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Water Circulation in Swansea Bay: Part 1

by

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NATURAL ENVIRONMENT RESEARCH COUNCIL
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CONTENTS

Part 1

Note: Part 2 of this report has been supplied to the Welsh National Water Development Authority only.

ABSTRACT

The results of the analysis of 8 current meter records from Swansea Bay are presented and briefly discussed.

A tentative interpretation of these results in terms of the overall residual circulation in Swansea Bay is presented and a preliminary analysis suggests the presence of an anti-clockwise residual circulation in the northern part of the Bay. Off Port Talbot there is a well-established residual flow to the N whereas off Sker Point, some 4 km to the SE, the flow is to the SE. An unexpectedly high and well-established residual flow towards the E has been observed just S of the White Oyster Ledge.

The measured long term residuals have been found to be of the order of 4 cm s^{-1} off Sker Point and Mumbles Head and 8 cm s^{-1} to the south of the White Oyster Ledge.

At nearshore locations, particularly off Port Talbot, the preliminary analysis has indicated that there may be a correlation between the tidal mean residuals and the wind speed and direction.

1. INTRODUCTION

The Institute of Oceanographic Sciences (IOS) has been carrying out research in Swansea Bay since 1974. This work is supported financially by the Department of the Environment and is described in a series of annual Progress Reports (Carr, 1975; Carr et al, 1976, 1977). One aspect of the study has been the measurement of tidal currents using recording current meters as part of the investigation of the overall circulation of the area.

It was therefore logical that the Welsh Office (WO) and the Welsh National Water Development Authority (WNWDA) should approach IOS with a request for the Institute to obtain supplementary current meter data on their behalf. The relevant Memorandum of Agreement between the Welsh Office and the Natural Environment Research Council (NERC) is included here as Appendix 1. It was agreed that IOS would collect the tidal current data and provide a limited data report. In general, meter deployment took place from late October to early or mid-December 1976.

This report describes the results from measurements of the tidal currents at 8 locations in the Bay (see Figure 1) using recording current meters.

A limited interpretation of these results in terms of the overall tidal and residual circulation in Swansea Bay is included here. Further analysis and discussion of the data are beyond the scope of the present report.

2. METHODS

The positions at which recording current meter measurements were made are shown in Figure 1.

The types of current meter used at each location, their approximate elevations above the sea bed and deployment periods are given in Table 1. Precise details of the data returns are given in Table 2.

The current meters were deployed from the RV Ocean Crest under charter from the University College of Wales, Swansea. This work was carried out by personnel from the Institute of Oceanographic Sciences' Taunton and Barry Laboratories.

Current Meters

Plessey MO21 recording current meters (Figure 2) were used for all the measurements described in this report. This meter records, in binary form, the outputs from the current speed and direction sensors on a magnetic tape. Four and six channel versions of the current meter were used for this work , the following parameters being recorded:

4 channel version: Reference number
Temperature
Direction
Speed

6 channel version: Direction
Temperature
Depth
Speed
Direction
Reference number

Each parameter is encoded as a 10 bit binary word and the beginning (4 channel) or end (6 channel) of a complete data cycle is indicated by an eleventh bit in the meter reference number. Temperature and depth parameters are not described in this report.

The current speed sensor is a conventional propeller type rotor having a starting velocity of 5 cm s^{-1} and the current meter was set up to record a maximum of 250 cm s^{-1}. The design accuracy of the sensor is $\pm$ 3 cm s^{-1} or $\pm$ 3% whichever is greater.

The direction sensor is a vane and compass system, the compass resolution being $\pm 2^{o}$ falling to $\pm 3^{o}$ in the dead gap (see below).

The timing sequence is controlled by a quartz crystal clock having an accuracy better than $\pm$ 10 seconds in 24 hours and the sampling interval may be set to 5, 10, 15 or 60 minutes. For all the measurements described in this report the sampling interval was set to 10 minutes.

Direction calibrations were performed on the meter before and after deployment using the facilities at IOS Barry. The compasses were calibrated in 10^{o} intervals from 0^{o} to 360^{o} and in 1^{o} intervals through the dead gap (usually set to around 360^{o}).

The dead gap is a feature common to all Plessey recording current meters and arises from the need to make electrical connections to the ends of the potentiometer rings in the encoder electronics of both the speed and direction sensors.

Speed sensors were not calibrated and the manufacturer's conversion formula was used, that is current speed(s) is given by,

$$S = .88 + 34.73\, n \quad cm\ s^{-1}.$$

Here n = rotor revs. s^{-1} and n is given by

$$n = \frac{RN}{1056t}$$

where R = gearbox ratio (standard 10,500:1)

N = difference between decimal equivalents of the binary numbers corresponding to consecutive readings.

t = sampling interval in seconds

Current meter moorings

Current meter moorings were of the conventional 'U' shape type (shown schematically in Figure 3). This mooring is well proven and has been used extensively by the Institute with very few problems. The current meters were secured to a meter wire, using the Plessey 'A' frame assembly, held taut by a 1m diameter stainless steel sub-surface buoy having a buoyancy of 172 kg. The sub-surface buoy and a toroidal surface marker buoy were then anchored to the sea-bed with 2 x 2500 kg chain clumps separated by a 100m ground wire. 12 mm galvanised steel wire ropes were used throughout. The toroidal buoys were marked and lit in accordance with IMCO recommendations and each carried a radar reflector. A 2m length of scrap chain was secured to the underside of each toroidal buoy to prevent it capsizing.

The moorings were laid over the side of the ship, current meter and sub-surface buoy first and toroidal buoy last; the moorings were recovered in the reverse order.

The position co-ordinates of each end of the mooring were recorded using Decca HiFix and Decca Main chain position fixing systems and the approximate bearing of the mooring also noted.

Precise details of the current meter locations, deployment periods and elevations above the sea-bed are given in Table 1.

3. DATA PROCESSING

Magnetic tape records from the current meters were translated at IOS Barry on to punched paper tape. These were input to IOS Taunton's PDP-11 computers for analysis.

Conversion of the decimal equivalent binary direction data was accomplished using a 'look-up' table procedure; this was considered to give a more faithful reproduction of the direction calibration curve than the usual linear regression technique and was computationally more efficient.

Prior to the final analyses of these data a detailed study was made of the errors occurring during the recording and conversion stages.

The current speed sensor is geared down by a ratio of 10,500:1 to a potentiometer forming part of a bridge circuit. One sweep of this potentiometer covers a range of binary numbers having decimal equivalents of 0 to 1023; speed values are obtained by taking the difference between normally decrementing successive decimal equivalents of these binary numbers.

The manufacturers recommend that if this difference includes a clear dead gap crossing then 32 should be added to that difference. Similarly if the sequence of decimal equivalent binary numbers includes a 0 or the value 1023, then 16 should be added to the preceding and next difference. When this correction was applied to these data it was found to generate spurious, but characteristic, results. In particular small oscillations having peak to peak amplitudes of 10 cm s^{-1} were found to be superimposed on the data. These were usually 1 - 2 data values wide and were simply an artefact of the conversion. No general solution to this problem is possible since the dead gap varies from 24 to 36 bits in width from meter to meter. Accordingly, dead gap crossings, zero(0) and maximum value (1023) conditions were detected and replaced with linearly interpolated values. Other errors were found to occur as a result of the rotor running backwards at times of low flow,(this condition being detected and erroneous values replaced by linearly interpolated values); or as a result of 1 or more bits being dropped either during translation or on conversion (so generating a parity error).

A comprehensive set of diagnostics was built up for each record and carried through onto the listing for the corresponding record. These include:

- Parity errors (data on punched paper tape should be even parity)
- Format errors (errors in format of paper tape)
- Detection of dead gap crossings
- Detection of zero values (0)
- Detection of maximum values (1023)

Gap crossings are detected by a negative difference test (ie differences between the normally decrementing binary numbers should be positive).

The converted data plus diagnostics were output to the line printer which also produced a graphical display of the speed and direction values. These data are presented in Part 2, Section 1, of this report.

Each record was then inspected, and erroneous values of speed and/or direction edited out. Editing was usually carried out by linear interpolation over one or two values. However in one or two records editing over longer data blocks was necessary; this was accomplished by replacing the erroneous data (usually 6 - 8 hours) by all or part of the preceding and corresponding part of the tidal cycle. This practice is not considered to introduce any serious errors and has the merit of enabling otherwise good records (of the order of 900 hours long) to be analysed as one continuous sequence.

4. RESULTS

Measurements of the tidal currents from the 8 locations in Swansea Bay at which current meters were deployed on behalf of the WO/WNWDA, have been routinely analysed using the suite of computer programs developed at IOS Taunton. Certain additional information, requested by the WNWDA, has been included in this report.

Table 2 summarises the data returns from all current meters and indicates the length of useful record, timing errors and the beginning and end of the useful data.

No corrections have been made for timing errors which in general were of the order ± 8 - 14 s per day, and therefore close to the manufacturer's stated tolerance of ± 10 s per day.

Two records, 626K6 and 573K5, produced abnormally large timing errors of approximately -32s per day and -56s per day respectively.

With the exception of meter No 626 at station G and meter No 534 at station C, all meters produced good records; meter No 626 showed a constant direction reading throughout the record and meter No 534 stopped recording after approximately 13 days. The record from meter No 573, moored at station G in 1975, has been included in this report to supplement the faulty data from meter No 626.

The results from the various analyses of the data are now described.

4.1 Time series of the resolved components of the tidal current

For each record the tidal current vector was resolved into orthogonal components using the N-S/E-W axes for convenience. These results are shown in Figures 4.1 - 4.22 . These records illustrate the neap-spring variation in tidal current amplitude at most stations.

4.2 Time series of the tidal current speed and direction

Time series of the tidal current speed and direction are shown in Figures 5.1 - 5.22 . These again illustrate the neap-spring variation in current speed and also show a semi-diurnal inequality at a number of locations. The increase in scatter of the direction readings at neap tides is also apparent (the weaker currents presumably being less effective in aligning the current meter with the mean flow); it is also evident that similar scatter occurs at the shallow water stations although in this case the scatter is probably due to wave action on the current meter.

4.3 Scatter plots of current speed and direction

These are shown in Figures 6.1 - 6.8 and in general illustrate the orientation and shape of the tidal current ellipse.

4.4 Unsmoothed and smoothed progressive vector plots

Unsmoothed and smoothed progressive vector plots are shown in Figures 7.1 - 7.16 . These illustrate the general direction of the residual water movements at each current meter station and are therefore Eulerian residuals. The progressive vector plots do not correspond to the trajectories of fluid particles.

The smoothed progressive vector plots were calculated using a 24 hr 50 min running mean and these illustrate that in the majority of cases residual water movements are consistently in one direction.

The measured tidal residuals at each station were calculated using the unsmoothed progressive vector plots; these data are presented in Table 3 and the overall residual circulation is presented diagrammatically in Figure 11.

4.5 Frequency histograms of current speed and direction values

Figures 8.1 - 8.8 show current speed and direction histograms for each record analysed. Speed values were examined in intervals of 10 cm s^{-1} up to a maximum of 150 cm s^{-1} and direction values in intervals of 18° from 0 - 360°. Details of the histograms are given in Table 4.

4.6 Phases of observed slack waters relative to predicted High Water (HW) and Low Water (LW) Swansea.

This information, additional to the requirements of the WO/WNWDA as outlined in Appendix 1, is presented in graphical form only in Figures 9.1 - 9.9 . To minimise the effects of timing errors and to examine the data for any neap-spring variations, the first 14 days of good data in each record have been analysed. Slack water has been taken here to mean 'minimum flow', the current not always falling to zero at some locations. The time of slackwater has been taken as the time of zero or minimum flow or, where there was any doubt, as the time when the direction of flow changed from ebb to flood or vice versa (the latter usually being a reliable indicator). These times were then compared with the predicted times of HW and LW Swansea, the HW and LW results being plotted separately.

4.7 Calculation of tidal mean residuals and their comparison with wind data

This information is additional to the requirements of the WO/WNWDA as outlined in Appendix 1 and this work should only be considered as a preliminary analysis.

12.5 hour tidal mean residuals, centred on 0000 and 1200 for each day, were calculated for all records and are tabulated in Part 2, Section 2, of this report. The information is presented graphically in Figures 10.1-10.8. The residual flow vectors have been resolved into orthogonal components (N - S and E - W) and in Figures 10.1, 10.2, 10.7 and 10.8 are compared with simultaneous readings of wind speed and direction for stations A, B, G and H. These stations were chosen on the basis that B, G and H were all in shallow water (depth range 7.5 - 17.5 m) and therefore more likely to show wind driven residual flows (this is confirmed for stations B and G shown in Figures 10.2 and 10.8). At station A in deeper water the effect is likely to be less apparent (see Figure 10.1).

It should be noted in Figures 10.1, 10.2, 10.7 and 10.8 that as an aid to comparison the wind direction is plotted in the same sense as the residual flow.

Fortnightly and monthly residuals were calculated (as requested by WNWDA) and are tabulated in Part 2, Section 2, of this report.

It should be borne in mind that sections 4.6 and 4.7 of this report do not constitute a rigorous analysis of the available data. Detailed comparisons of tidal elevations and currents, and investigations of the relationships between residual water movements and meteorological conditions, constitute a major part of the Institute's own work in the Swansea Bay area, on behalf of the Department of the Environment. It is hoped that this information will be available in relevant reports during 1978.

Note: Wind speed and direction measurements were made at Port Talbot.

5. CONCLUSIONS

A detailed discussion of the results of this investigation is beyond the scope of the present report. However a number of salient features emerge from the data and these are briefly discussed and summarised below:

5.1 Residual water movements

The results of the residual flow calculations are summarised in Figure 11 . A surprising and unexpected feature of the measured residual circulation in Swansea Bay is the dominance of the residual current at Station E which is of the order 8.0 cm s^{-1}. This is approximately twice the measured residuals at Stations C and F, which were anticipated as being the largest due to their proximity to headlands or narrow tidal channels (the different meter elevations should be noted in this context).

Another conspicuous feature is the divergence in the residual flow field between Stations B and H; at B the flow is consistently to the N and at H, from a contemporary measurement, consistently to the SW.

The different residual flow directions at Stations E and F suggests that the channels N and S of the White Oyster Ledge may act as ebb and flood residual channels.

There is also some evidence to suggest an anti-clockwise residual gyre in the northern part of the Bay although a more comprehensive analysis of the available data is required before this feature can be firmly established.

Neap-Spring variations in the strength of the tidal mean residual are particularly apparent at Stations C, E and F as shown in Figures 10.3, 10.5 and 10.6.

5.2 Relative phase of slackwater and predicted HW and LW at Swansea

The preliminary analysis of the relative phases of the observed slackwater and the predicted High and Low water at Swansea is summarised below. It should be noted that these are visual estimates only, taken from the data presented in Figures 9.1 to 9.9.

Station	Estimated phase of slackwaters relative to LW and HW Swansea		Comments
	LW slack (mins)	HW slack (mins)	
A	±20	-15	LW slacks variable. No apparent neap spring variation.
B	-10	-20	No apparent neap spring variation.
C	up to +30	-20	No apparent neap spring variation.
D	-30	-20	No apparent neap spring variation.
E	±30	-20	Pronounced neap spring variation on LW slacks.
F	±30	±30	Variable. No apparent neap spring variation.
G	up to +60	±60	Highly variable. No apparent neap spring variation.
H	+20	-30	No apparent neap spring variation.

Note: Positive and Negative phase differences imply that the times of slackwater lead or lag the HW/LW times respectively.

5.3 Comparison of measured residual flows with wind speed

Four stations (A, B, H and G) were selected for comparisons of wind speed with the measured tidal mean residuals.

At Station A, in deeper water there is no apparent correlation between the observed wind speed and the tidal mean residual in either the N-S or E-W components.

However Stations B and G show some correlation between the wind speed and the tidal residual, particularly in the N-S component at B (which is expected since this component is roughly parallel to the coast) and in the E-W component at G (for similar reasons). However at Station H there is no obvious correlation.

It should be noted that no smoothing has been applied to the readings of wind speed and direction.

6. FUTURE WORK

The data described in this report constitute only a fraction of the data available to the Institute for its own investigations into the tidal and residual circulation in Swansea Bay. In particular the results from another 50 or so current meter records are being analysed, including the data from the long term current meter mooring at Station A (which has now been in operation for 2 years). Up to 2 years of tidal elevation and meteorological data are being analysed in conjunction with the current meter records.

