Captions for Figures:

Figure 1. Gridprinted field of max wind speeds in knots (contoured in 20 kt intervals) for 1200 GMT, 4 January 1982. (Produced at NMC).

Figure 1a. Chart of max wind speeds in knots. The value of the wind speed is shown only when the speed exceeds 60 kts. (Produced at Bracknell).

Figures 2. and 2a. Charts for 0000 GMT, 5 January 1982.

Figures 3. and 3a. Charts for 1200 GMT, 5 January 1982.

Figures 4. and 4a. Charts for 0000 GMT, 6 January 1982.

Figures 5. and 5a. Charts for 1200 GMT, 6 January 1982.

Figures 6. and 6a. Charts for 0000 GMT, 7 January 1982.

Figures 7. and 7a. Charts for 1200 GMT, 7 January 1982.

Figures 8. and 8a. Charts for 0000 GMT, 8 January 1982.

Figures 9. and 9a. Charts for 1200 GMT, 8 January 1982.

Figures 10. and 10a. Charts for 0000 GMT, 9 January 1982.

Figure 11. Graph of the bias statistics (pressure levels) presented in Table 1. The graph shows that the computed pressure levels are usually higher than the observed.

Figure 12. Graph of the bias statistics (wind speeds) present in Table 1. The graph shows that there is very little difference between the computed wind speeds and the observed wind speeds.

Figure 13. Graph of the average rms wind speed differences by categories (Values from Table 2.)

Captions for Figures: (Continued)

Figure 14. Graph of the average rms pressure differences by wind speed categories. (Values from Table 2.)

Table 1. Mean and RMS differences between computed and observed wind data.

Table 2. Averages of RMS differences.

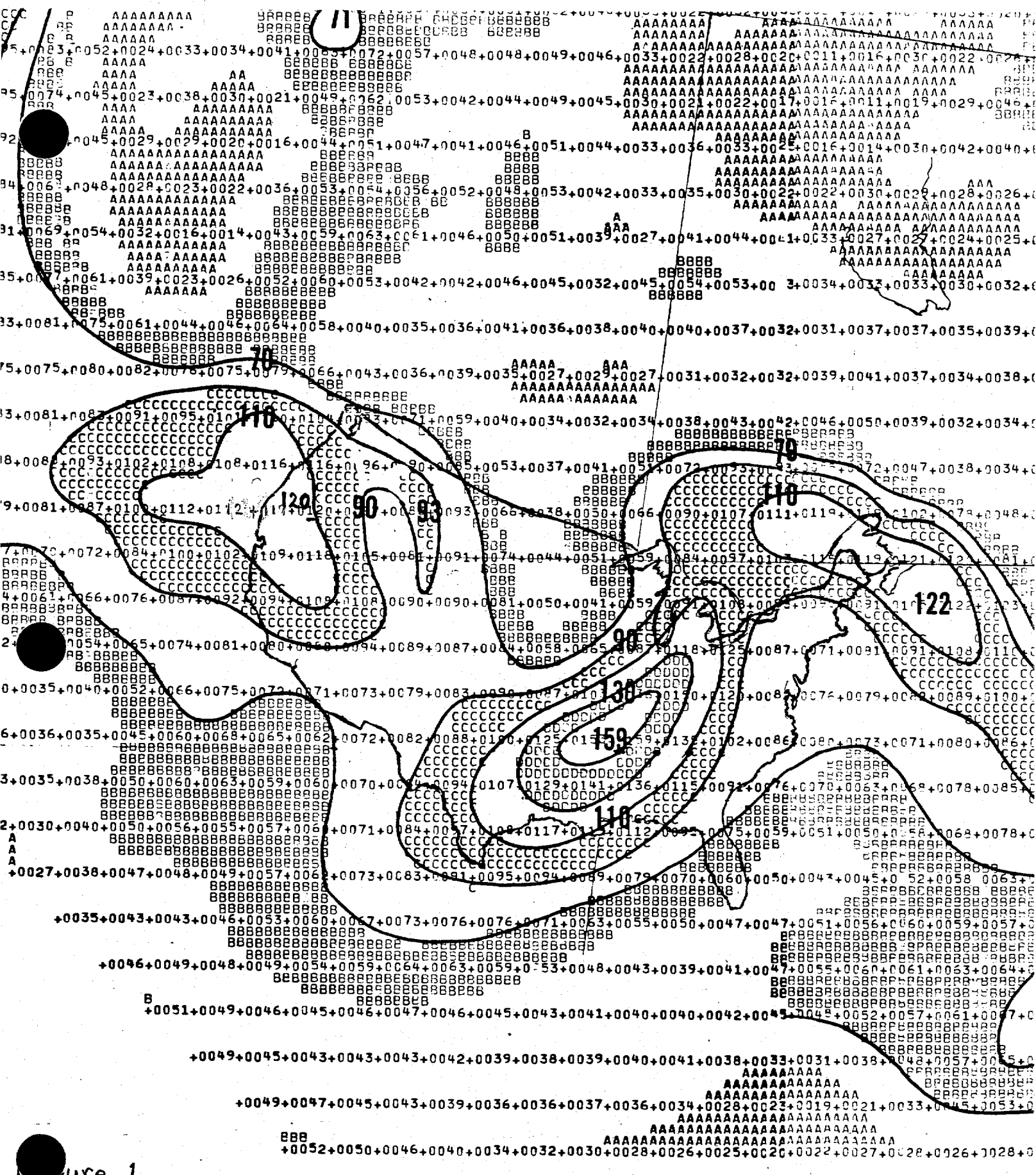


Figure 1

+09 +10 +11 +12 +13 +14 +15 +16 +17 +18 +19 +20 +21 +22 +23 +24 +25 +26 +27 +28 +29 +30 +3

TER 127 4 JAN 82 WMC/NMC WASHINGTON.
0 K= 27 UN= R= 3 G= 22 J= 4225 B= 8498 Z=38693 A=-0.14100037E+01 N= 6 TRO WIND F
00000840 5201040C 03161081 21329725 C1168F60 00000006 00000000 =0 N= 0 F1= 0 F2= 0 CD= 200 00271082 00000000 00000

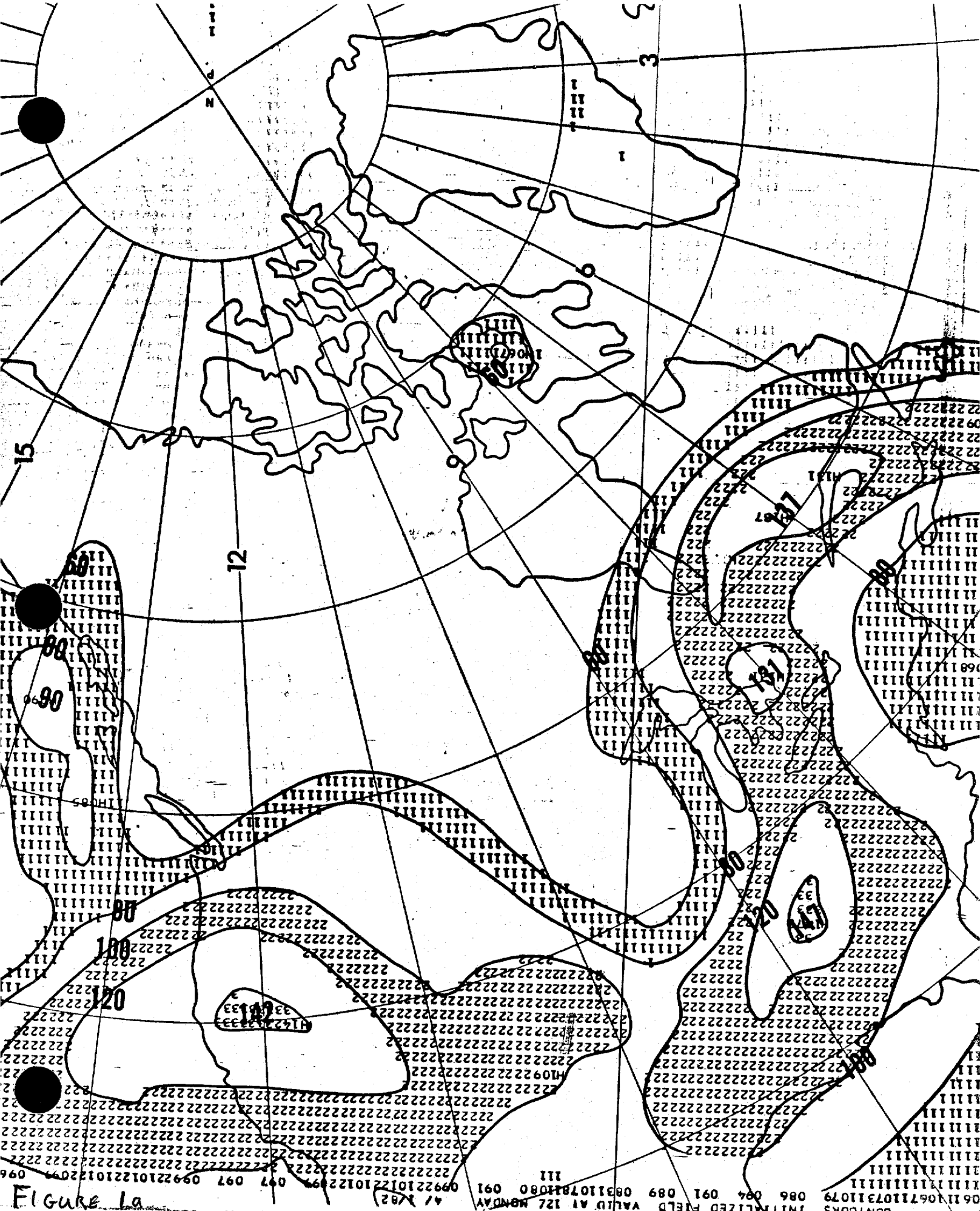

CONTOURS INITIALIZED FIELD VALID AT 12Z MONDAY
4/ 3/82
091 089 088 087 086 085
091 089 088 087 086 085
N.P.
3
6
9
12
15
60
80
100
120
140
160
180