It is therefore emphasised that the results described in this report are a preliminary analysis only and that future work at the Institute will involve the analysis of longer data sets. It is hoped that the results of this work will be described in various topic reports during 1978.

7. ACKNOWLEDGEMENTS

The assistance of the IOS Taunton Computer Services Section in the preparation of these data is gratefully acknowledged. Plessey recording current meters were supplied by the Marine Scientific Equipment Services Section at IOS Barry and meteorological data were supplied by the Meteorological Office.

TABLE 1

RECORDING CURRENT METER LOCATIONS, ELEVATIONS AND DEPLOYMENT PERIODS IN SWANSEA BAY (WO/WNWDA DEPLOYMENT PERIOD ONLY)

Station	Meter Type	Record No	Elevation (m)	Min/Max depths(m)	Deployed		Location			
							Lat	Long	Decca (Chain IB/MP)	
					From	To	N	W	Green	Purple
A	237/P6	237J6	10	16.5/26.0	28/9/76	1/12/76	51°31.5'	3°52.5'	D41.05	B64.80
B	680/P4	680K6	2	7.5/17.0	29/10/76	30/11/76	51°33.4'	3°48.0'	D38.85	B74.80
C	594/P4	594K6	2	11.0/20.5	29/10/76	4/12/76	51°29.5'	3°36.30	D36.30	B69.60
D	244/P6	244K5	12	23.5/33.0	26/10/76	3/12/76	51°27.0'	3°52.5'	D38.95	B55.20
E	269/P4	269K6	12	22.5/32.0	26/10/76	3/12/76	51°29.5'	3°57.0'	D44.55	B51.70
F	260/P4	260K6	10	26.5/35.5	27/10/76	1/12/76	51°33.2'	3°58.3'	D46.00	B59.25
G	626/P4	626K6	2	7.5/17.0	27/10/76	30/11/76	51°35.0'	3°52.5'	D42.65	B70.60
G*	573/P4	573K5	1	7.5/17.0	11/10/75	25/11/75	51°35.0'	3°52.5'	D42.65	B70.60
H	534/P4	534K6	2	8.0/17.5	29/10/76	16/12/76	51°31.5'	3°46.5'	D36.95	B74.10

P6 = Plessey MO 21 6 channel recording current meter

P4 = " " 4 " " " "

* Record included to supplement faulty data from meter No 626.

TABLE 2

DATA RETURNS FROM RECORDING CURRENT METERS IN SWANSEA BAY (WO/WNWDA DEPLOYMENT PERIOD ONLY)

Record	Length of useful date (hrs	mins)	Data analysed Starts	Ends	Timing error (secs.day $^{-1}$)	% good data in record	% return on time in water (approx)
237J6	939	00	1610 - 28/9/76	1900 - 6/11/76	N	79.9	61.0
680K6	769	40	1340 - 29/10/76	1510 - 30/11/76	-14.96	100.0	100.0
594K6	857	20	1550 - 29/10/76	0900 - 4/12/76	+11.67	99.2	99.2
244K6	908	10	1400 - 26/10/76	1010 - 3/12/76	+12.10	99.5	99.5
269K6	810	10	1520 - 26/10/76	0920 - 29/11/76	-10.27	88.9	88.8
260K6	840	30	1520 - 27/10/76	1540 - 1/12/76	- 8.83	99.8	99.8
626K6*	911	20	-	-	-31.72	-	-
573K5	973	20	0000 - 16/10/75	1310 - 25/11/75	-56.44	89.8	89.8
534K6[⁑]	319	40	1420 - 29/10/76	2150 - 11/11/76	N	95.5	27.7

Notes: Negative timing error implies quartz crystal clock running slow

* - Speed only

⁑ - Current meter stopped recording after approximately 14 days

N - Timing errors not known

TABLE 3

MAGNITUDES AND DIRECTIONS OF MEASURED TIDAL CURRENT RESIDUALS FROM MOORINGS A - J IN SWANSEA BAY

Station	Record	Elevation (m)	Residual flow Speed (cm s^{-1})	Direction (^{o}N)	Duration (hrs	mins)
A	237J6	10	1.08	355	939	00
B	680K6	2	1.43	354	769	40
C	594K6	2	4.40	152	857	20
D	244K5	12	2.63	229	908	10
E	269K6	12	8.30	071	810	10
F	260K6	10	4.62	240	840	30
G	626K6	2	N/A	N/A	911	20
G	573K5	1	0.65	288	973	20
H	534K6	2	4.31	137	319	40
I	534F6	2	0.39	086	1225	30
J	532F6	2	1.44	171	767	00

Notes: (a) Record 626K5 not analysed (N/A) due to faulty direction sensor

(b) Records from Stations I and J not discussed in this report

(c) Further details of records are given in Tables 1 and 2

METER 237		DATE 28 9 76
INTERVAL		FREQUENCY
0. 0	10. 0	512
10. 0	20. 0	806
20. 0	30. 0	841
30. 0	40. 0	964
40. 0	50. 0	921
50. 0	60. 0	706
60. 0	70. 0	542
70. 0	80. 0	288
80. 0	90. 0	54
90. 0	100. 0	0
100. 0	110. 0	0
110. 0	120. 0	0
120. 0	130. 0	0
130. 0	140. 0	0
140. 0	150. 0	0

INTERVAL		FREQUENCY
0. 0	18. 0	57
18. 0	36. 0	56
36. 0	54. 0	82
54. 0	72. 0	148
72. 0	90. 0	669
90. 0	108. 0	1329
108. 0	126. 0	370
126. 0	144. 0	122
144. 0	162. 0	65
162. 0	180. 0	35
180. 0	198. 0	25
198. 0	216. 0	17
216. 0	234. 0	30
234. 0	252. 0	72
252. 0	270. 0	394
270. 0	288. 0	1483
288. 0	306. 0	407
306. 0	324. 0	126
324. 0	342. 0	91
342. 0	360. 0	56

METER 680		DATE 29 10 76
INTERVAL		FREQUENCY
0. 0	10. 0	962
10. 0	20. 0	1787
20. 0	30. 0	1429
30. 0	40. 0	427
40. 0	50. 0	13
50. 0	60. 0	0
60. 0	70. 0	0
70. 0	80. 0	0
80. 0	90. 0	0
90. 0	100. 0	0
100. 0	110. 0	0
110. 0	120. 0	0
120. 0	130. 0	0
130. 0	140. 0	0
140. 0	150. 0	0

INTERVAL		FREQUENCY
0. 0	18. 0	125
18. 0	36. 0	127
36. 0	54. 0	110
54. 0	72. 0	88
72. 0	90. 0	136
90. 0	108. 0	252
108. 0	126. 0	438
126. 0	144. 0	570
144. 0	162. 0	290
162. 0	180. 0	208
180. 0	198. 0	110
198. 0	216. 0	104
216. 0	234. 0	97
234. 0	252. 0	90
252. 0	270. 0	99
270. 0	288. 0	149
288. 0	306. 0	354
306. 0	324. 0	619
324. 0	342. 0	405
342. 0	360. 0	247

TABLE 4.1

Frequency distributions of current speed (top) and direction (bottom) for records 237J6 and 680K6 from Stations A and B respectively. Speed classwidth 10 cm s^{-1}; direction classwidth 18^{o}.

METER 594		DATE 29 10 76
INTERVAL		FREQUENCY
0. 0	10. 0	282
10. 0	20. 0	475
20. 0	30. 0	457
30. 0	40. 0	518
40. 0	50. 0	593
50. 0	60. 0	760
60. 0	70. 0	708
70. 0	80. 0	672
80. 0	90. 0	455
90. 0	100. 0	190
100. 0	110. 0	33
110. 0	120. 0	1
120. 0	130. 0	0
130. 0	140. 0	0
140. 0	150. 0	0
INTERVAL		FREQUENCY
0. 0	18. 0	86
18. 0	36. 0	63
36. 0	54. 0	47
54. 0	72. 0	45
72. 0	90. 0	73
90. 0	108. 0	185
108. 0	126. 0	393
126. 0	144. 0	1051
144. 0	162. 0	640
162. 0	180. 0	213
180. 0	198. 0	93
198. 0	216. 0	47
216. 0	234. 0	33
234. 0	252. 0	18
252. 0	270. 0	62
270. 0	288. 0	146
288. 0	306. 0	434
306. 0	324. 0	888
324. 0	342. 0	470
342. 0	360. 0	157

METER 244		DATE 26 10 76
INTERVAL		FREQUENCY
0. 0	10. 0	314
10. 0	20. 0	438
20. 0	30. 0	385
30. 0	40. 0	405
40. 0	50. 0	434
50. 0	60. 0	524
60. 0	70. 0	694
70. 0	80. 0	582
80. 0	90. 0	516
90. 0	100. 0	432
100. 0	110. 0	324
110. 0	120. 0	222
120. 0	130. 0	109
130. 0	140. 0	61
140. 0	150. 0	9
INTERVAL		FREQUENCY
0. 0	18. 0	11
18. 0	36. 0	16
36. 0	54. 0	21
54. 0	72. 0	34
72. 0	90. 0	111
90. 0	108. 0	1155
108. 0	126. 0	1145
126. 0	144. 0	177
144. 0	162. 0	62
162. 0	180. 0	36
180. 0	198. 0	25
198. 0	216. 0	19
216. 0	234. 0	28
234. 0	252. 0	52
252. 0	270. 0	137
270. 0	288. 0	1750
288. 0	306. 0	548
306. 0	324. 0	65
324. 0	342. 0	41
342. 0	360. 0	16

TABLE 4.2

Frequency distributions of current speed (top) and direction (bottom) for records 594K6 and 244K6 from Stations C and D respectively. Speed classwidth 10 cm s^{-1}; direction classwidth 18^{o}.

METER 269		DATE 26 10 76
INTERVAL		FREQUENCY
0. 0	10. 0	360
10. 0	20. 0	530
20. 0	30. 0	490
30. 0	40. 0	478
40. 0	50. 0	691
50. 0	60. 0	679
60. 0	70. 0	641
70. 0	80. 0	529
80. 0	90. 0	317
90. 0	100. 0	133
100. 0	110. 0	13
110. 0	120. 0	0
120. 0	130. 0	0
130. 0	140. 0	0
140. 0	150. 0	0
INTERVAL		FREQUENCY
0. 0	18. 0	30
18. 0	36. 0	47
36. 0	54. 0	53
54. 0	72. 0	93
72. 0	90. 0	833
90. 0	108. 0	1351
108. 0	126. 0	217
126. 0	144. 0	56
144. 0	162. 0	31
162. 0	180. 0	22
180. 0	198. 0	24
198. 0	216. 0	28
216. 0	234. 0	20
234. 0	252. 0	46
252. 0	270. 0	345
270. 0	288. 0	989
288. 0	306. 0	432
306. 0	324. 0	139
324. 0	342. 0	57
342. 0	360. 0	48

METER 260		DATE 27 10 76
INTERVAL		FREQUENCY
0. 0	10. 0	418
10. 0	20. 0	538
20. 0	30. 0	501
30. 0	40. 0	549
40. 0	50. 0	652
50. 0	60. 0	617
60. 0	70. 0	687
70. 0	80. 0	474
80. 0	90. 0	279
90. 0	100. 0	182
100. 0	110. 0	102
110. 0	120. 0	31
120. 0	130. 0	11
130. 0	140. 0	2
140. 0	150. 0	0
INTERVAL		FREQUENCY
0. 0	18. 0	34
18. 0	36. 0	40
36. 0	54. 0	121
54. 0	72. 0	907
72. 0	90. 0	1199
90. 0	108. 0	210
108. 0	126. 0	28
126. 0	144. 0	27
144. 0	162. 0	19
162. 0	180. 0	19
180. 0	198. 0	15
198. 0	216. 0	27
216. 0	234. 0	53
234. 0	252. 0	973
252. 0	270. 0	1117
270. 0	288. 0	125
288. 0	306. 0	49
306. 0	324. 0	29
324. 0	342. 0	28
342. 0	360. 0	23

TABLE 4.3

Frequency distributions of current speed (top) and direction (bottom) for records 269K6 and 260K6 from Stations E and F respectively. Speed classwidth 10 cm s^{-1}; direction classwidth 18^{o}.

METER 573 DATE 16 10 75

INTERVAL		FREQUENCY
0.0	10.0	2391
10.0	20.0	2747
20.0	30.0	672
30.0	40.0	27
40.0	50.0	1
50.0	60.0	1
60.0	70.0	1
70.0	80.0	0
80.0	90.0	0
90.0	100.0	0
100.0	110.0	0
110.0	120.0	0
120.0	130.0	0
130.0	140.0	0
140.0	150.0	0

INTERVAL		FREQUENCY
0.0	18.0	62
18.0	36.0	72
36.0	54.0	139
54.0	72.0	643
72.0	90.0	980
90.0	108.0	654
108.0	126.0	315
126.0	144.0	121
144.0	162.0	82
162.0	180.0	84
180.0	198.0	36
198.0	216.0	31
216.0	234.0	48
234.0	252.0	572
252.0	270.0	751
270.0	288.0	679
288.0	306.0	216
306.0	324.0	136
324.0	342.0	126
342.0	360.0	93

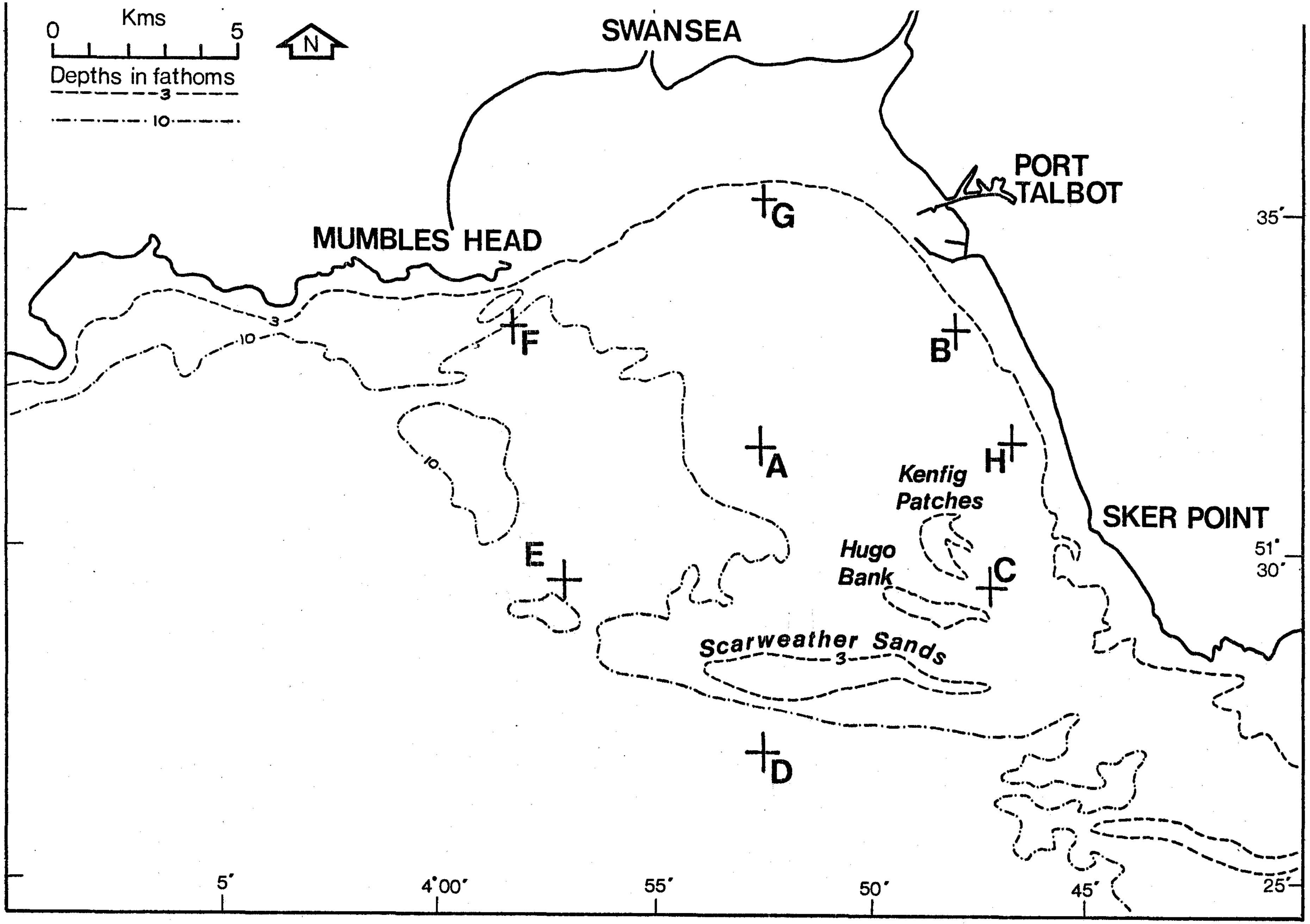
METER 534 DATE 29 10 76

INTERVAL		FREQUENCY
0.0	10.0	254
10.0	20.0	333
20.0	30.0	378
30.0	40.0	400
40.0	50.0	445
50.0	60.0	107
60.0	70.0	1
70.0	80.0	0
80.0	90.0	0
90.0	100.0	0
100.0	110.0	0
110.0	120.0	0
120.0	130.0	0
130.0	140.0	0
140.0	150.0	0

INTERVAL		FREQUENCY
0.0	18.0	97
18.0	36.0	41
36.0	54.0	25
54.0	72.0	26
72.0	90.0	28
90.0	108.0	35
108.0	126.0	98
126.0	144.0	206
144.0	162.0	299
162.0	180.0	191
180.0	198.0	124
198.0	216.0	48
216.0	234.0	29
234.0	252.0	14
252.0	270.0	22
270.0	288.0	26
288.0	306.0	51
306.0	324.0	102
324.0	342.0	231
342.0	360.0	225

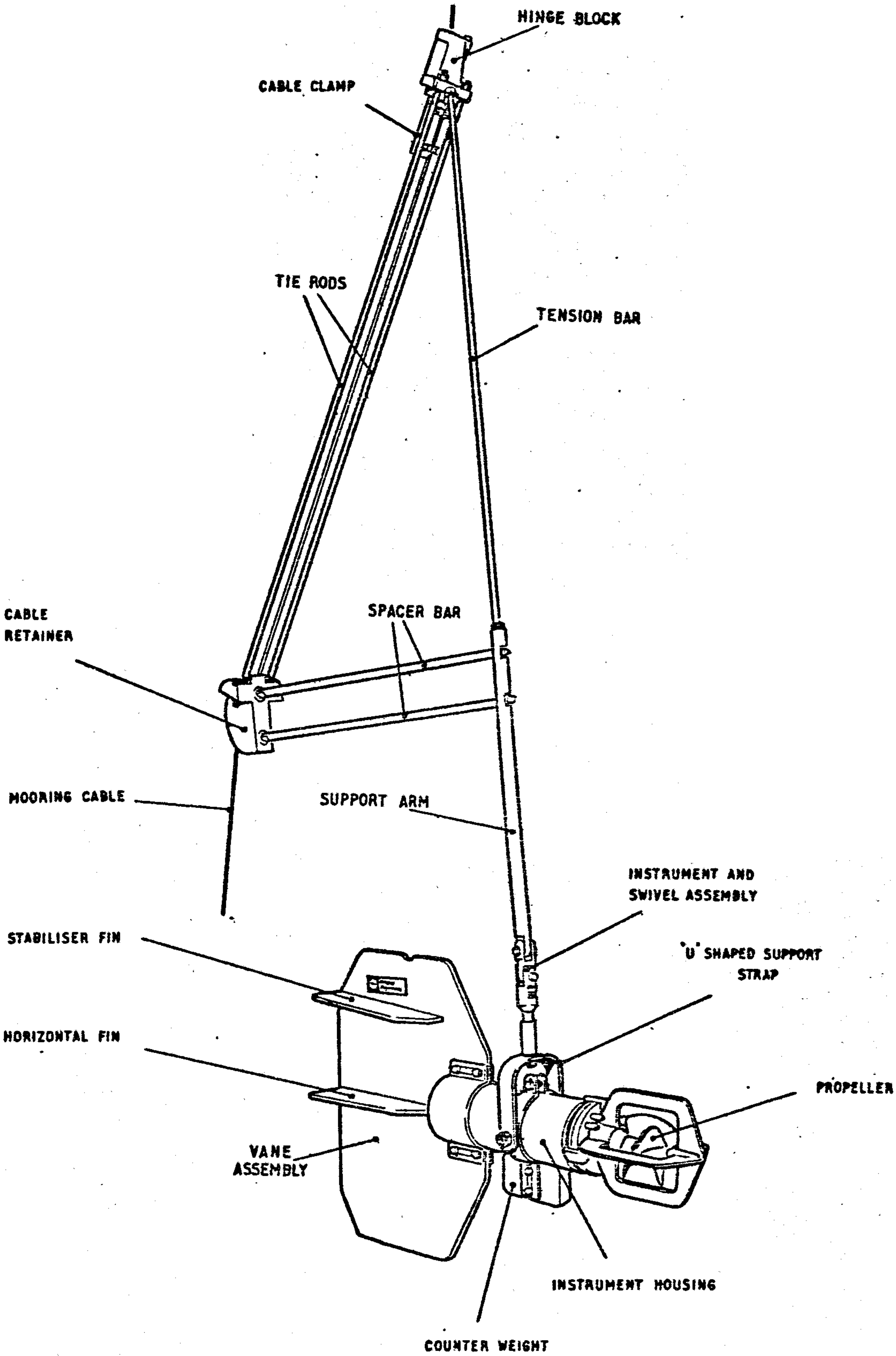
TABLE 4.4

Frequency distributions of current speed (top) and direction (bottom) for records 573K5 and 534K6 from Stations G and H respectively. Speed classwidth 10 cm s^{-1}; direction classwidth 18°.



Location of recording current meter moorings in Swansea Bay during WO/ WNWDA deployment.

Fig.1



The Plessey recording current meter model M021
(Reproduced courtesy of the Plessey Company Ltd)

Fig. 2

CURRENT METER MOORING SYSTEM I.O.S.

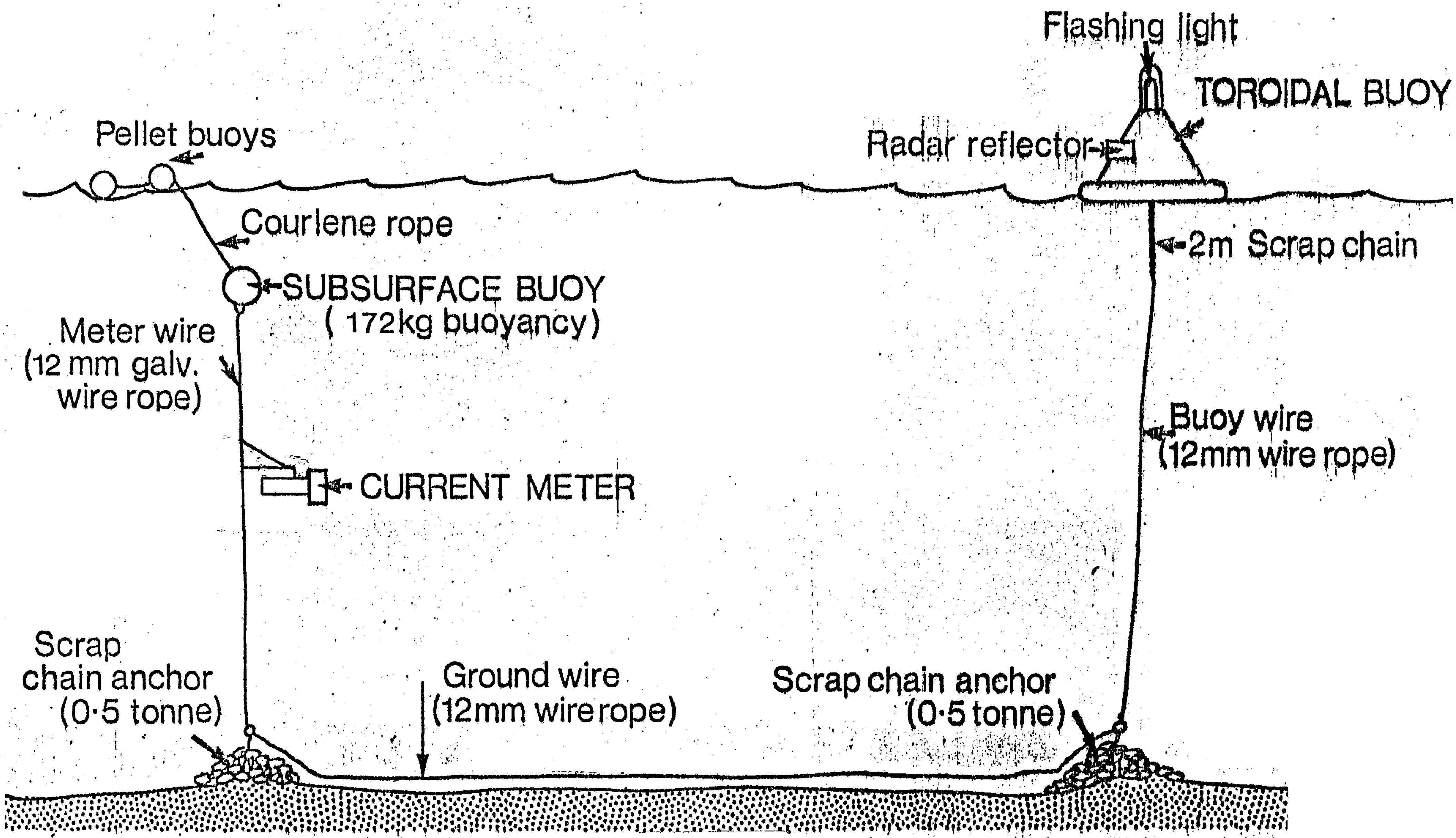


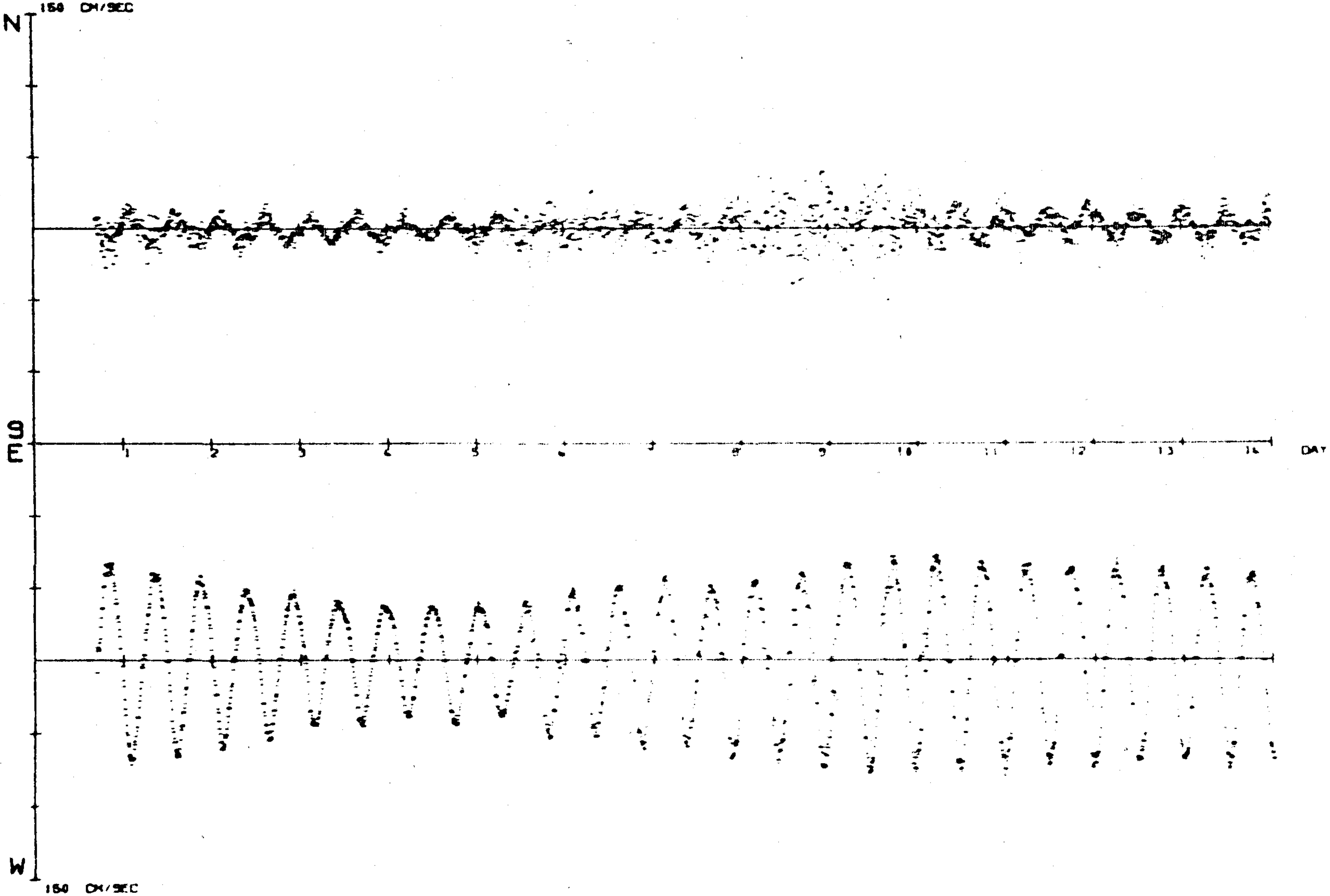
Fig. 3

Figures 4.1 - 4.22

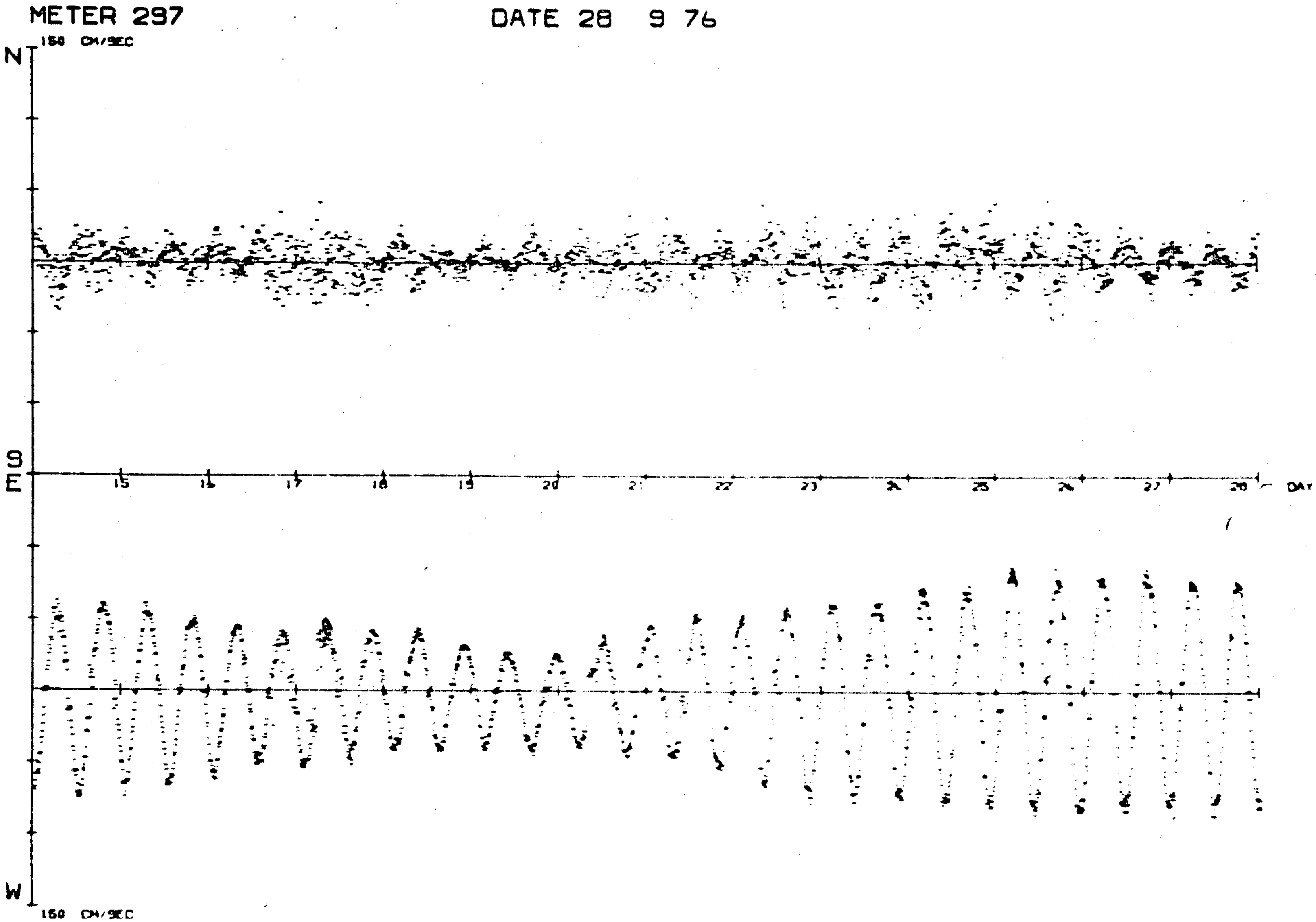
Time series of the resolved components of current speed and direction readings