FIGURE 1a

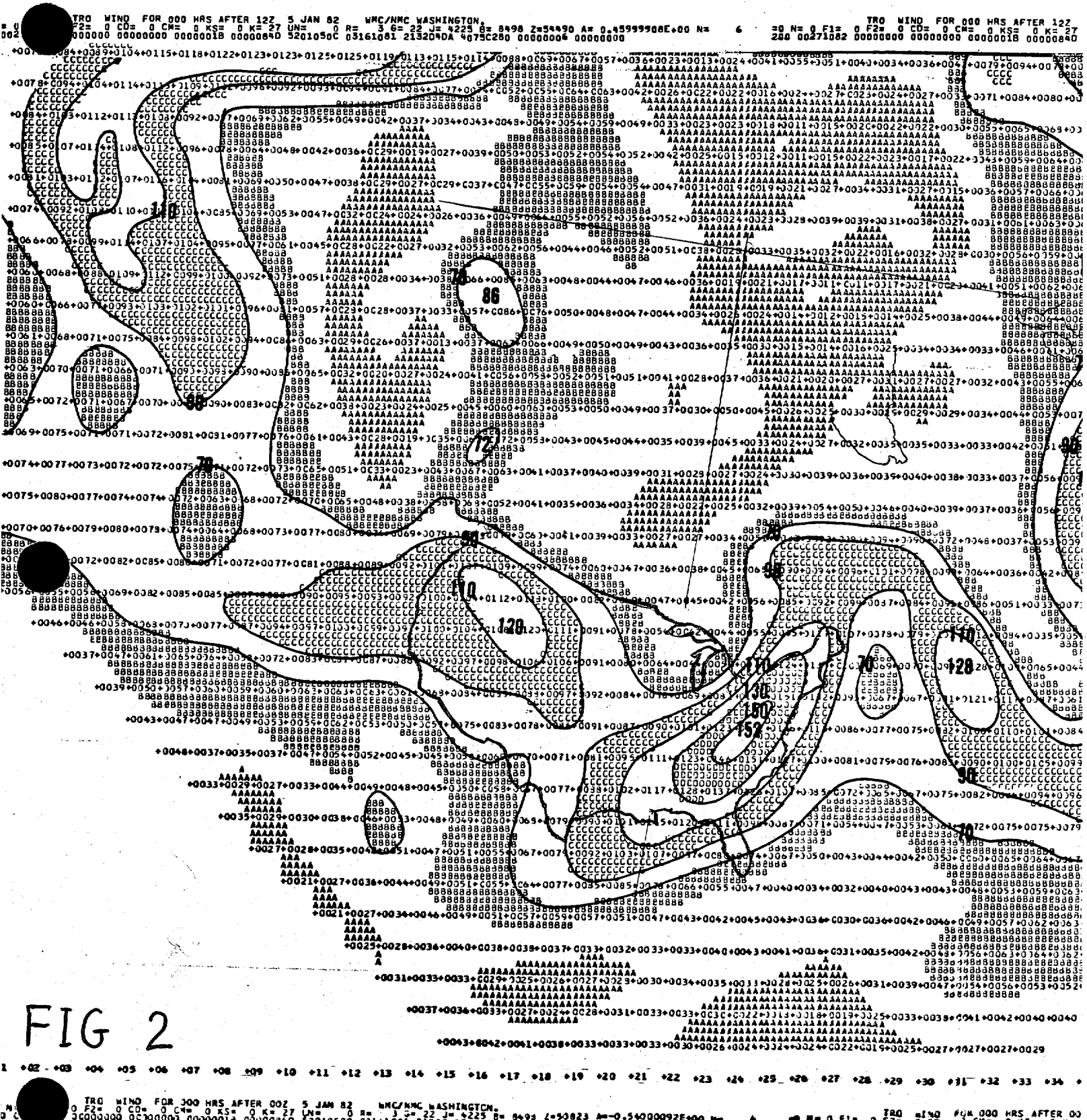
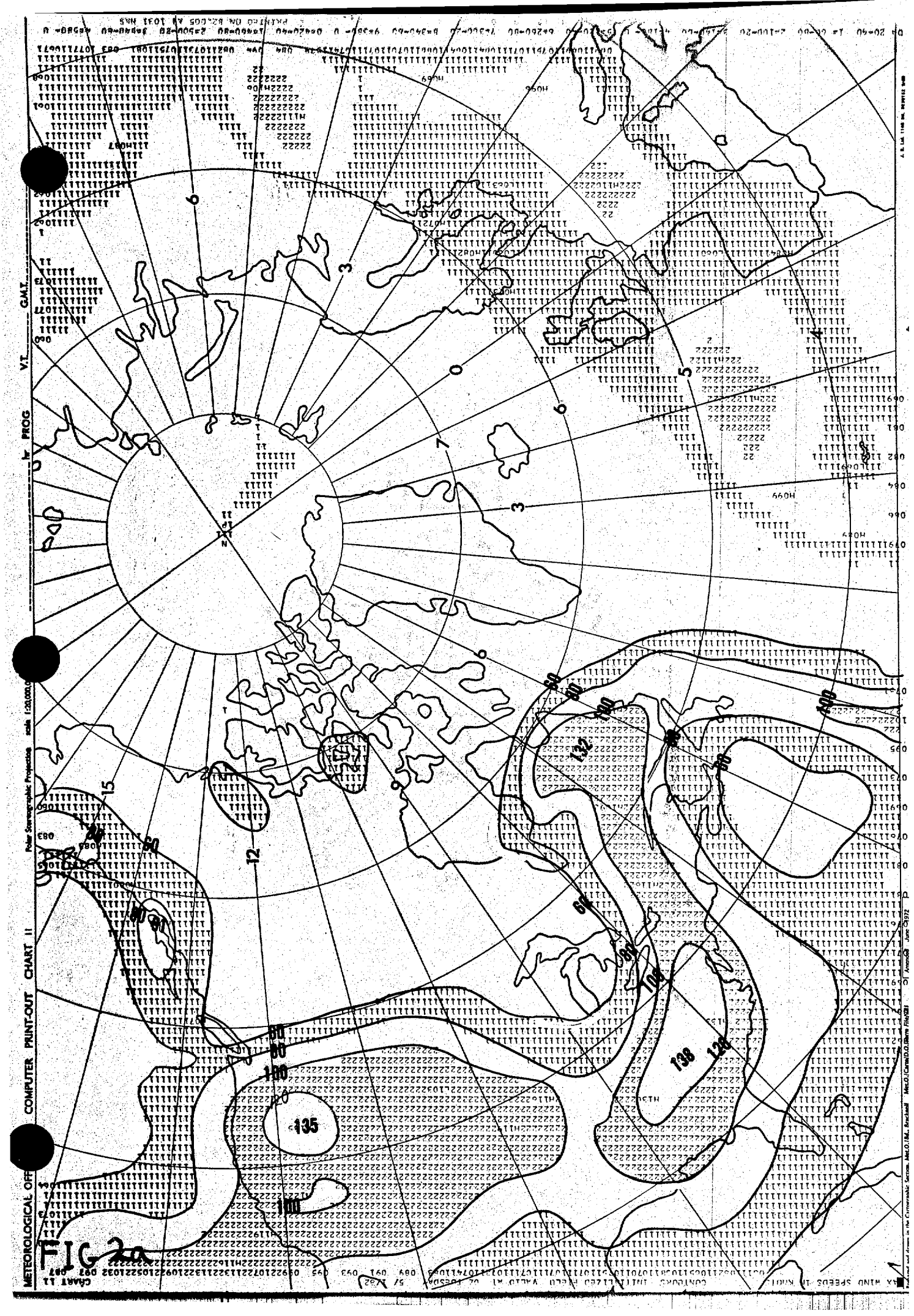

TRO WIND FOR 000 HRS AFTER 12Z 5 JAN 82 WMC/NMC WASHINGTON.
TRO WIND FOR 000 HRS AFTER 12Z

FIG 2


METEOROLOGICAL OFF
COMPUTER PRINT-OUT CHART II
Polar Stereographic Projection scale 1:20,000,0
hr PROG V.T. G.M.T.
135
138
120
100
80
60
FIG 2a

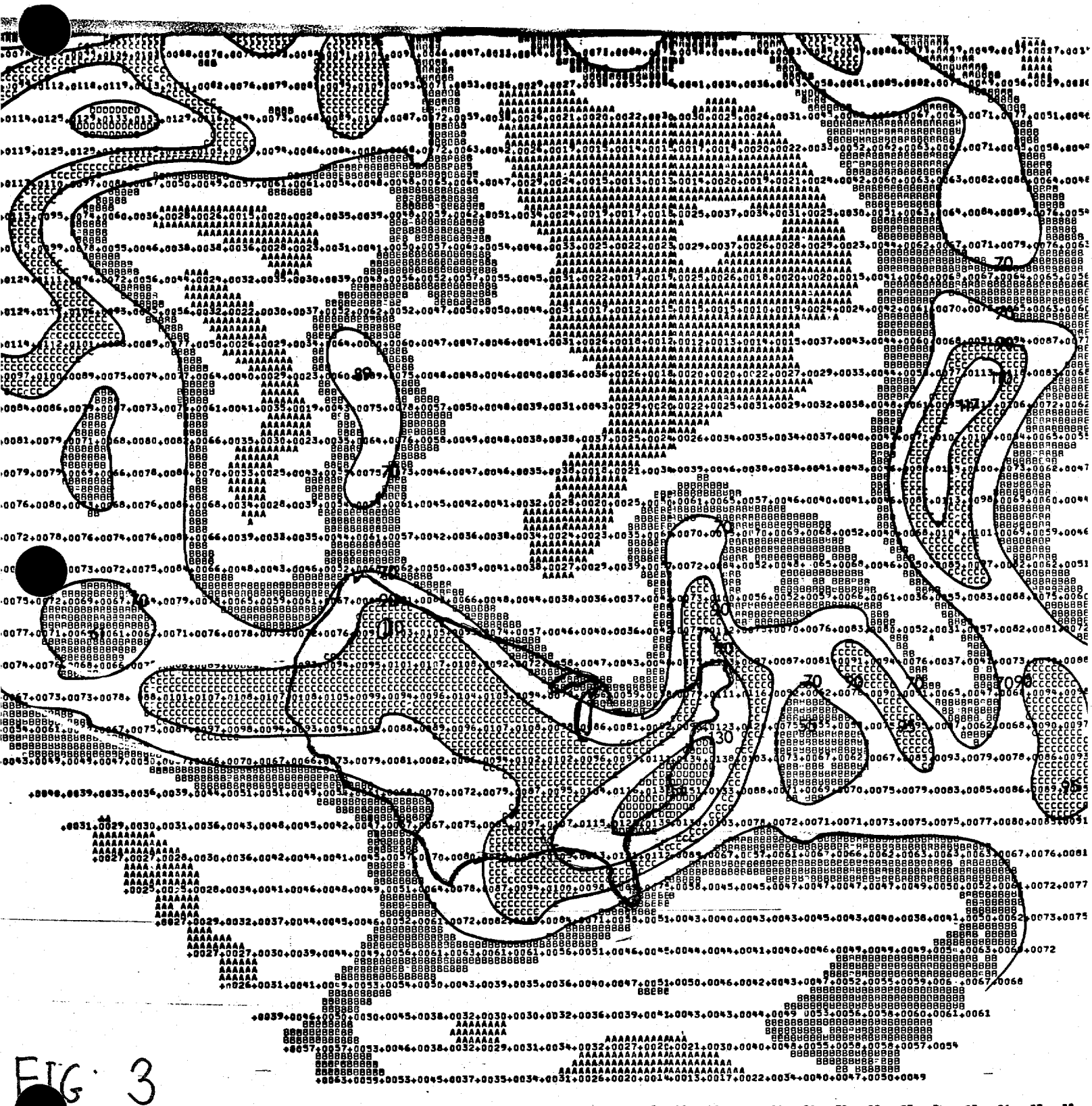


FIG. 3

5 JAN 12 Z

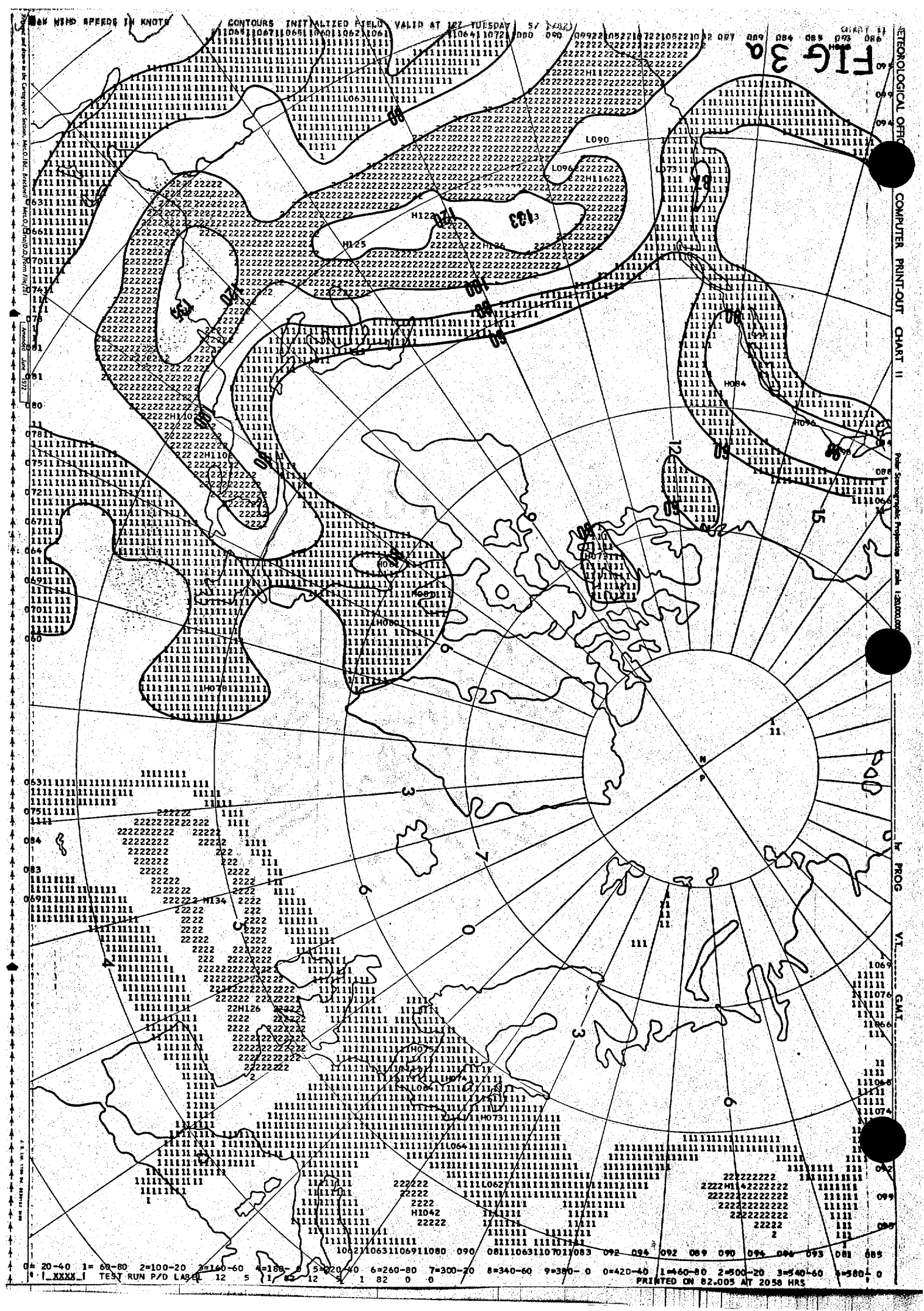


FIG 3a
CONTOURS INITIALIZED FIELD VALID AT 12Z TUESDAY
COMPUTER PRINT-OUT CHART II
PROG V.T. GMT
Polar Stereographic Projection scale 1:20,000,000
0= 20-40 1= 60-80 2=100-20 3=140-60 4=180- 0 5=220-40 6=260-80 7=300-20 8=340-60 9=380- 0 0=420-40 1=460-80 2=500-20 3=540-60 4=580- 0
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PRINTED ON 82.005 AT 2058 HRS