Figure(s)	Record	Station
4.1 - 4.3	237J6	A
4.4 - 4.6	680K6	B
~~4.7 - 4.9~~	~~594K6~~	~~C~~
4.10 - 4.12	244K6	D
4.13 - 4.15	269K6	E
4.16 - 4.18	260K6	F
4.19 - 4.21	573K5	G
4.22	524K6	H

METER 237 DATE 28 9 76



4.1



METER 297
DATE 28 9 76
150 CM/SEC
N
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DAY
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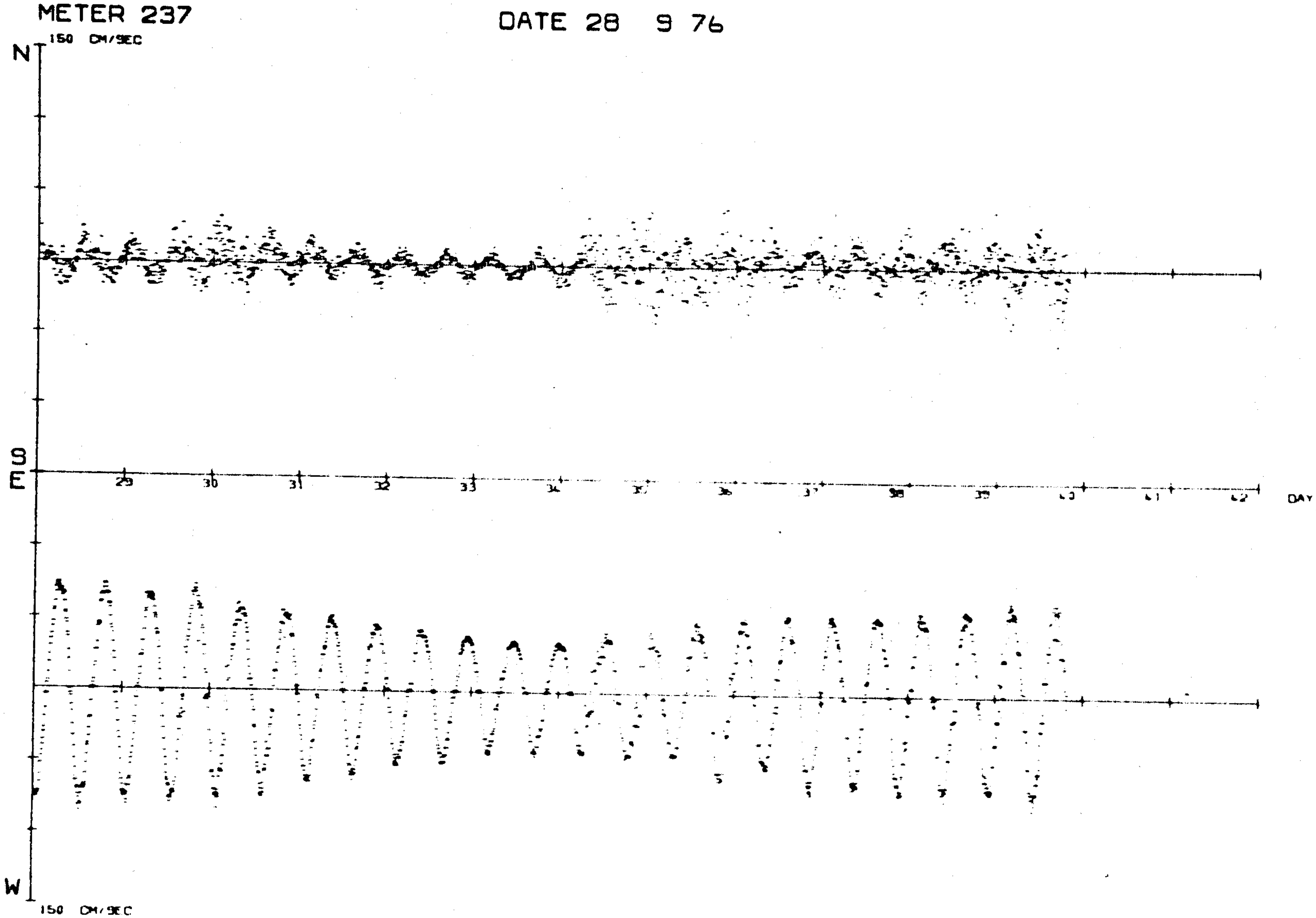
27
150 CM/SEC



METER 237
DATE 28 9 76
150 CM/SEC
N
S
E
W
150 CM/SEC
29
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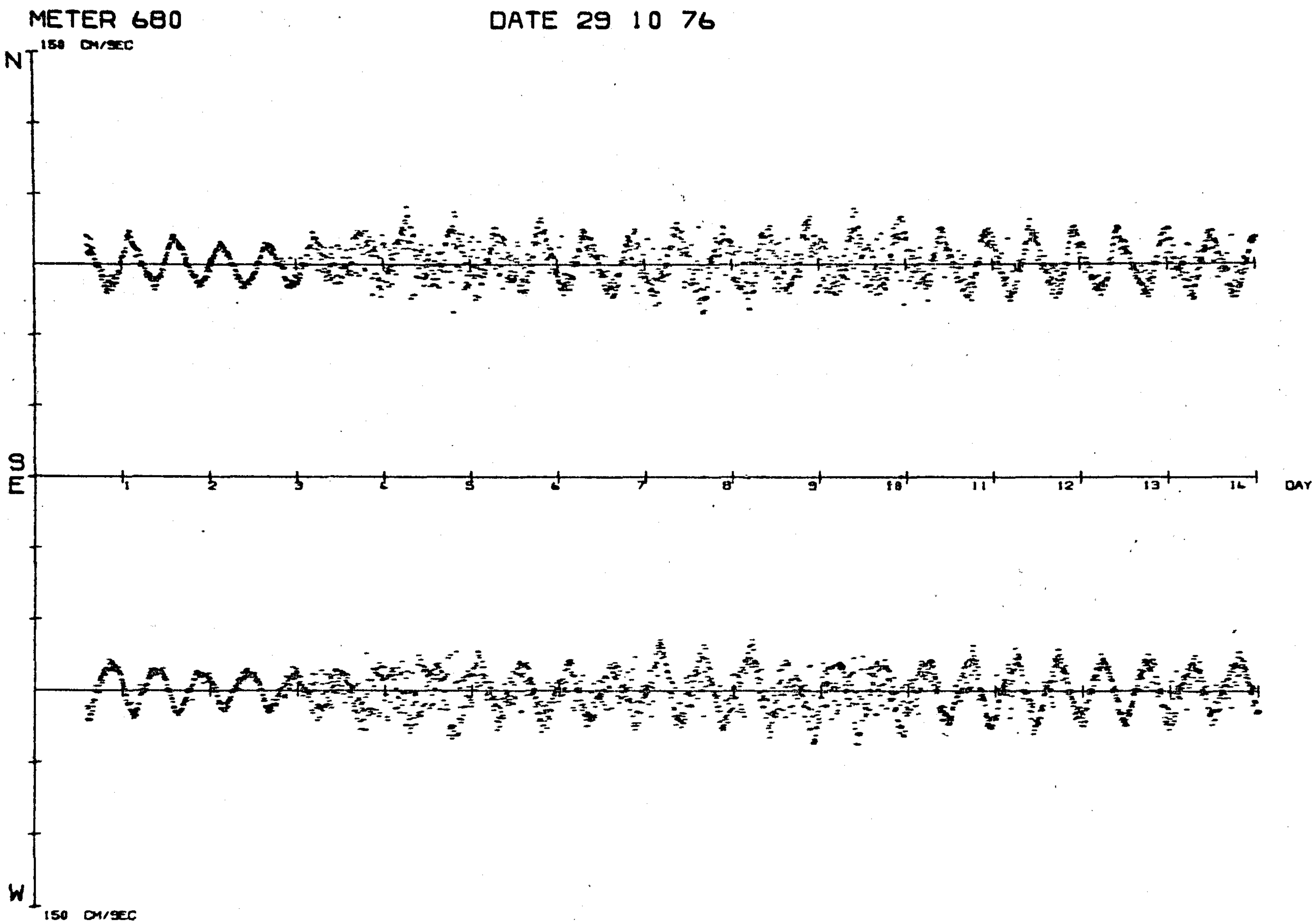
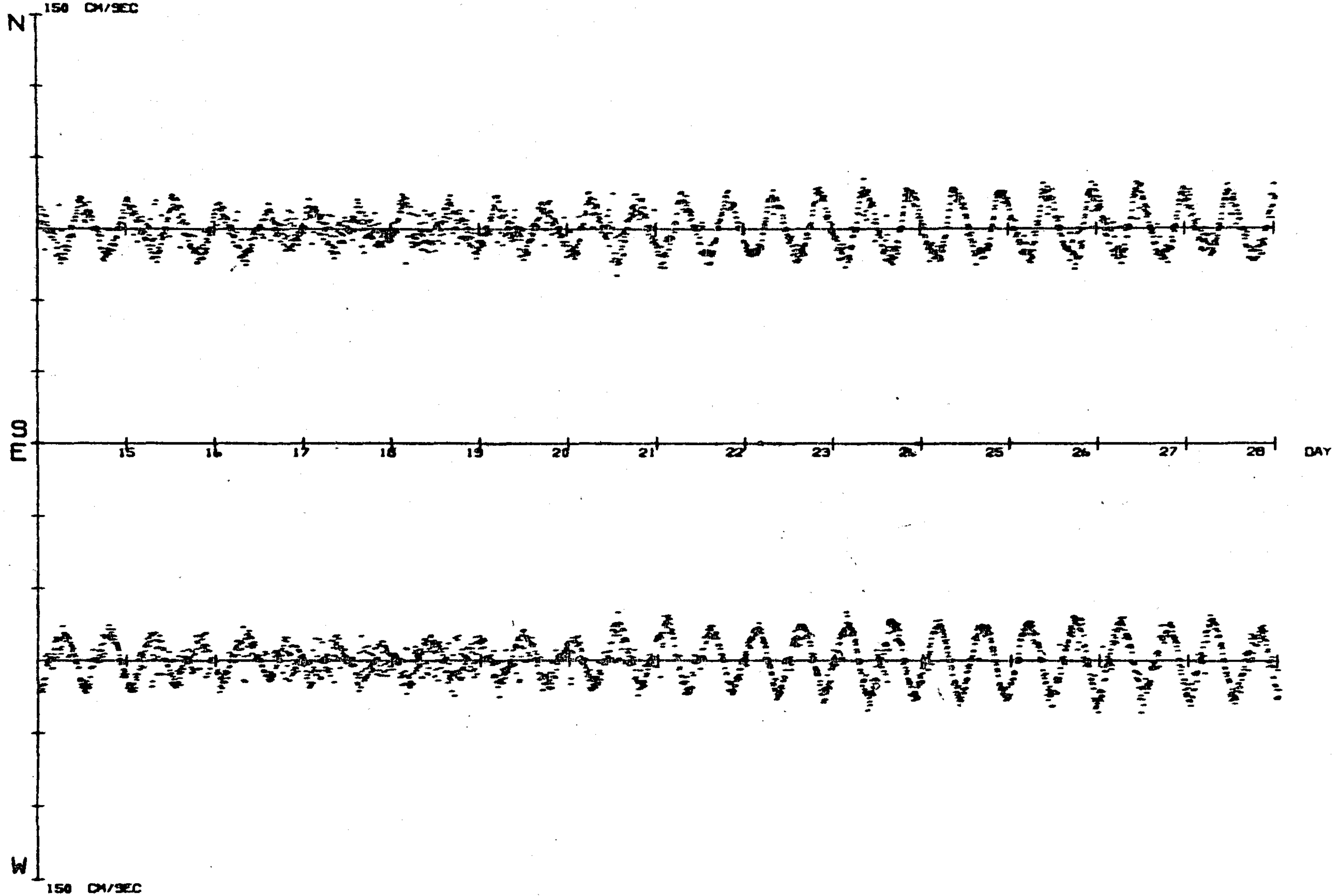
31
32
33
DAY

4.3

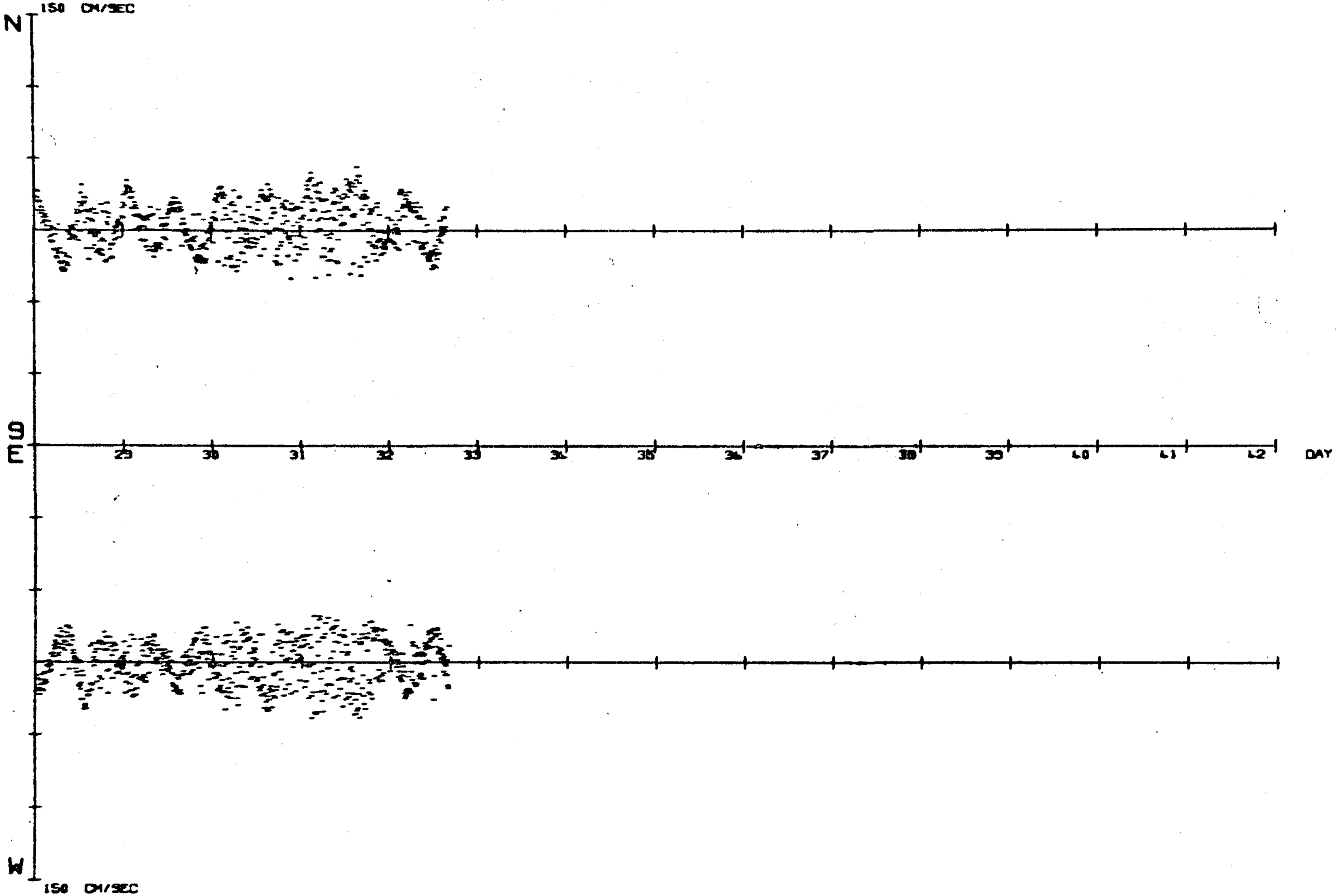

METER 680
DATE 29 10 76
150 CM/SEC
N
S
E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
DAY
W
150 CM/SEC

4.4

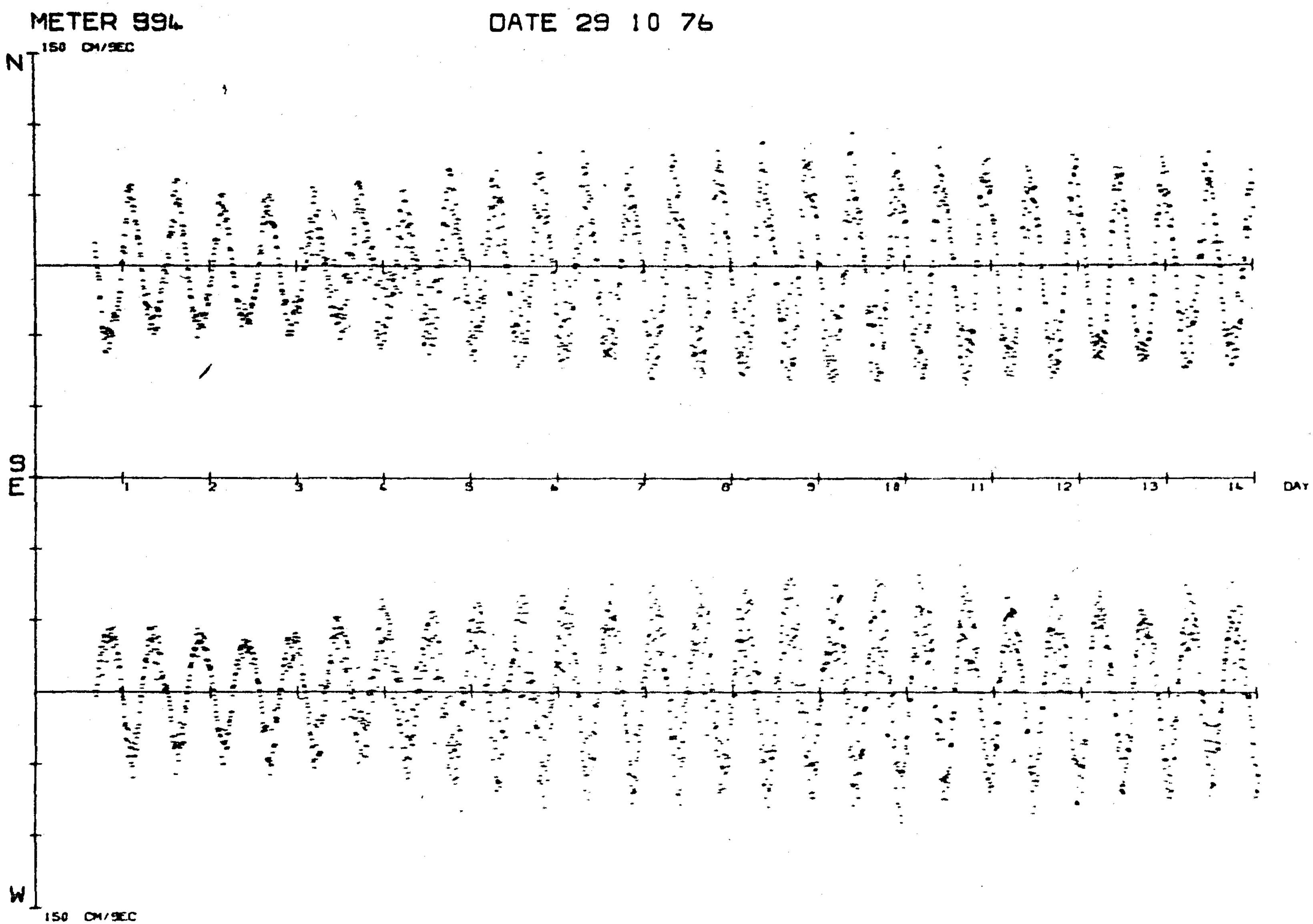
METER 680 DATE 29 10 76



METER 680 DATE 29 10 76



4.6


METER 994
DATE 29 10 76
150 CM/SEC
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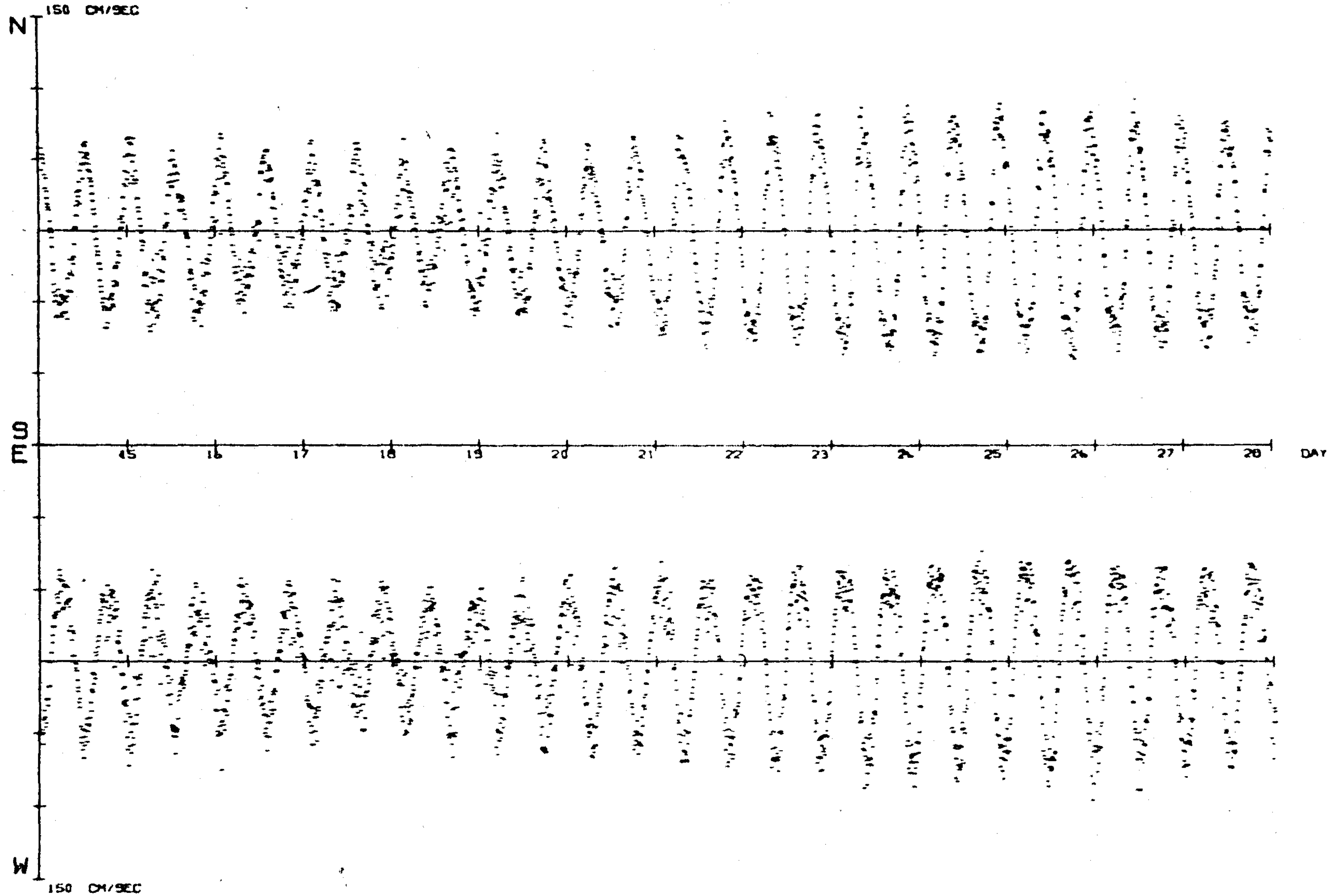
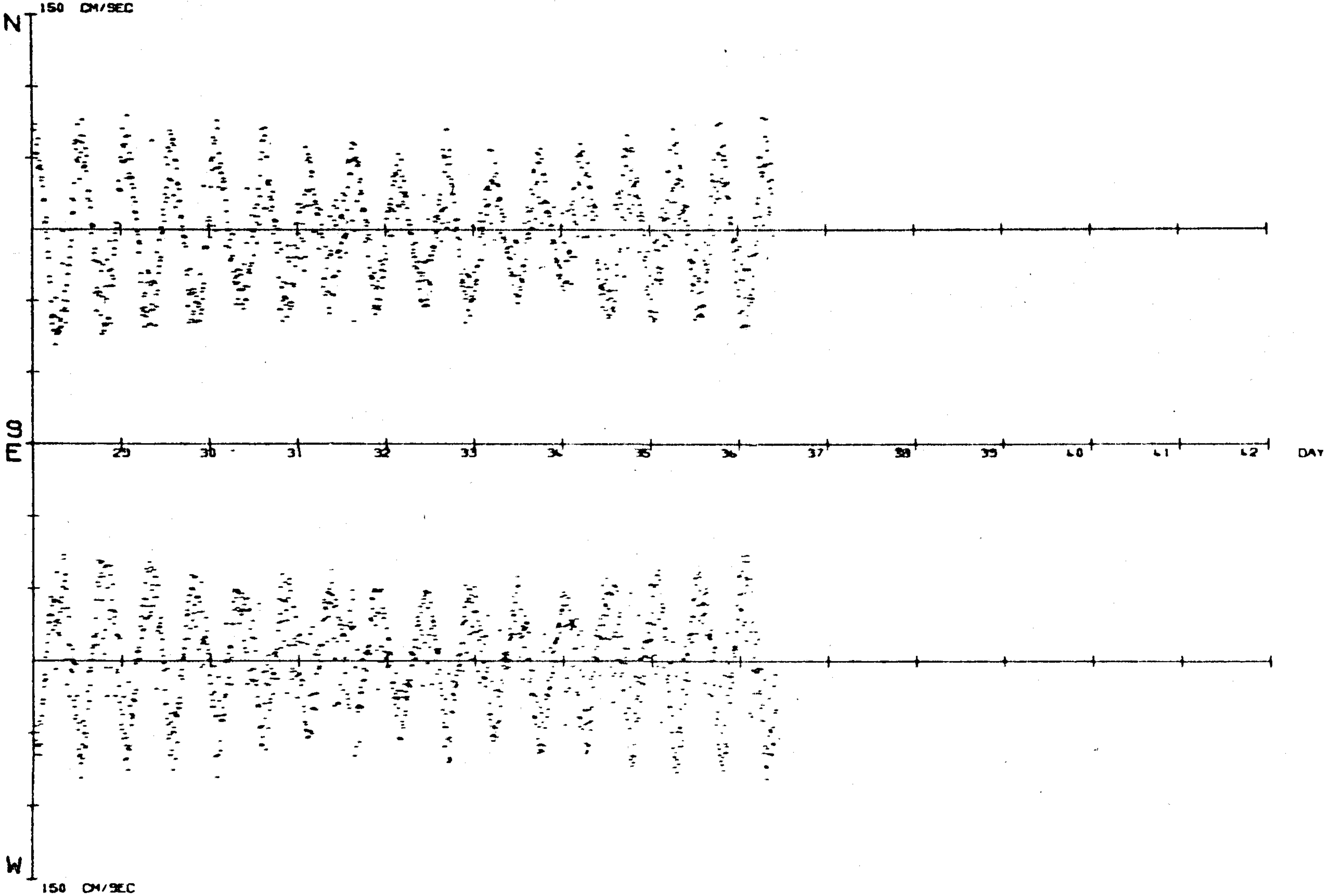
DAY
150 CM/SEC