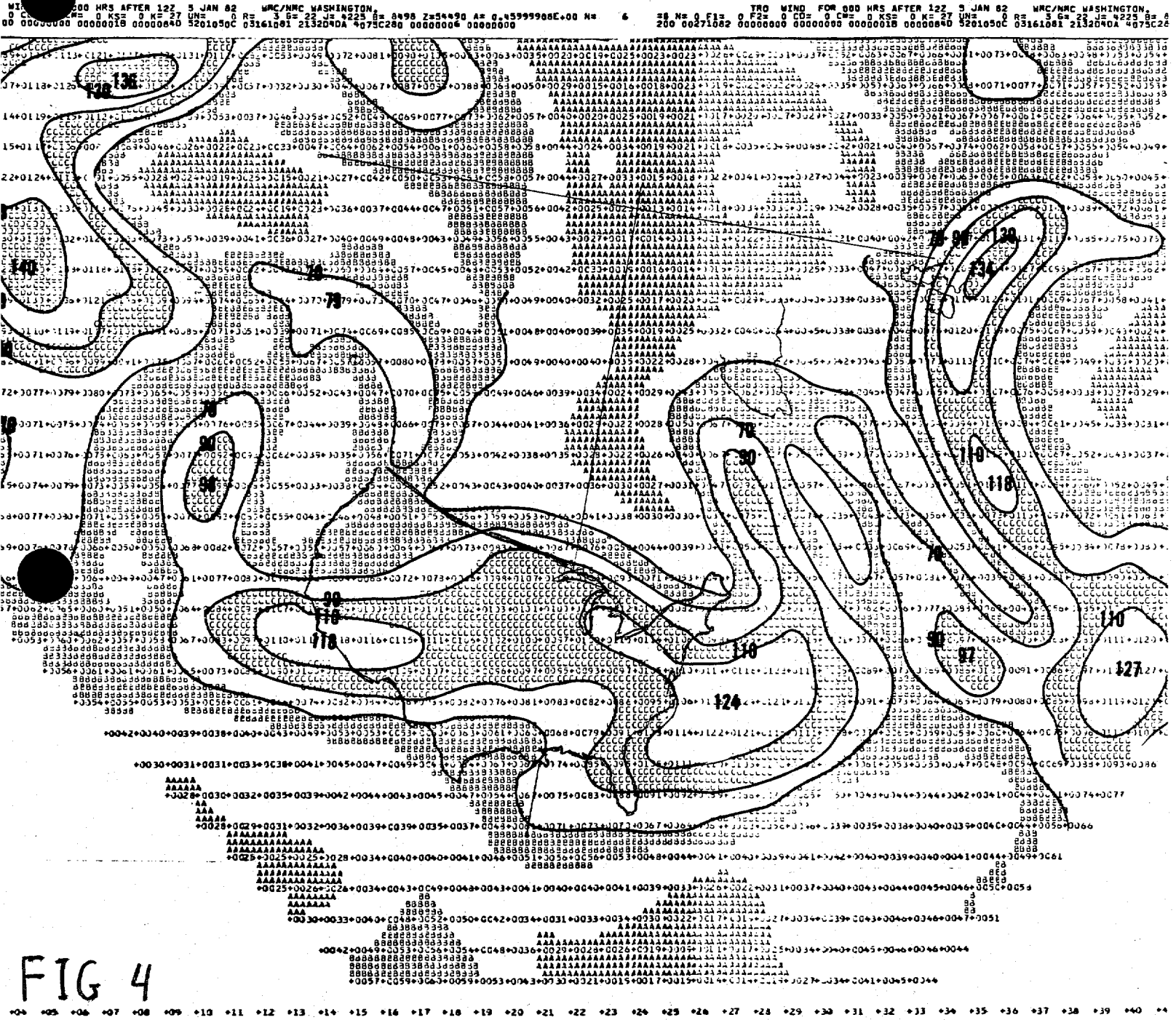
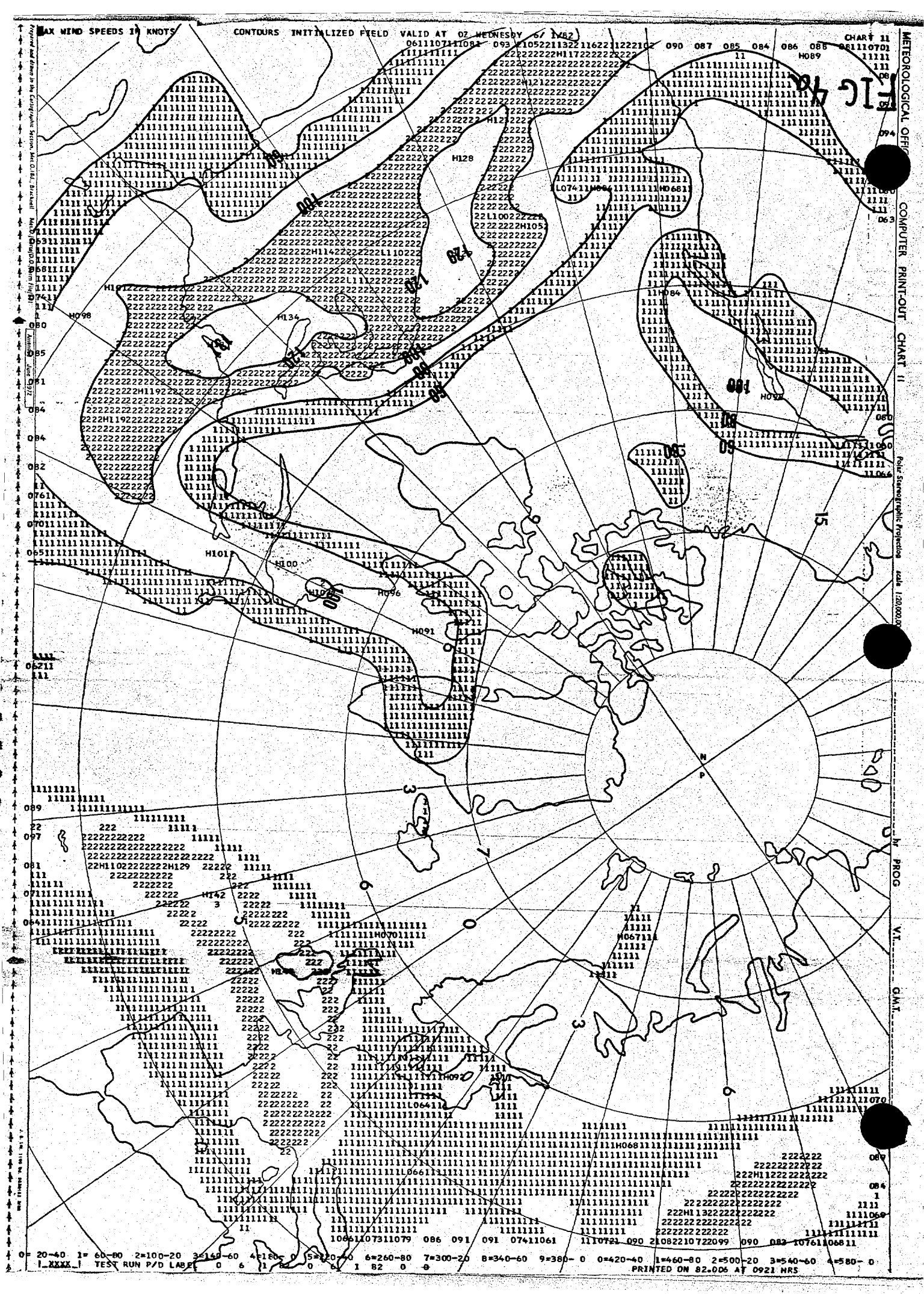


FIG 4


MAX WIND SPEEDS IN KNOTS
CONTOURS INITIALIZED FIELD VALID AT 02 WEDNESDY 6/ 1982
CHART 11
METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART 11
Prepared and drawn in the Cartographic Section, Met.O.18d., Bracknell
Polar Stereographic Projection
scale 1:20,000,000
hr PROG
V.T.
G.M.T.
0= 20-40 1= 60-80 2=100-20 3=140-60 4=180- 0 5=220-40 6=260-80 7=300-20 8=340-60 9=380- 0 0=420-40 1=460-80 2=500-20 3=540-60 4=580- 0
TEST RUN P/D LABEL
PRINTED ON 82.006 AT 0921 HRS

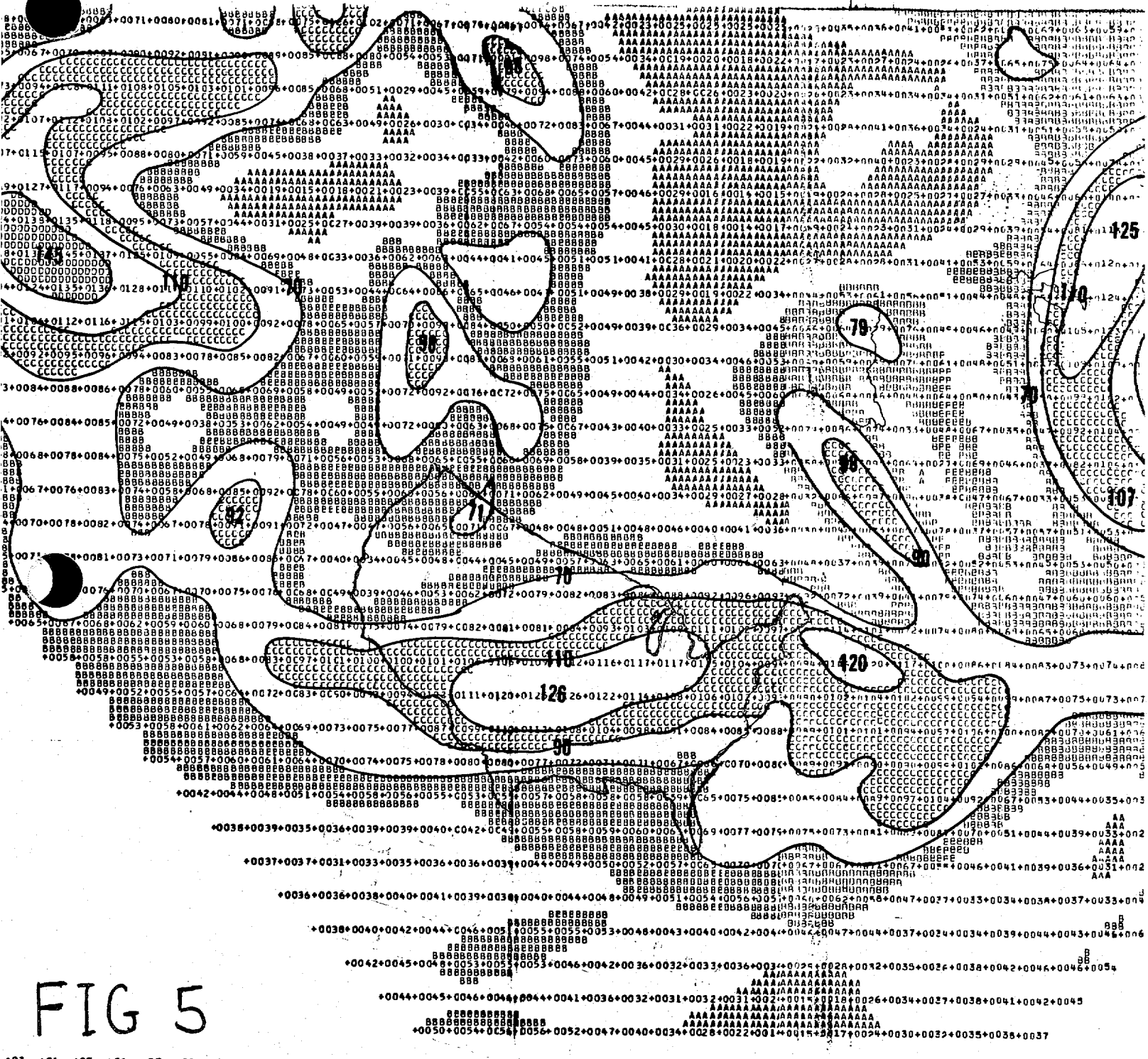


FIG 5

TRO WIND FOR 000 HRS AFTER 12Z 6 JAN 82 WMC/NMC WASHINGTON.

TRO WINC FOR 000 HRS AFTER 12Z 6 JAN

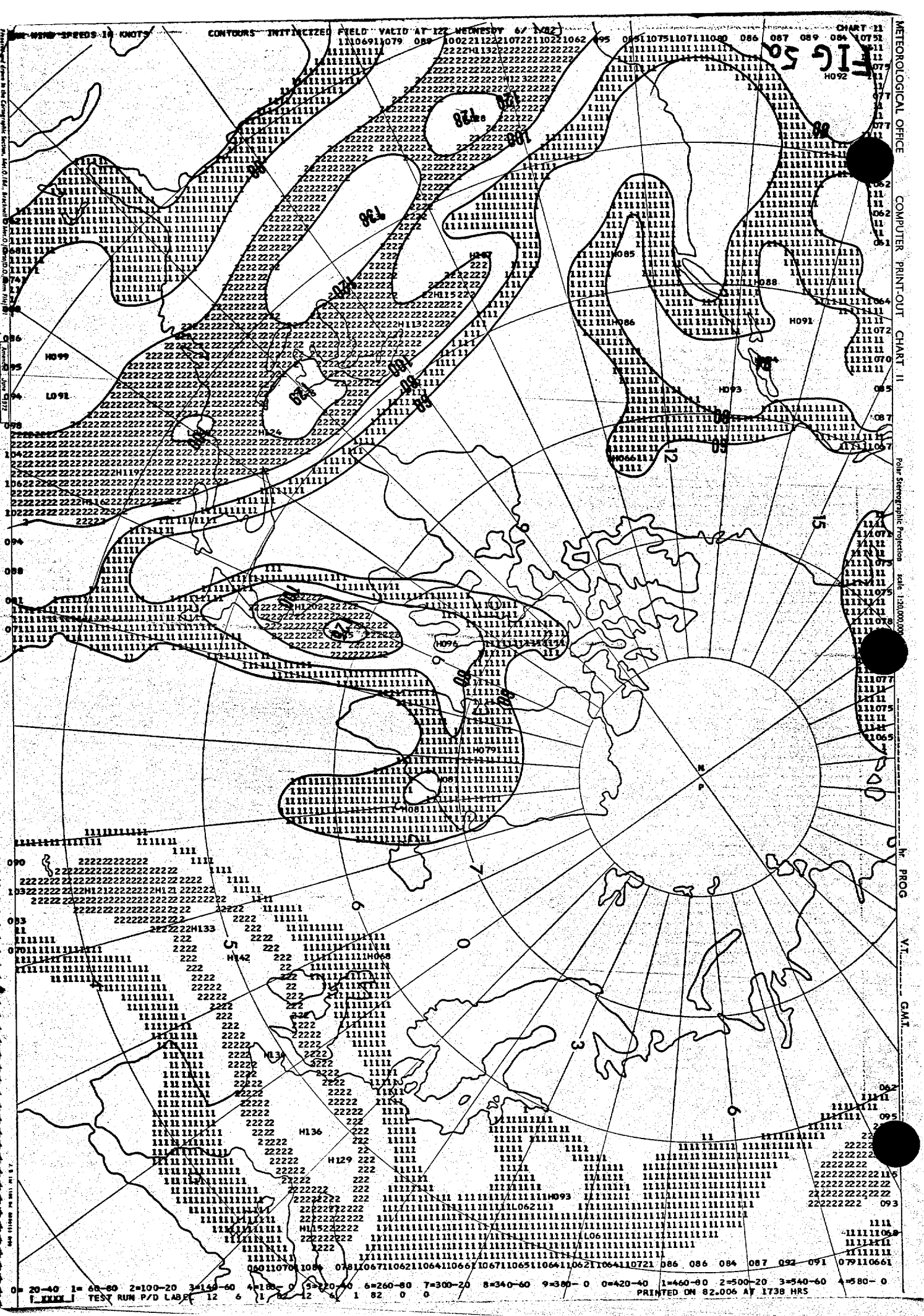

METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART 11
Polar Stereographic Projection scale 1:20,000,000
CONTOURS INITIALIZED FIELD VALID AT 12Z WEDNESDY
CHART 11
hr PROG
V.T.
G.M.T.
PRINTED ON 82.006 AT 1738 HRS
TEST RUN P/D LABEL

FIG 5a

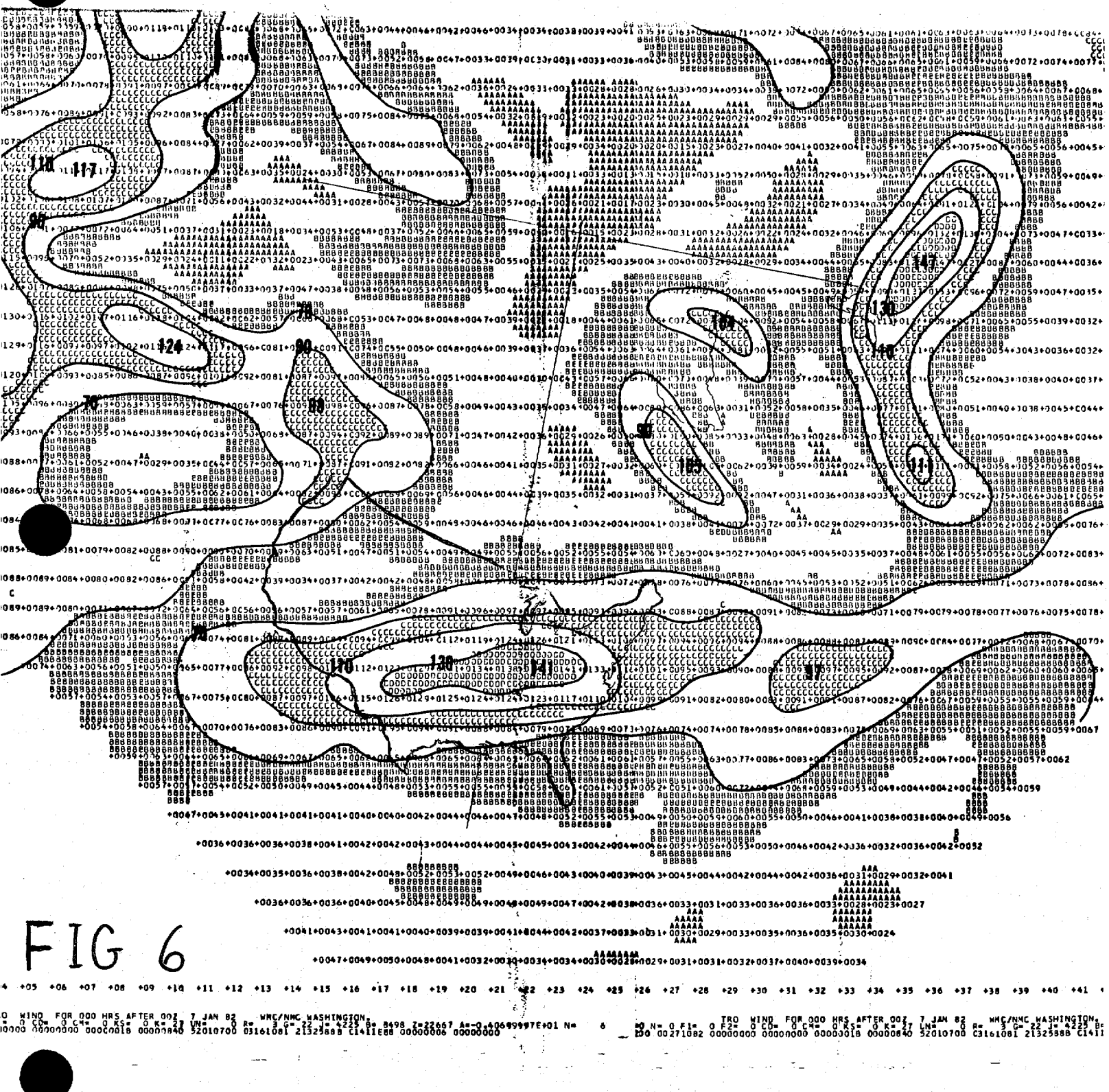

WIND FOR 000 HRS AFTER 00Z 7 JAN 82 WMC/NMC WASHINGTON.
WIND FOR 000 HRS AFTER 00Z 7 JAN 82 WMC/NMC WASHINGTON.

FIG 6

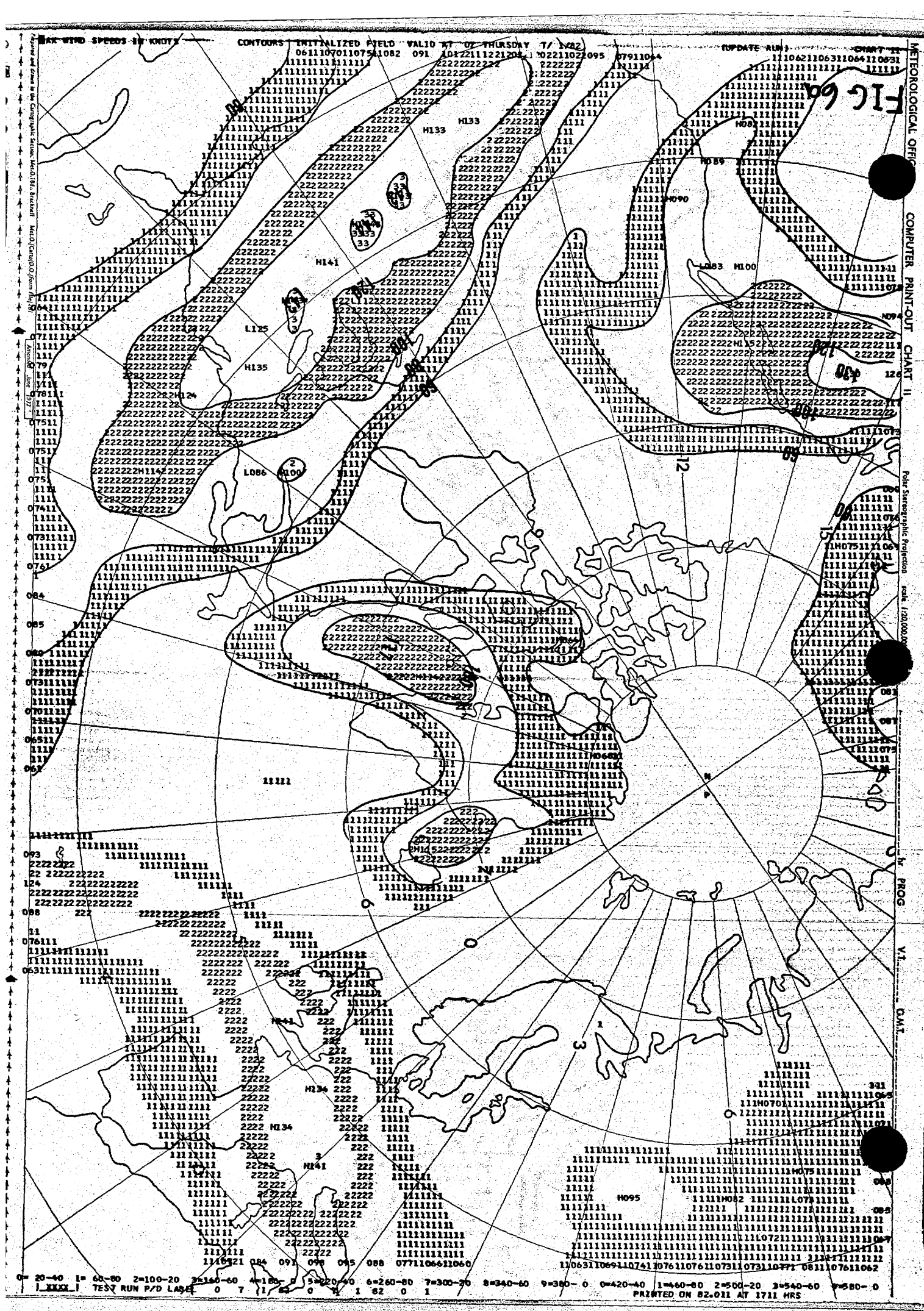


FIG 6a
METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART II
CONTOURS INITIALIZED FIELD VALID AT 07 THURSDAY
UPDATE RUN
Polar Stereographic Projection
PROG
V.T.
G.M.T.
PRINTED ON 82.011 AT 1711 HRS