METER 594 DATE 29 10 76



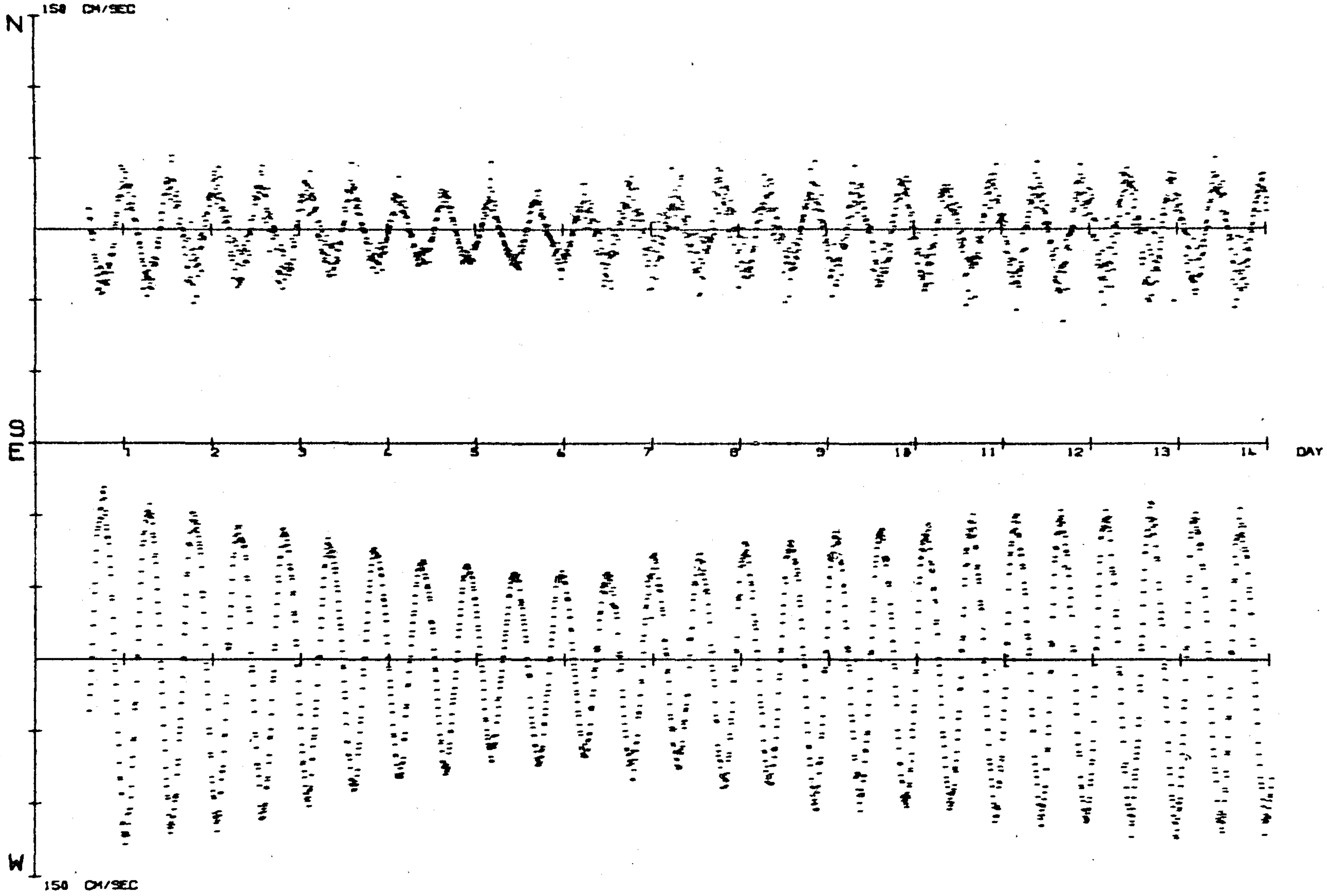
4.8

METER 994 DATE 29 10 76



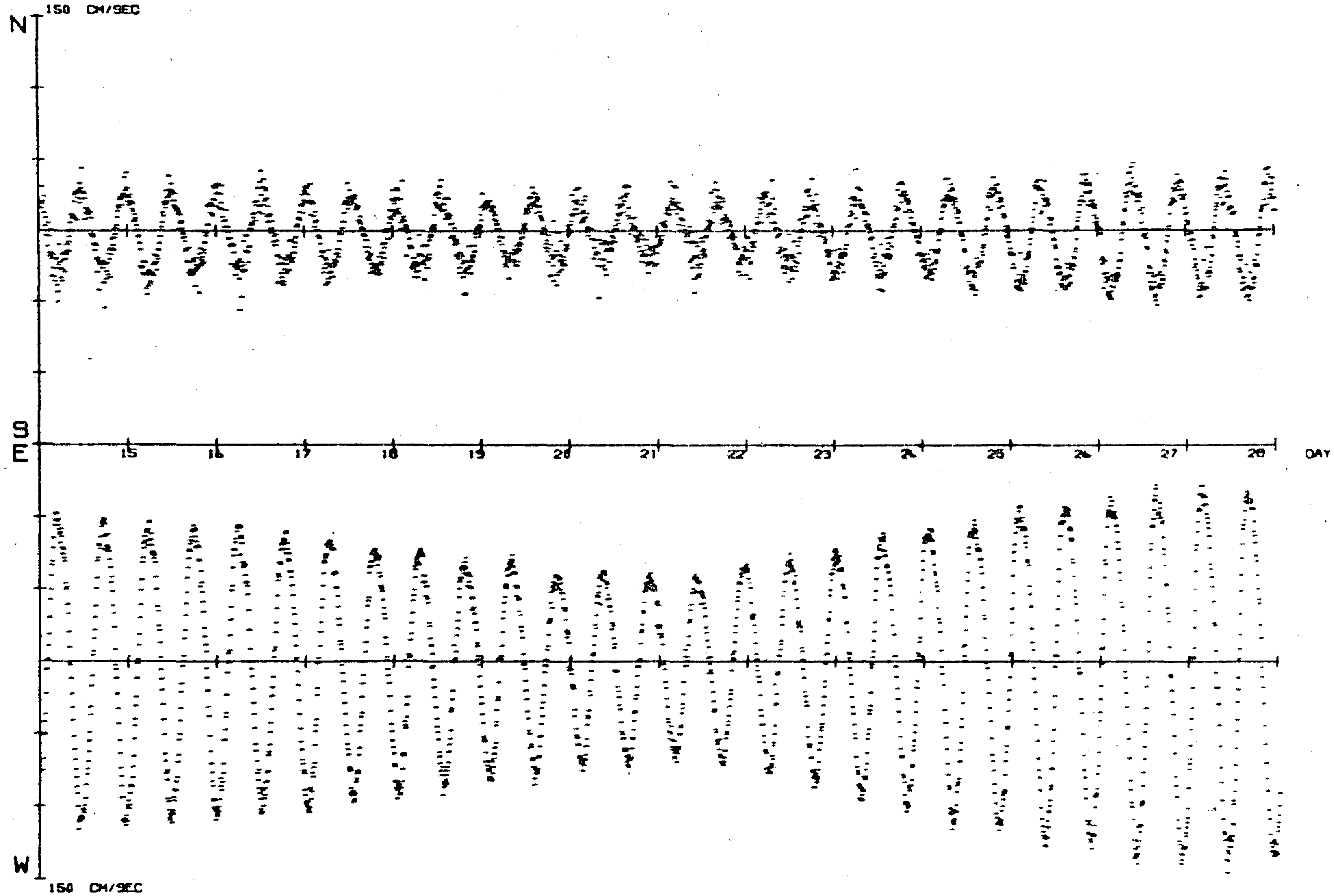
4.9

METER 244 DATE 26 10 76



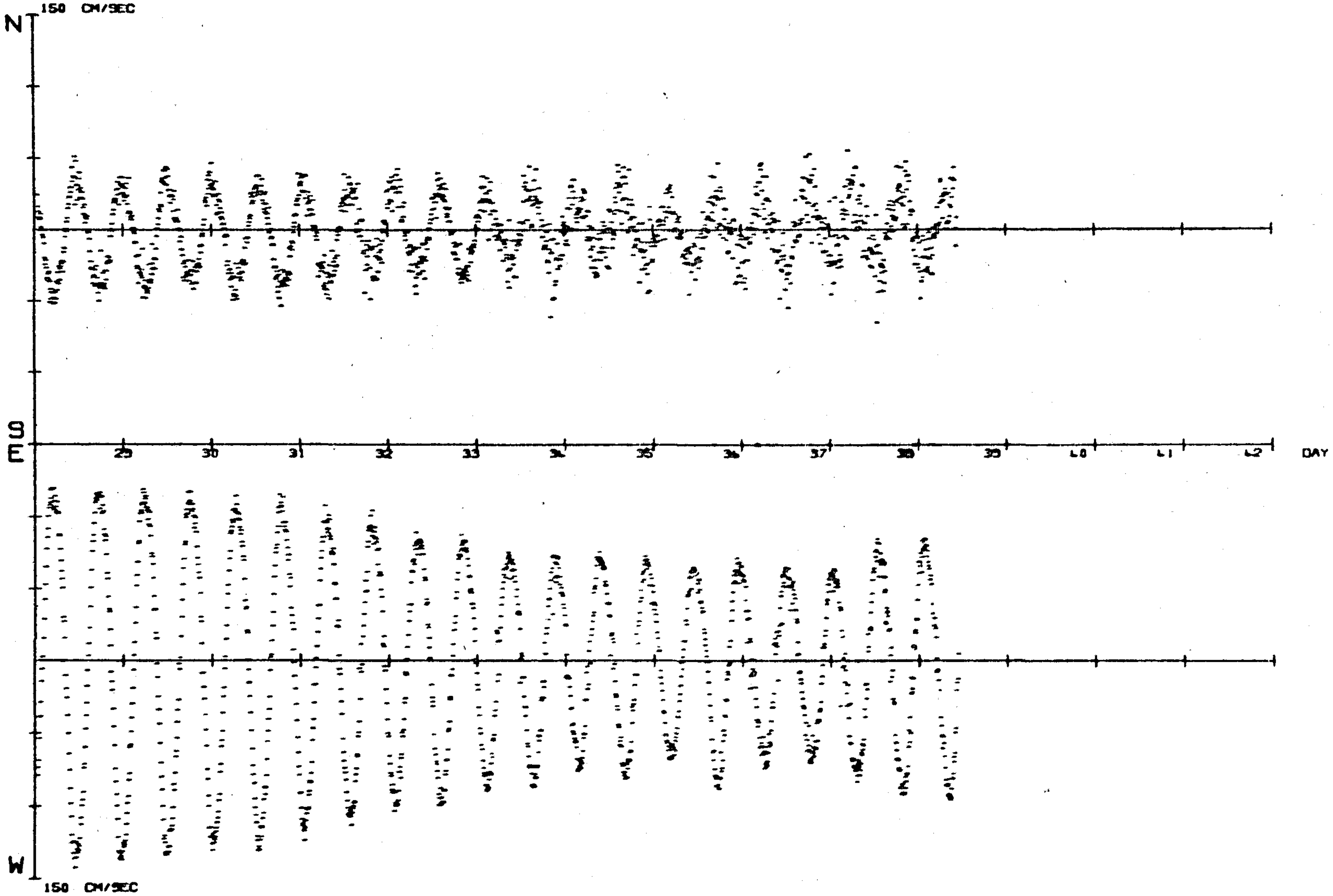
4.10

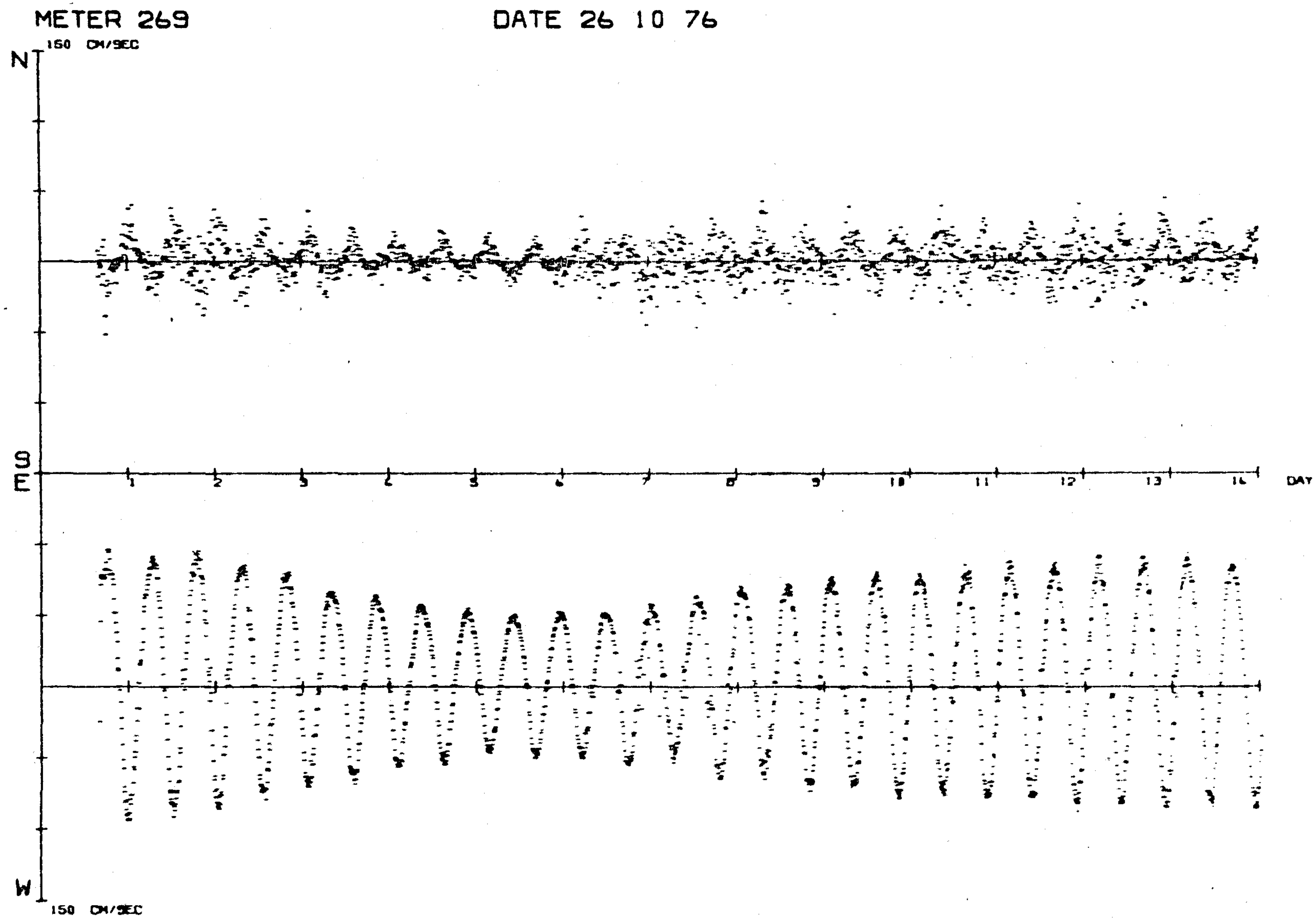
METER 244 DATE 26 10 76



4.11

METER 244 DATE 26 10 76





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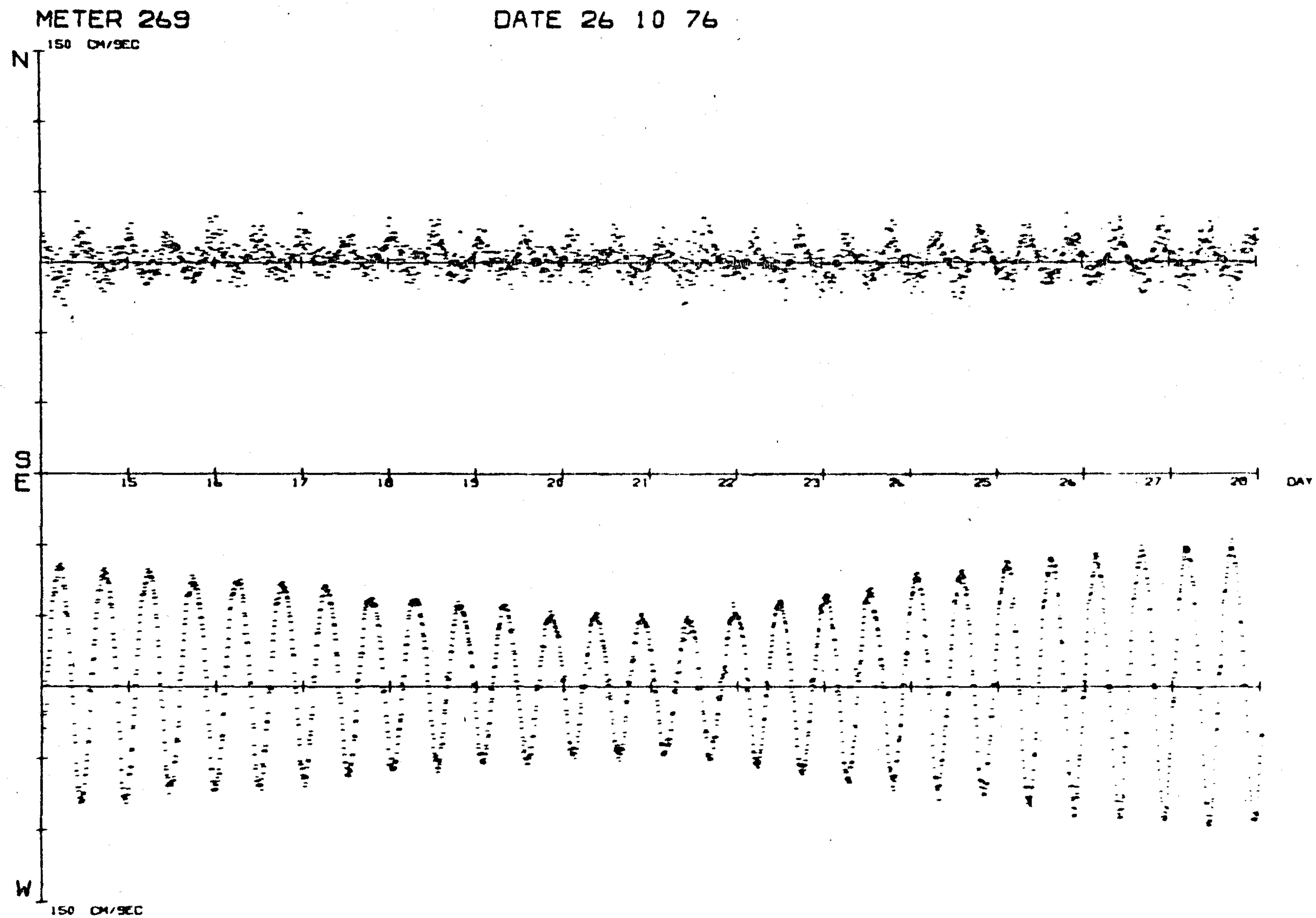
METER 269
DATE 26 10 76
150 CM/SEC
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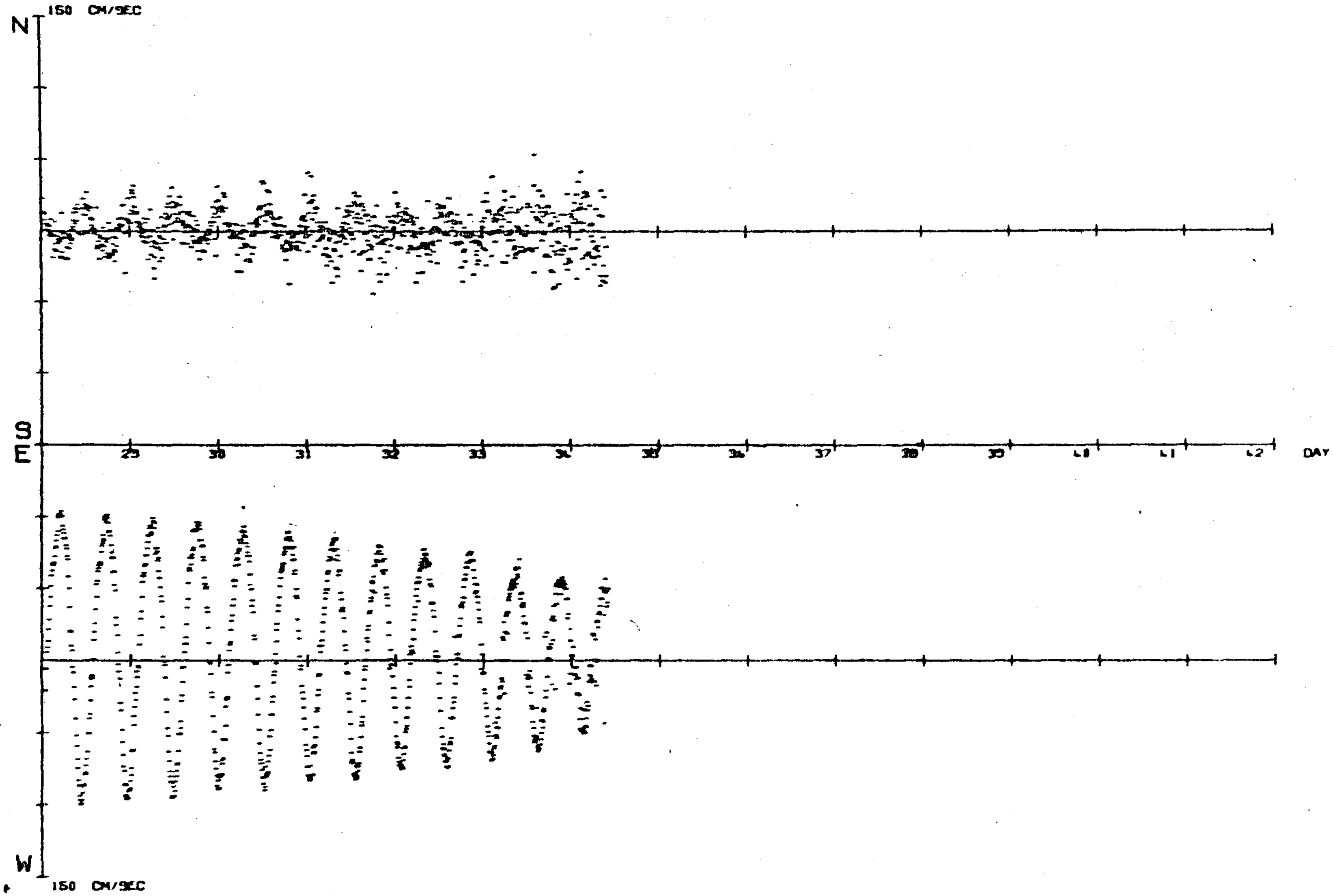
DAY
W
150 CM/SEC