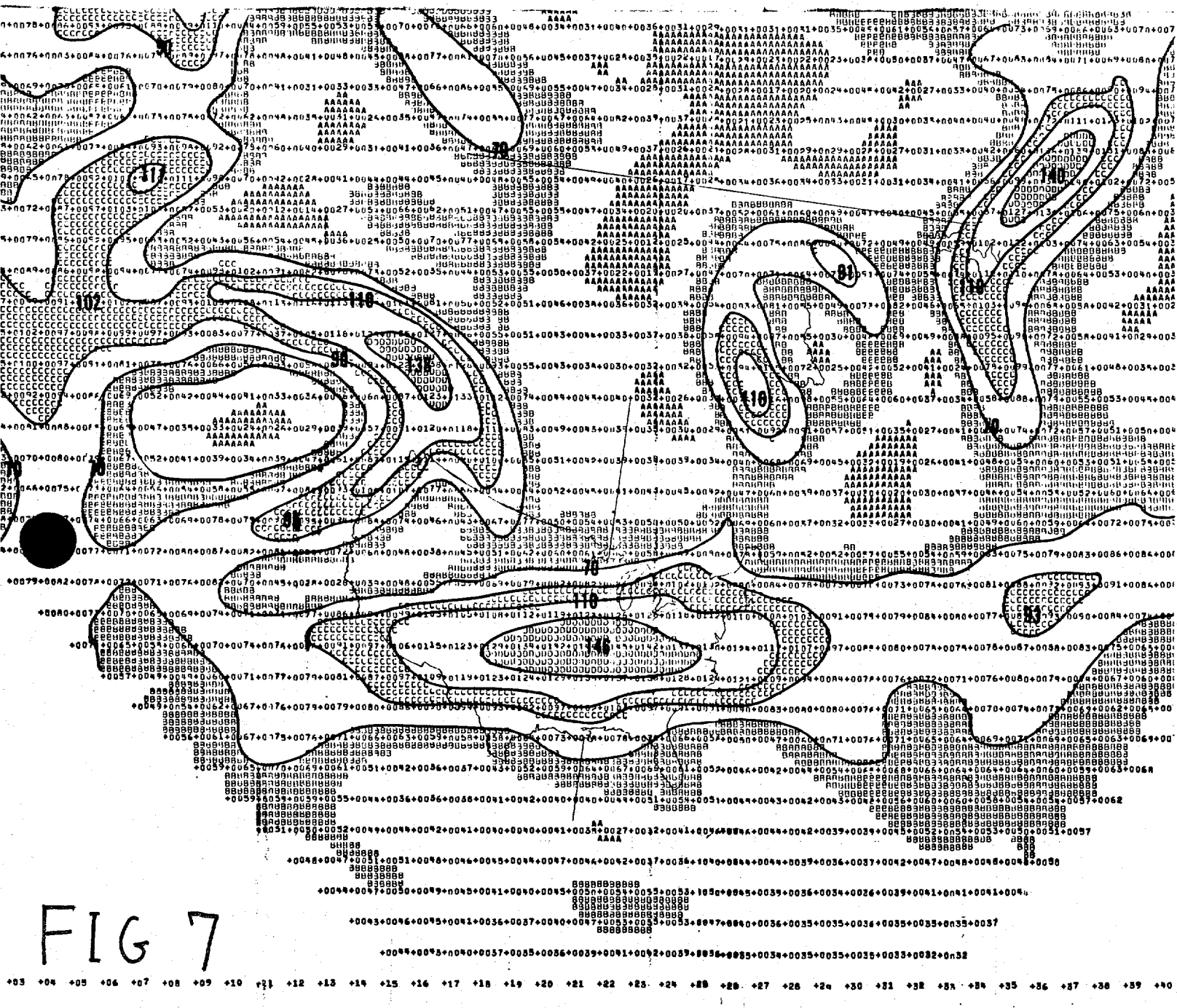


FIG 7

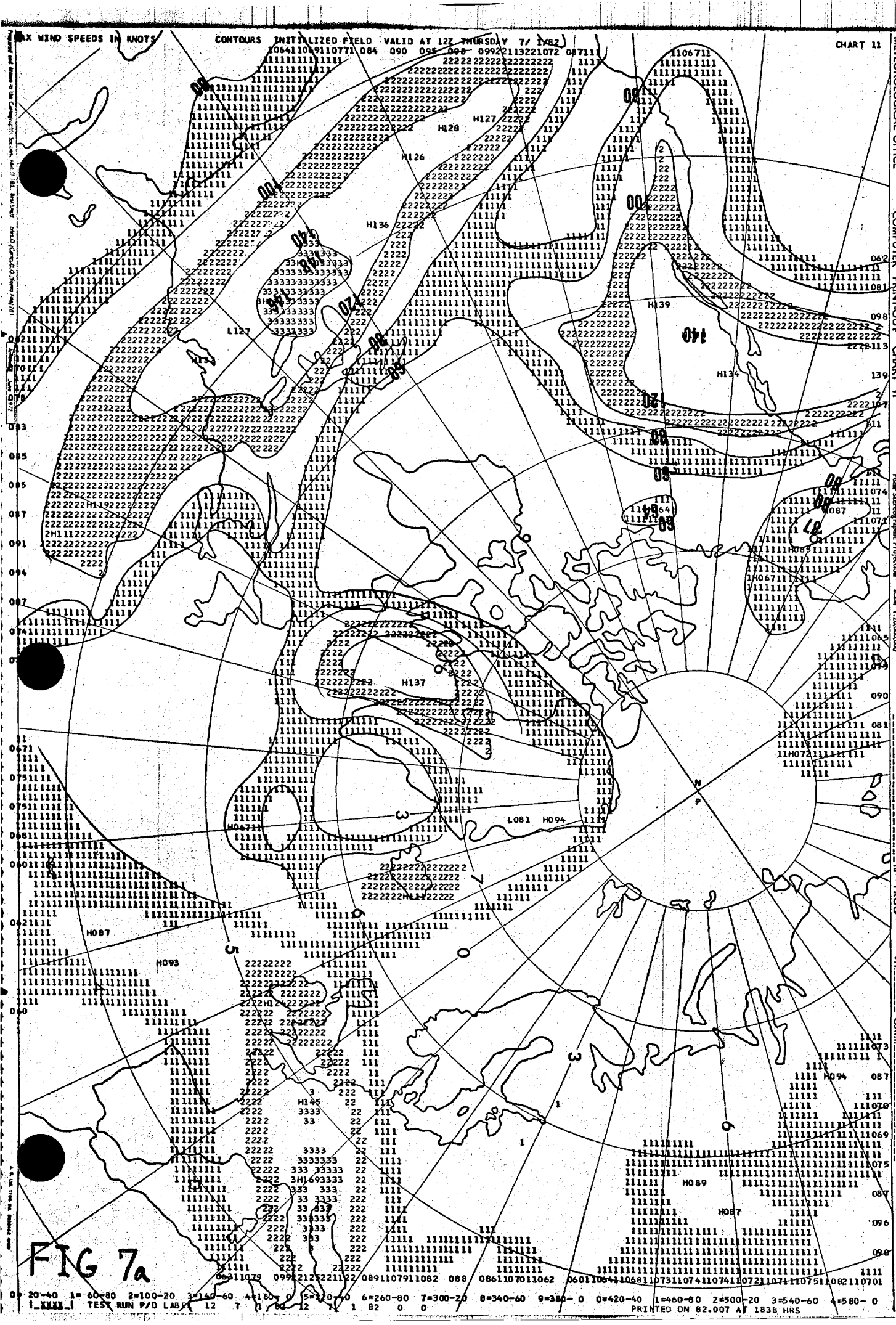

MAX WIND SPEEDS IN KNOTS
CONTOURS INITIALIZED FIELD VALID AT 12Z THURSDAY 7/ 1982
CHART 11
0= 20-40 1= 60-80 2=100-20 3=140-60 4=180- 0 5=220-40 6=260-80 7=300-20 8=340-60 9=380- 0 0=420-40 1=460-80 2=500-20 3=540-60 4=580- 0
TEST RUN P/D LABEL 12 7 1 82 12 7 1 82 0 0
PRINTED ON 82.007 AT 1836 HRS

FIG 7a

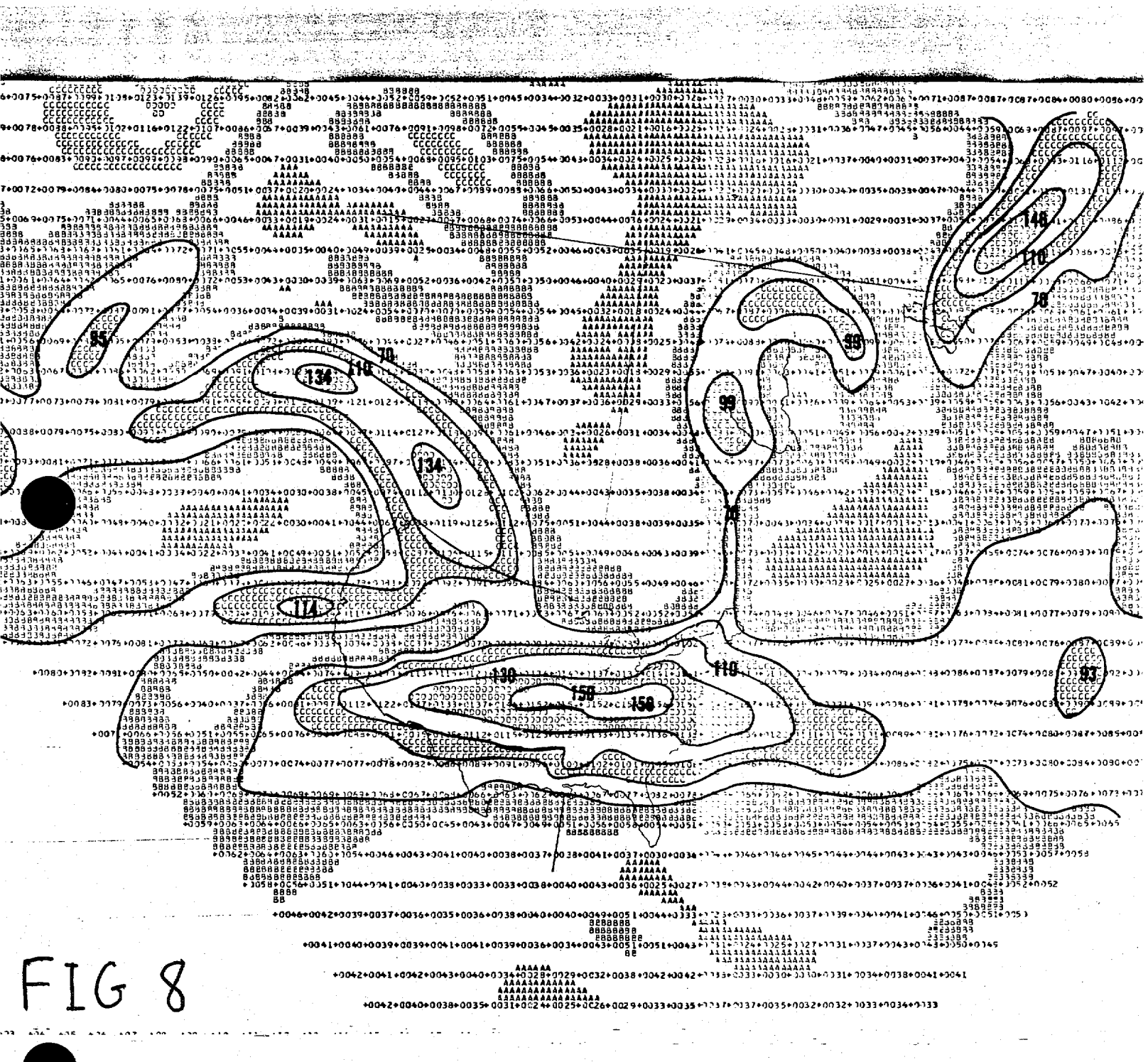


FIG 8

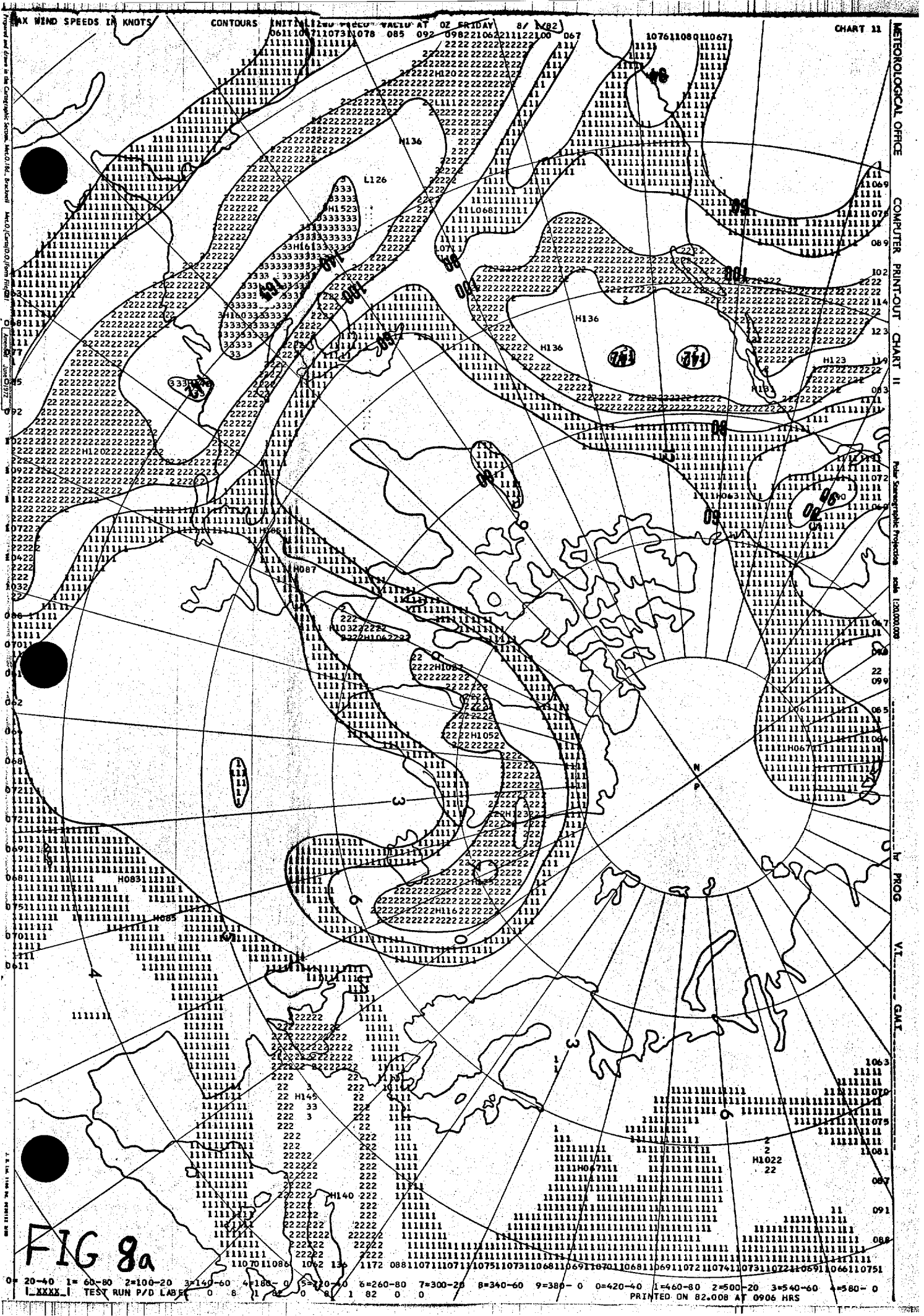

MAX WIND SPEEDS IN KNOTS
CONTOURS
CHART 11
METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART 11
Polar Stereographic Projection
PROG
V.T.
GMT
0= 20-40 1= 60-80 2=100-20 3=140-60 4=180- 0 5=220-40 6=260-80 7=300-20 8=340-60 9=380- 0 0=420-40 1=460-80 2=500-20 3=540-60 4=580- 0
TEST RUN P/D LABEL
PRINTED ON 82.008 AT 0906 HRS

FIG 8a

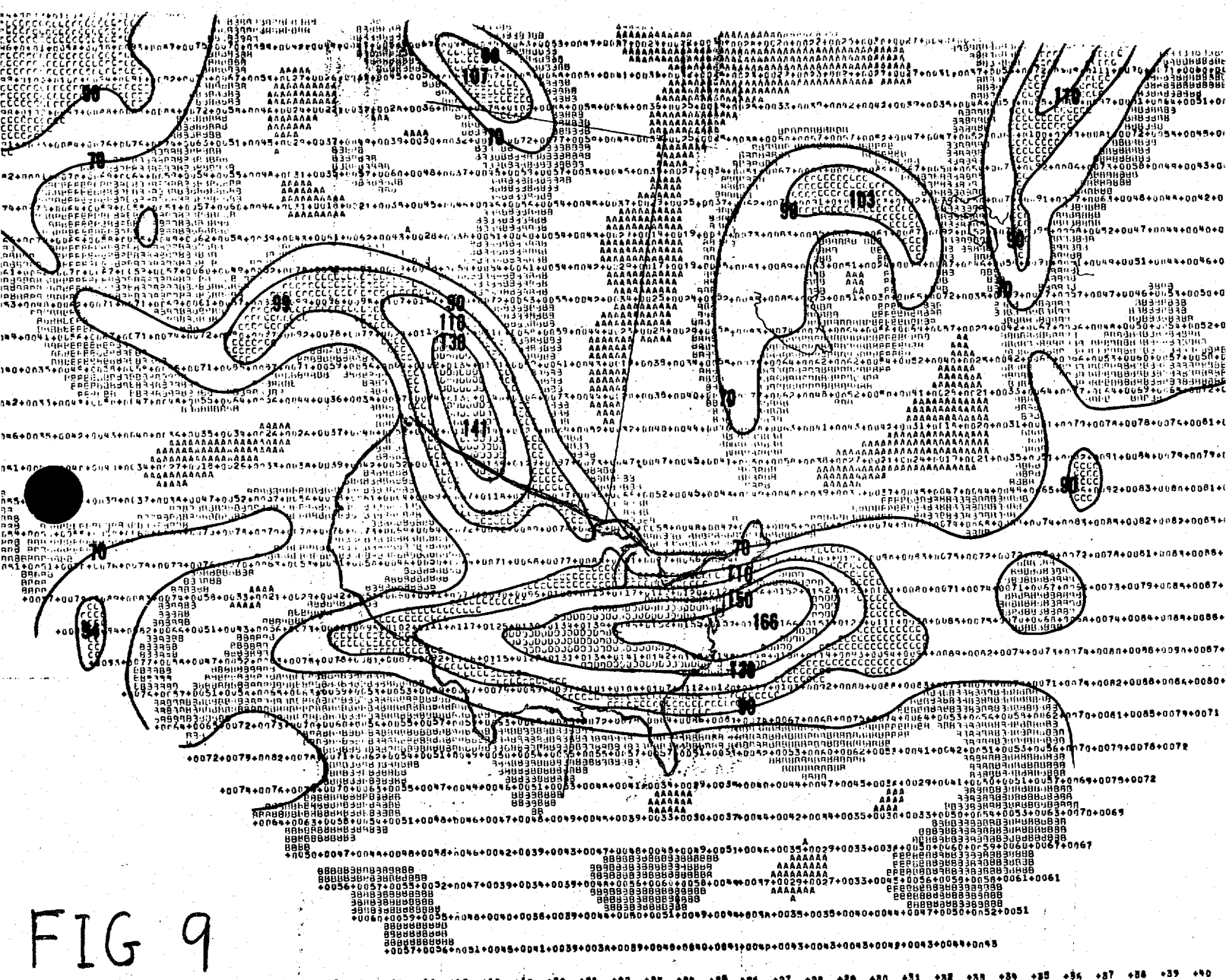


FIG 9

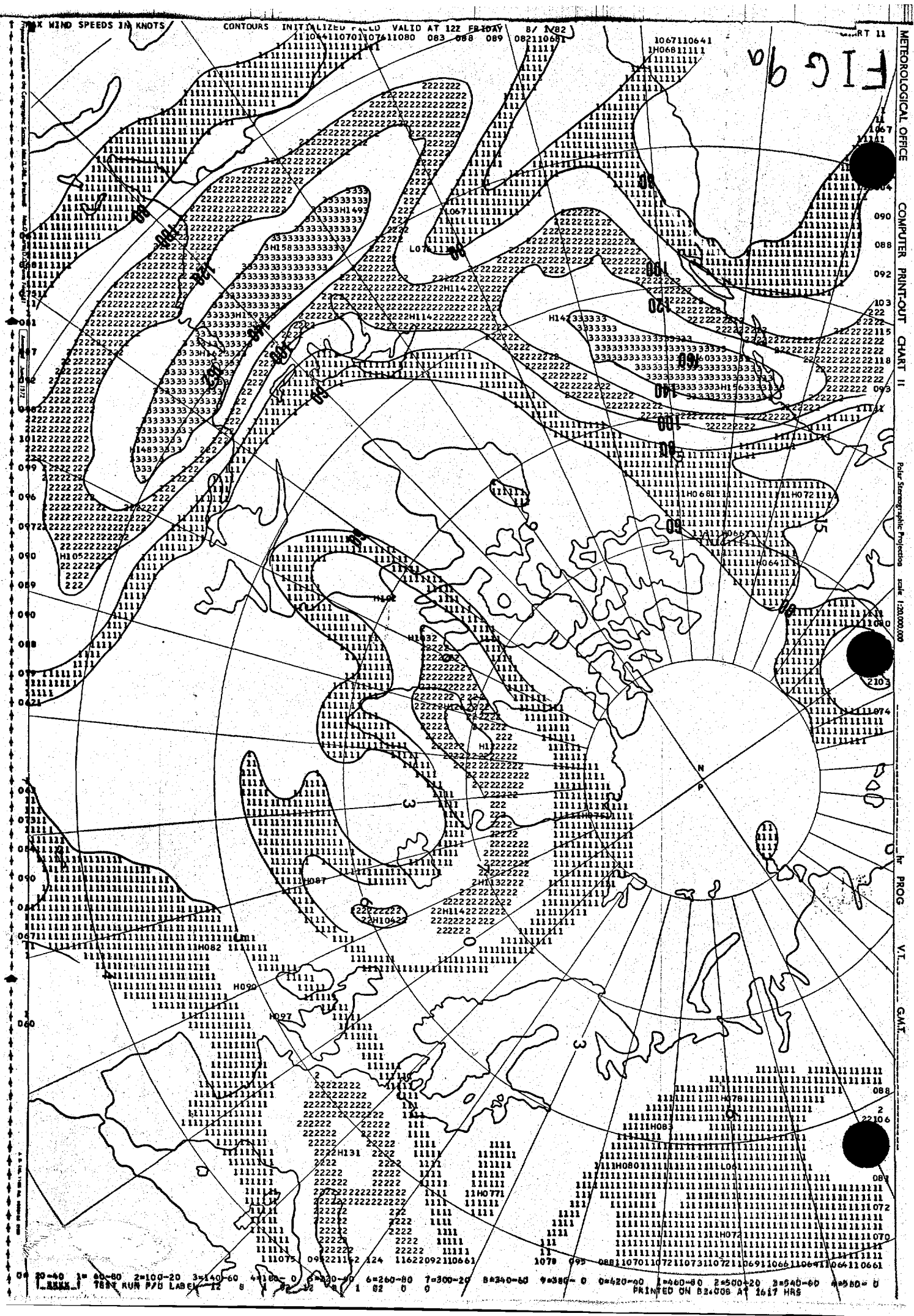

MAX WIND SPEEDS IN KNOTS
CONTOURS INITIALIZED FIELD VALID AT 12Z FRIDAY 8/ 1/82
METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART 11
Polar Stereographic Projection scale 1:20,000,000
V.T. hr PROG G.M.T.
PRINTED ON 82/008 AT 1617 HRS