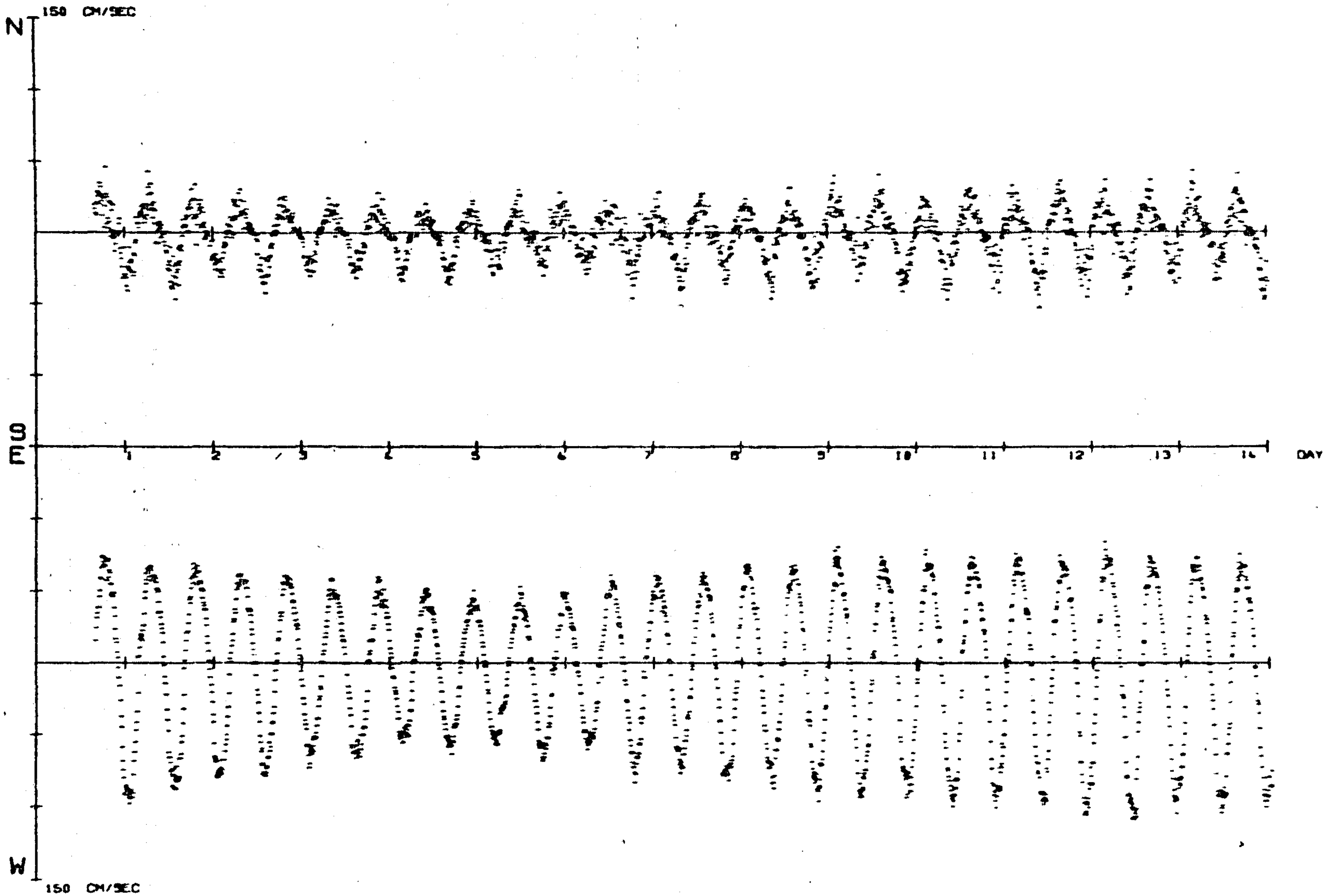
4.14

METER 269 DATE 26 10 76



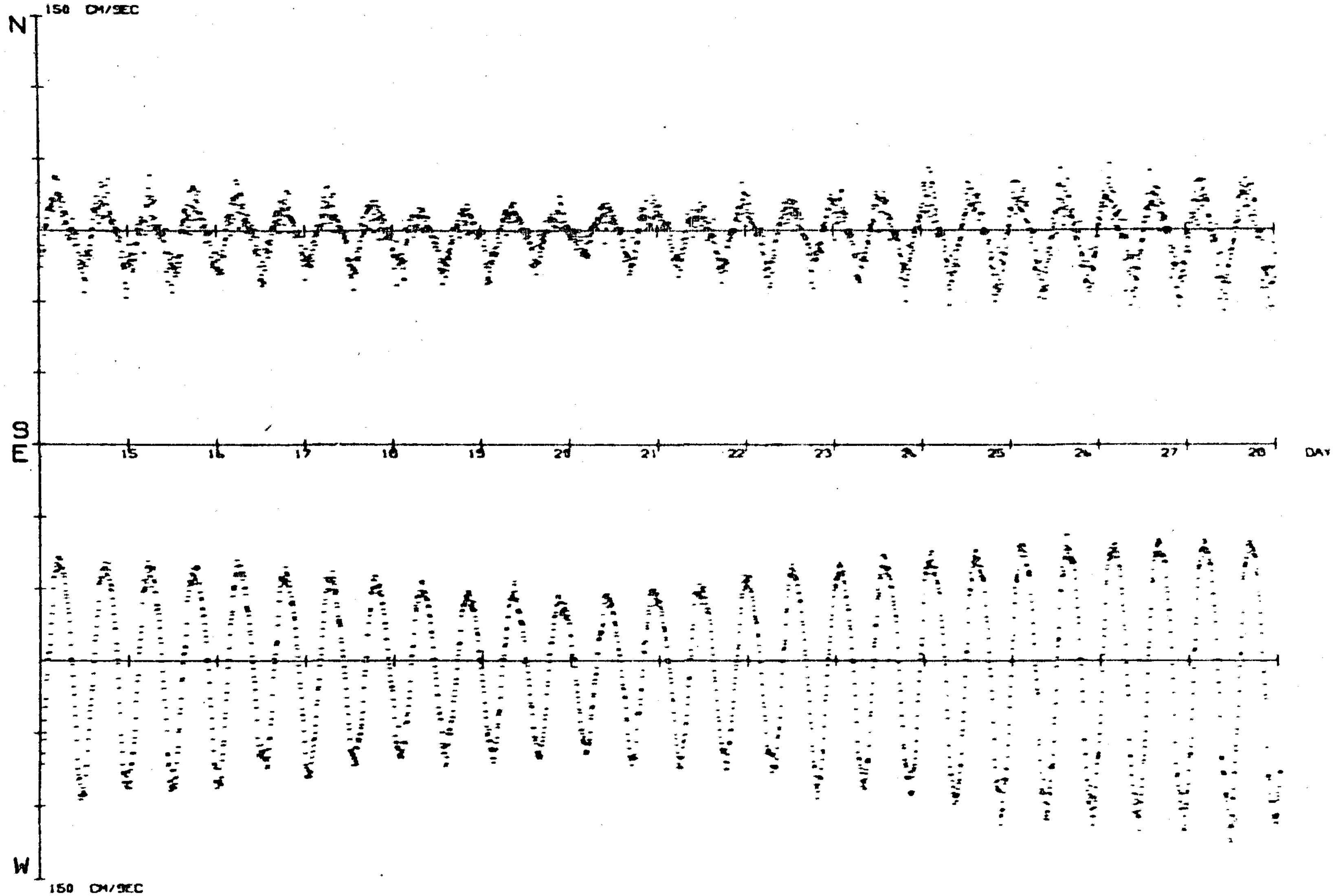
4.15

METER 260 DATE 27 10 76

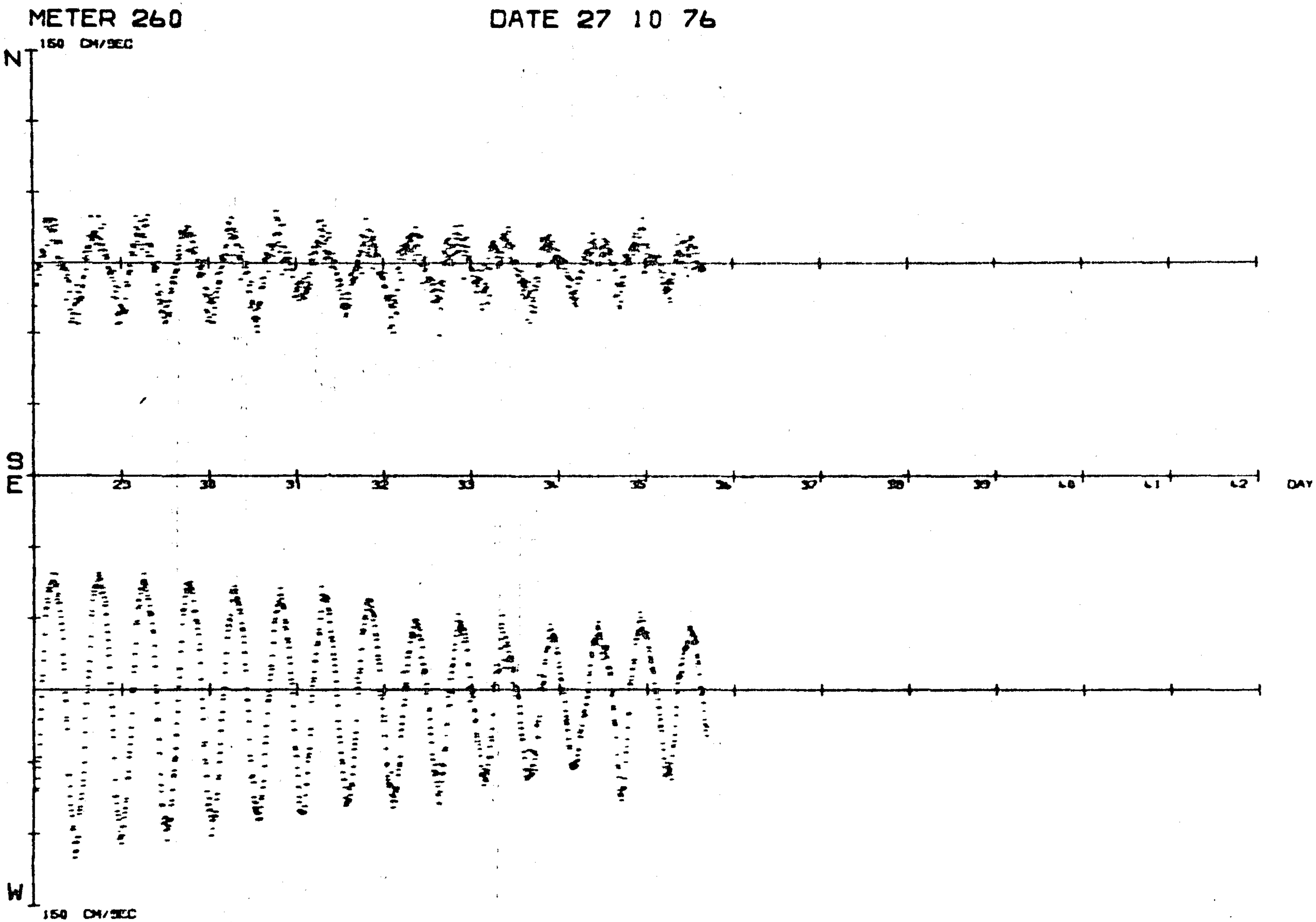


4.16

METER 260 DATE 27 10 76



4.17



METER 260
DATE 27 10 76
150 CM/SEC
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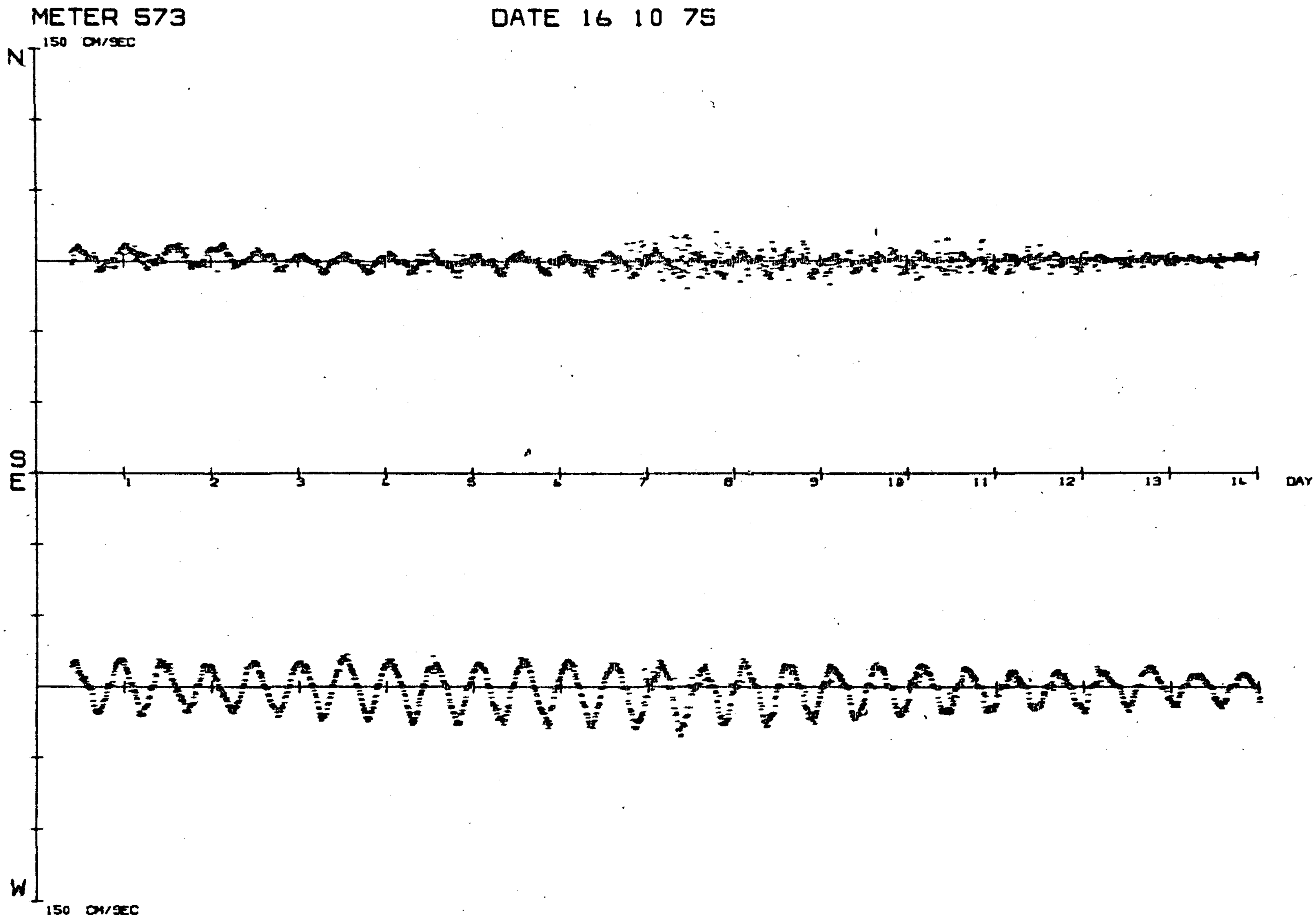
DAY
W
150 CM/SEC