FIG 9a

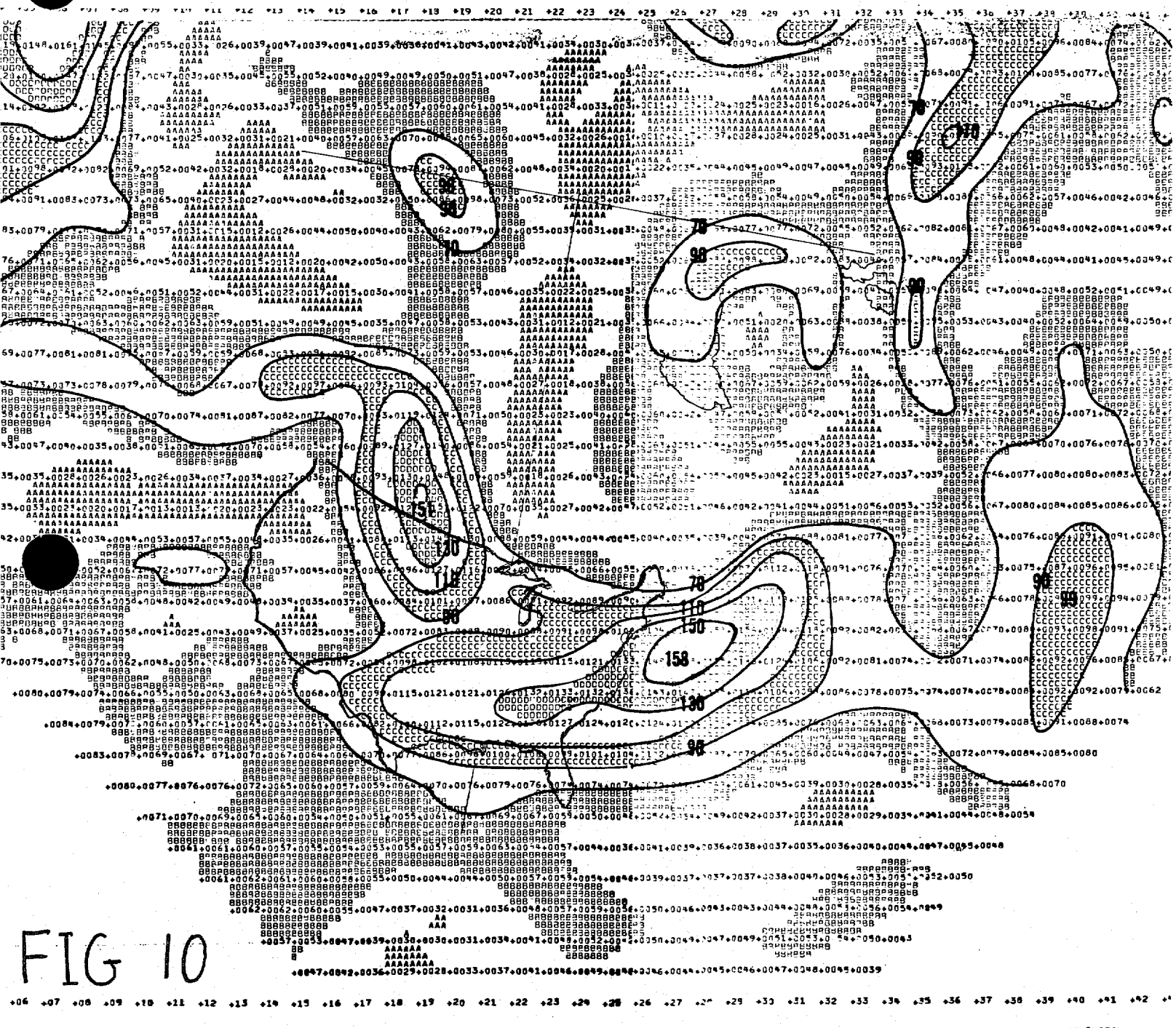
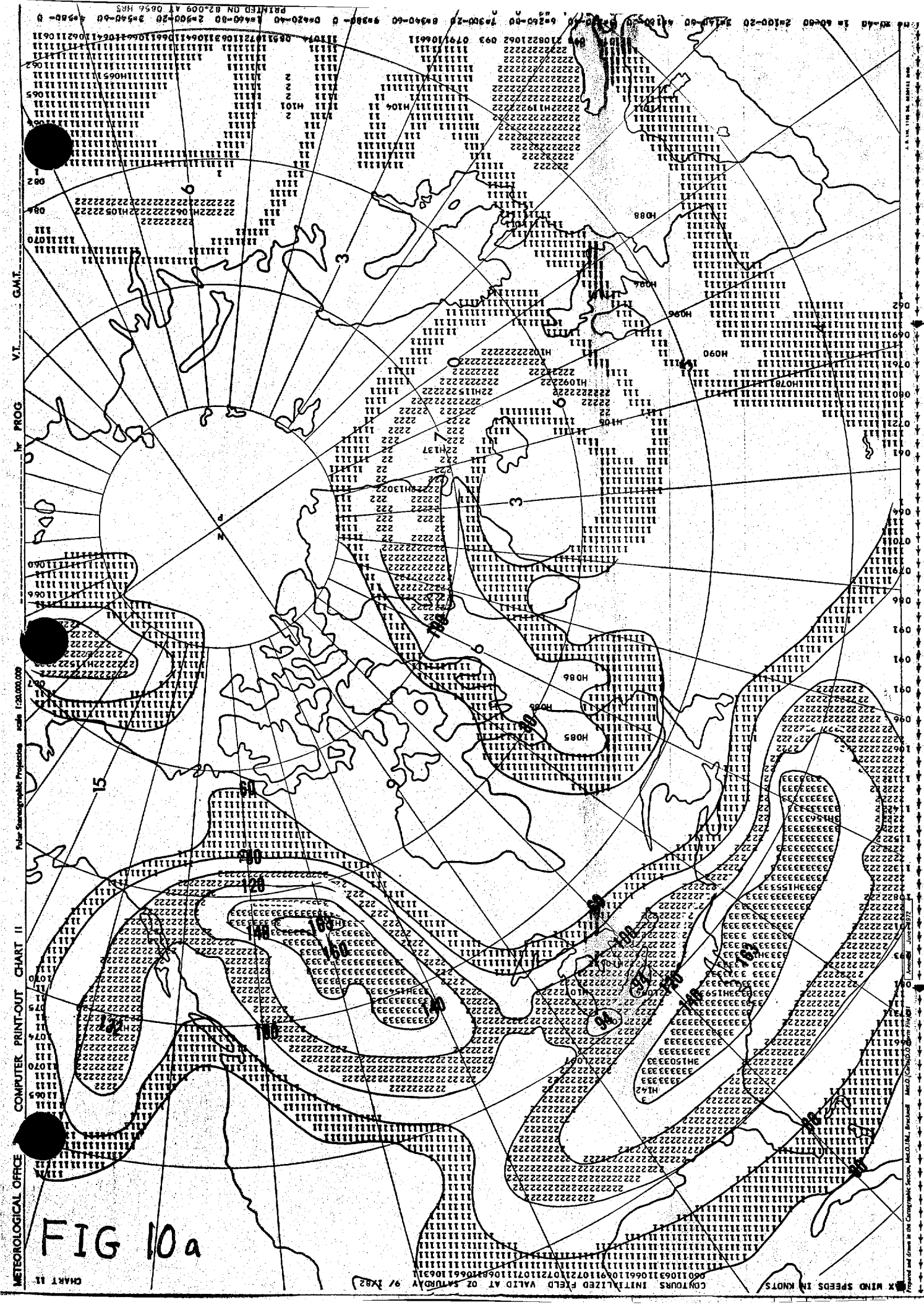


FIG 10

FOR 000 HRS AFTER 00Z 9 JAN 82 WMC/NMC WASHINGTON.

FOR 000 HRS AFTER 00Z 9 JAN 82 WMC/NMC WASHINGTON.


METEOROLOGICAL OFFICE
COMPUTER PRINT-OUT CHART II
Polar Stereographic Projection scale 1:20,000,000
hr PROG
V.T. G.M.T.
CONTOURS INITIALIZED FIELD VALID AT 02 SATURDAY 9/ IX82
MAX WIND SPEEDS IN KNOTS
CHART II
FIG 10a

NO. 340-M DIETZGEN GRAPH PAPER
MILLIMETER

DIETZGEN CORPORATION
MADE IN U.S.A.

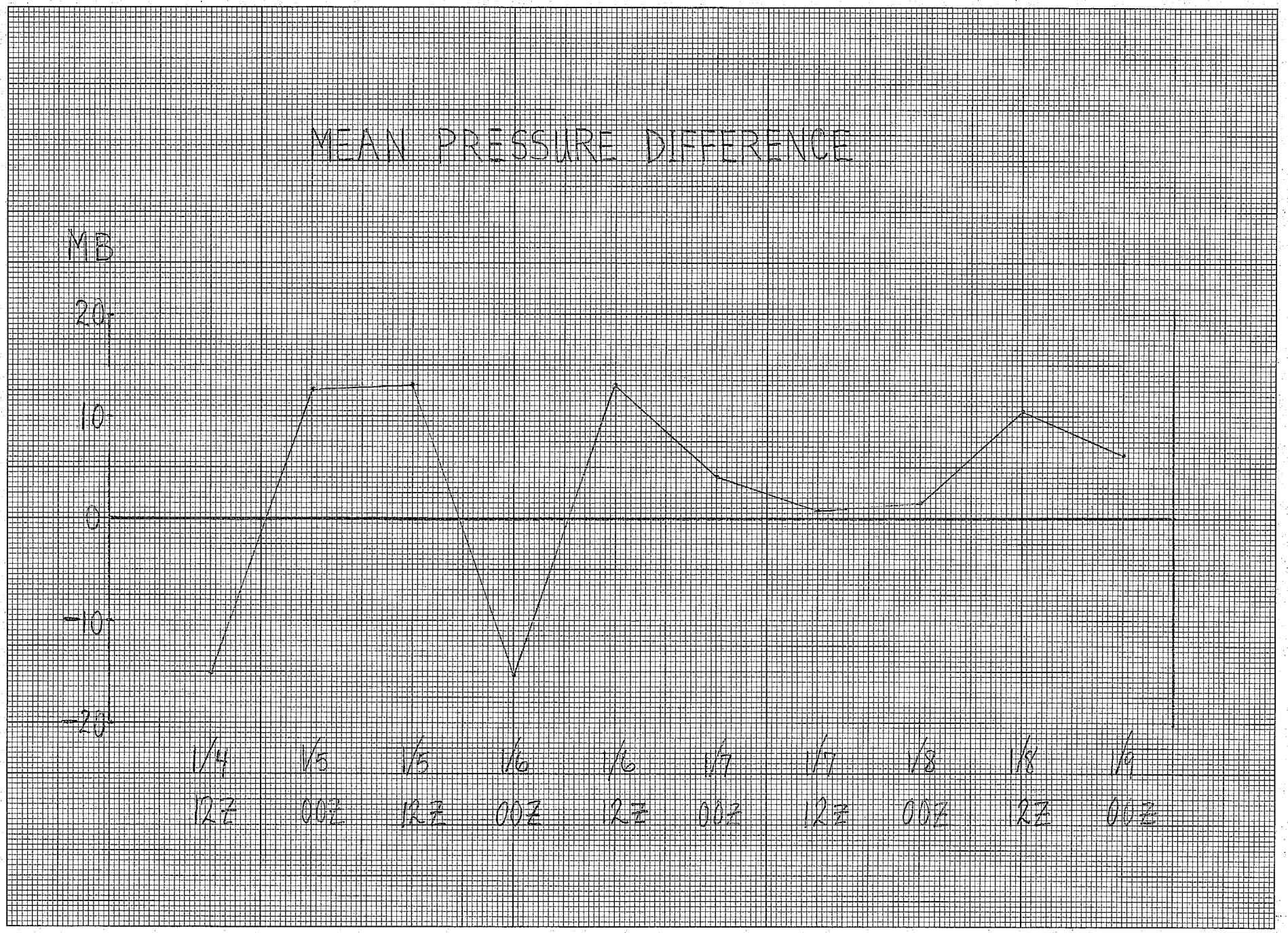


FIG 11

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MILLIMETER

DIETZGEN CORPORATION
MADE IN U.S.A.

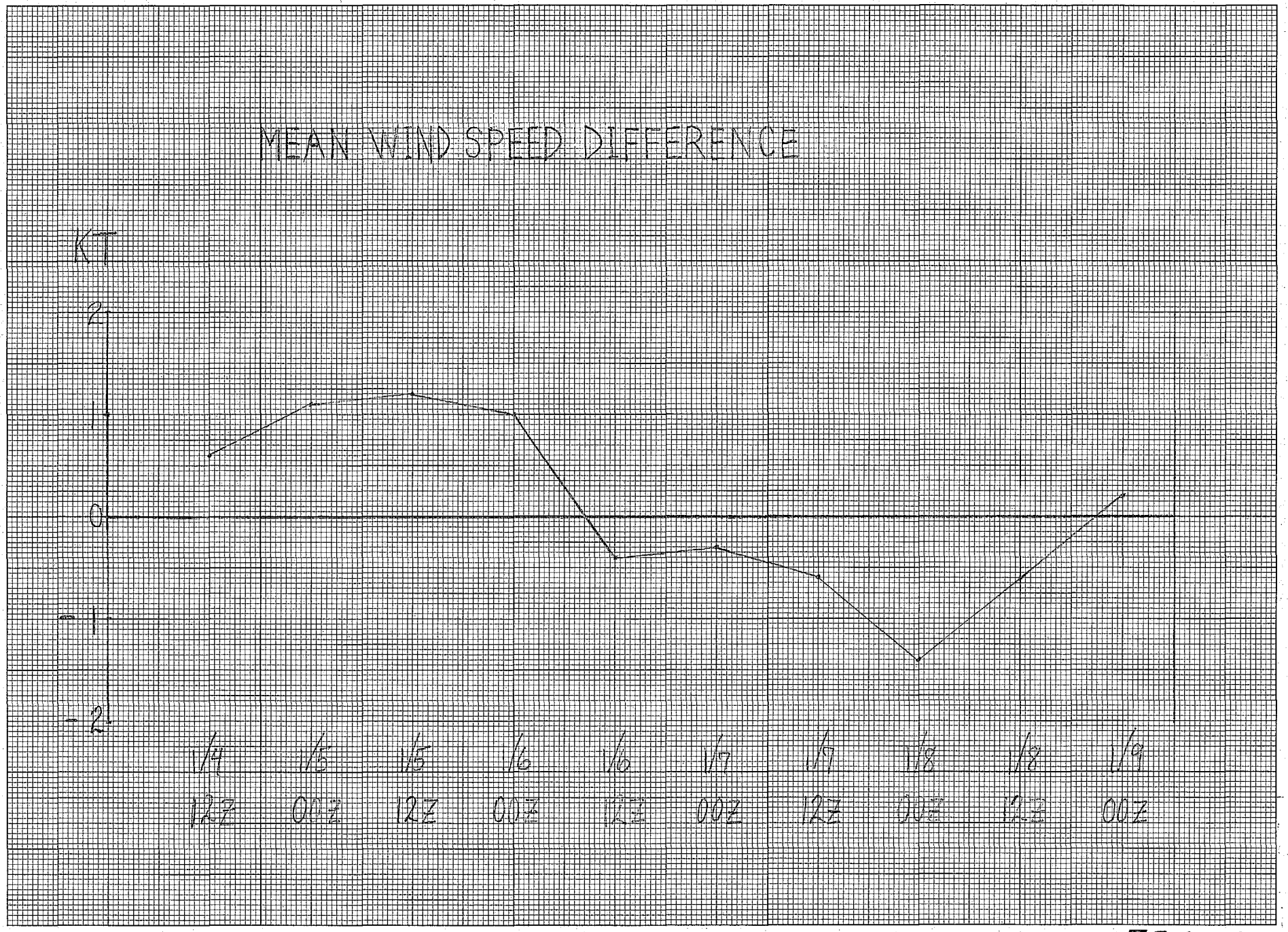

FIG 12

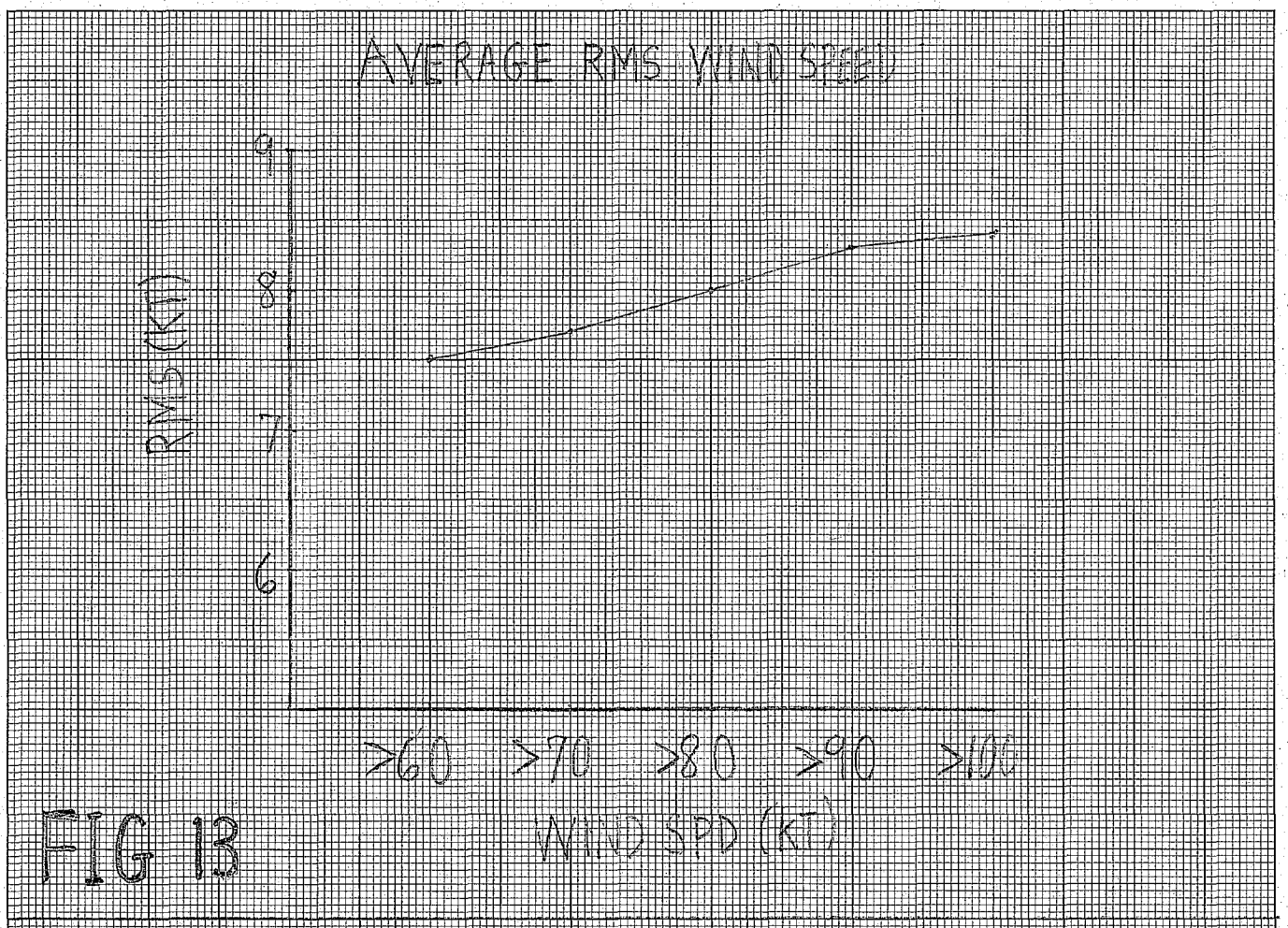

FIG 13

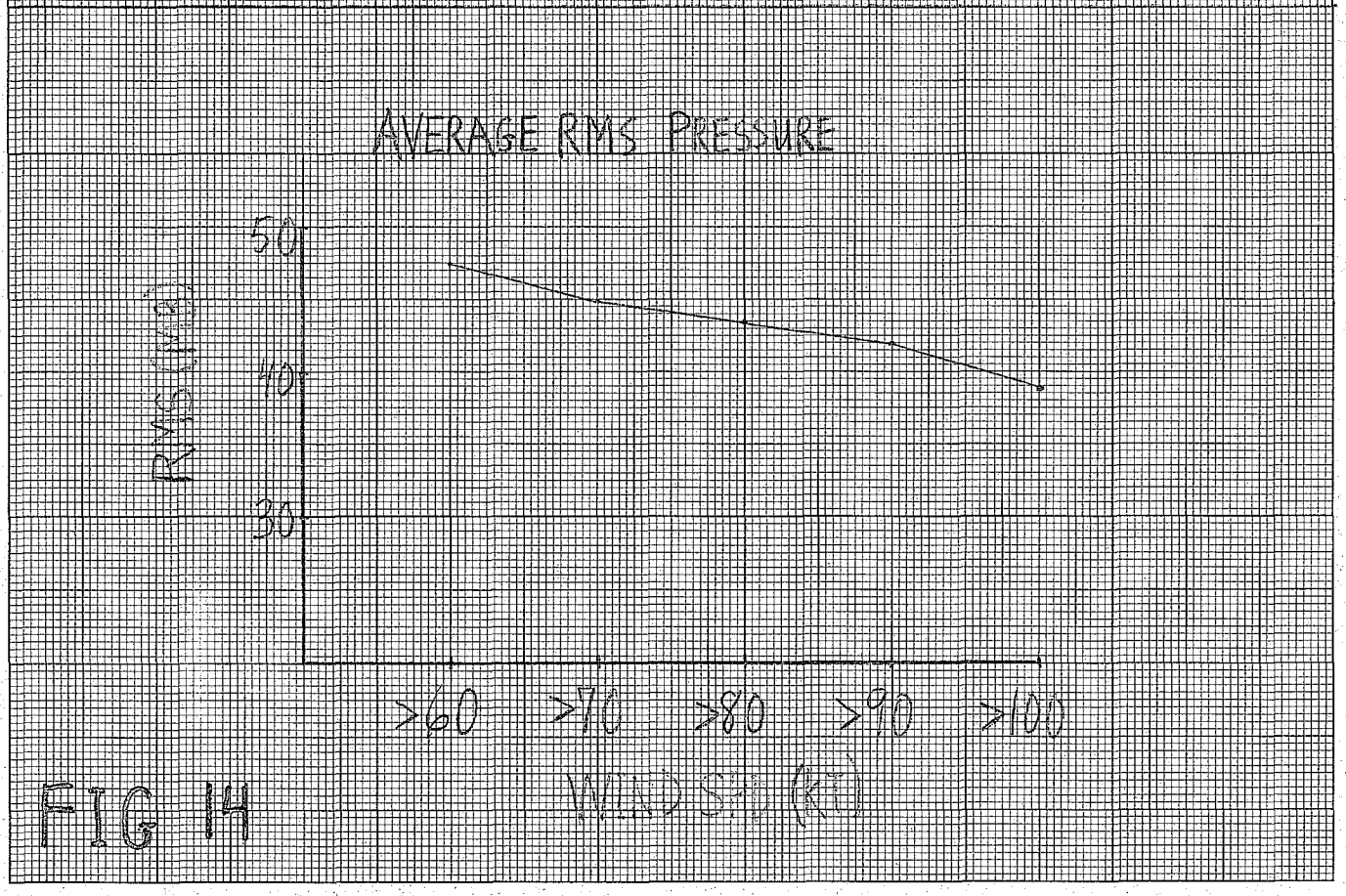

FIG 14

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MILLIMETER