METER 573
DATE 16 10 75
150 CM/SEC
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150 CM/SEC
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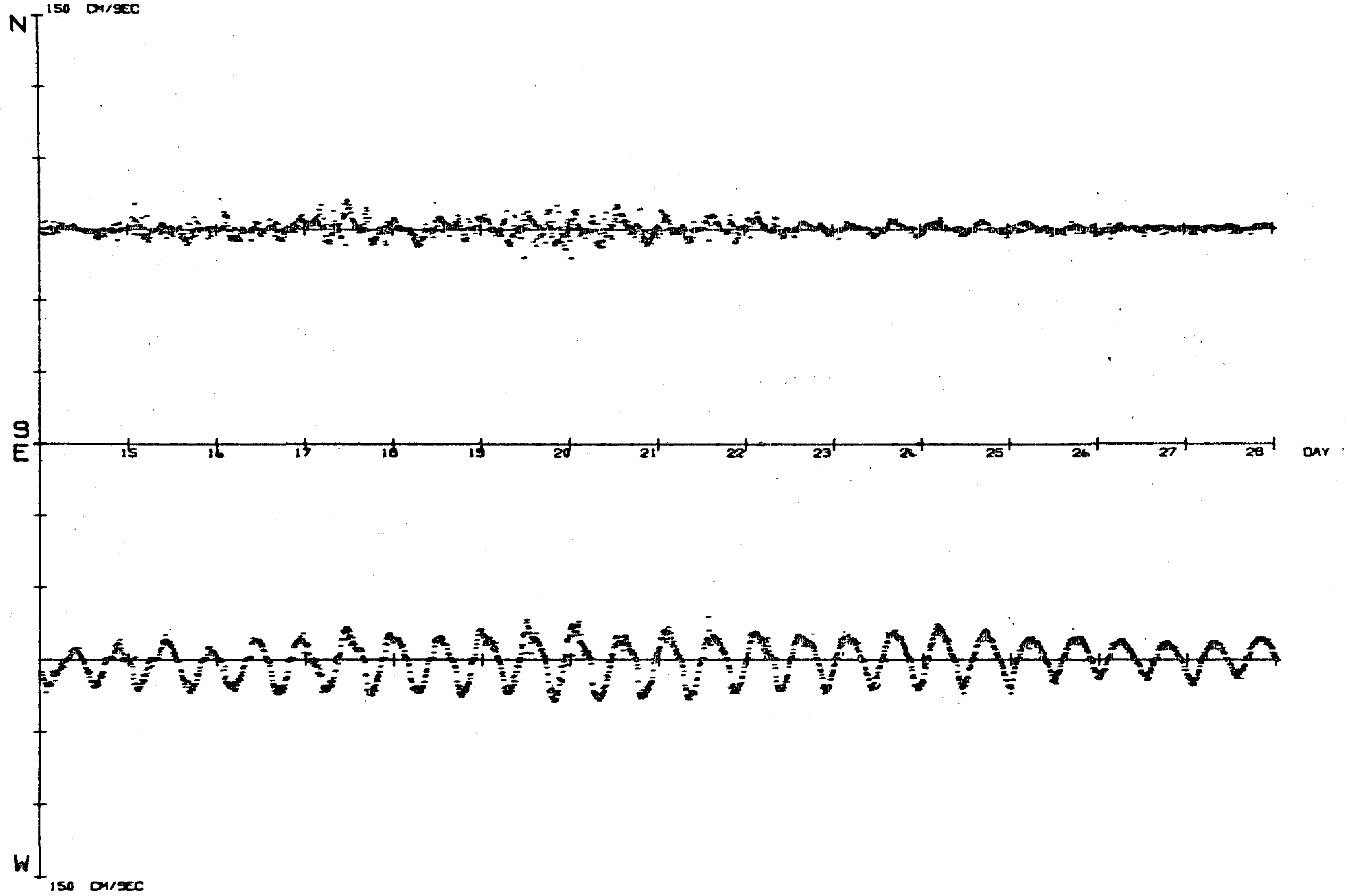
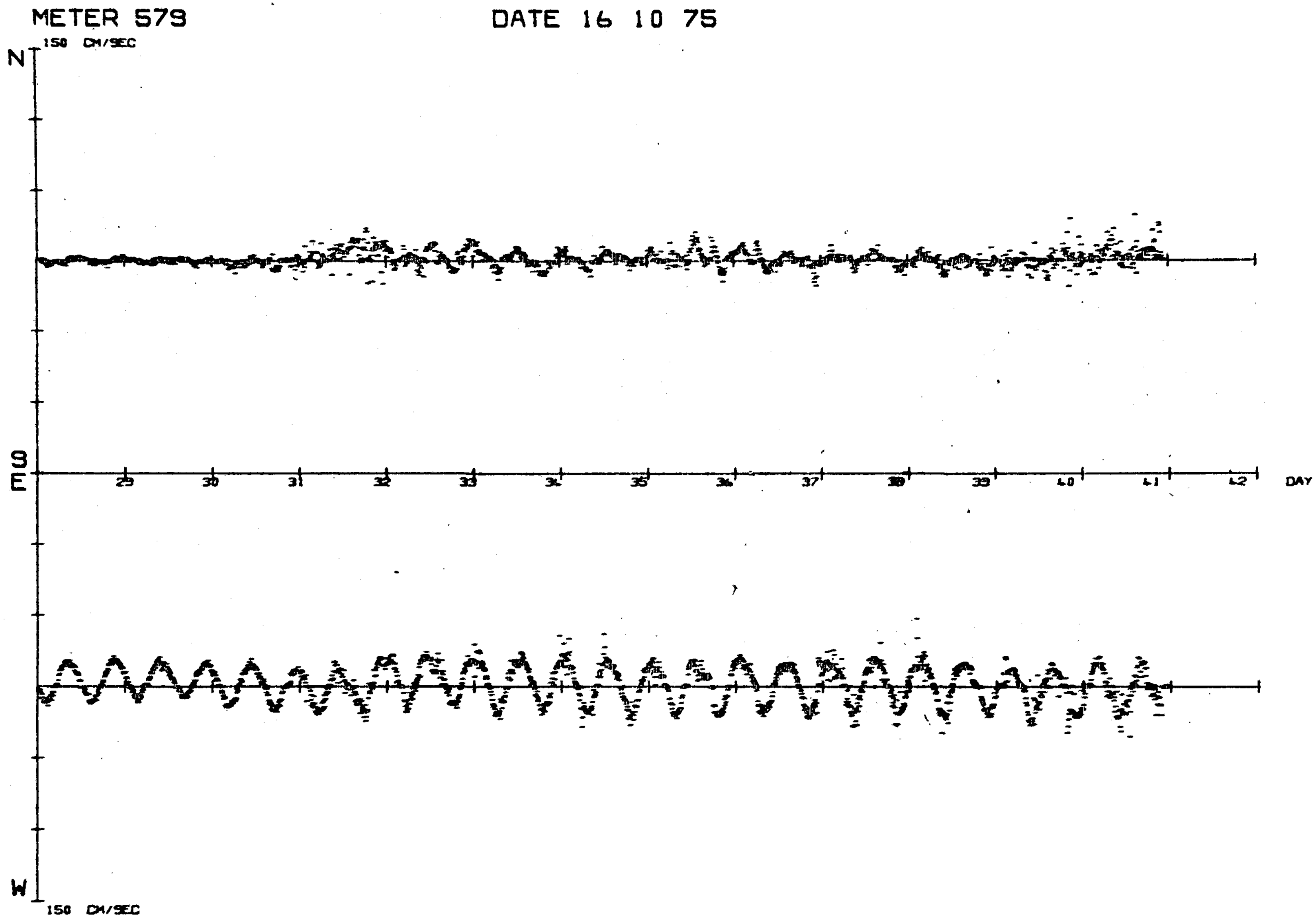
14
DAY

4.19

METER 573   DATE 16 10 75





METER 579
DATE 16 10 75
150 CM/SEC
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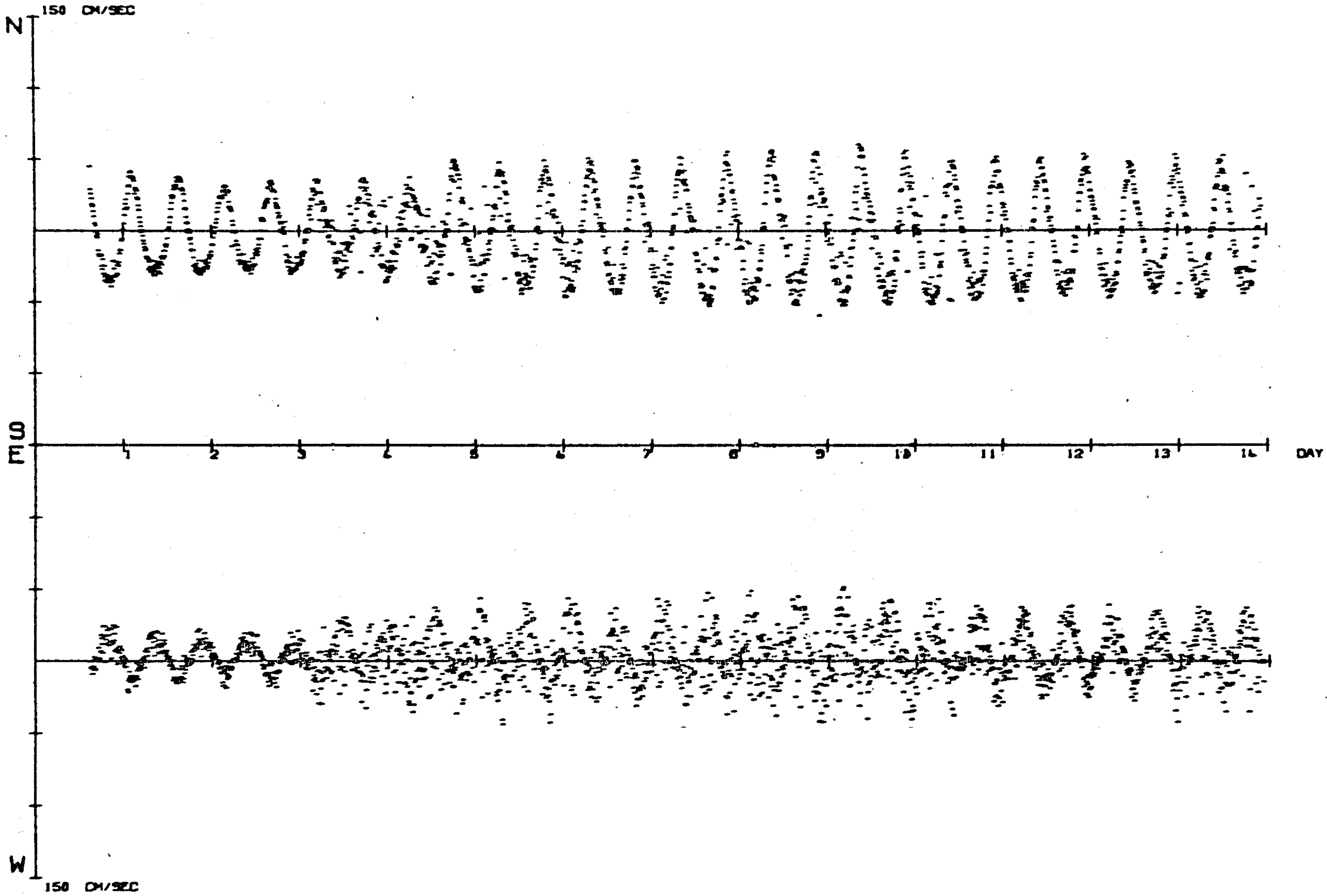
42
DAY
150 CM/SEC

4.21

METER 534 DATE 29 10 76

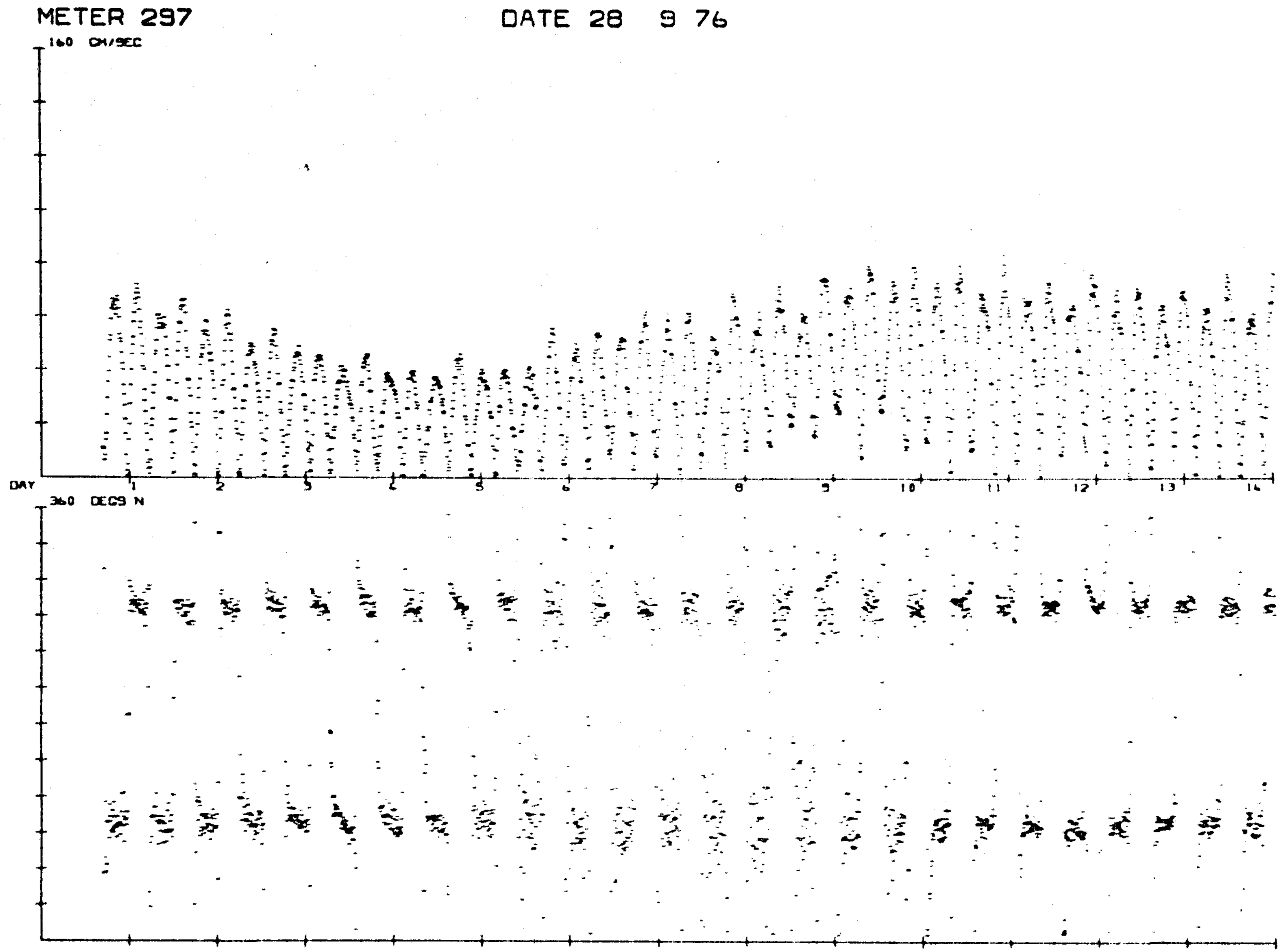


4.22

Figures 5.1 - 5.22

Time series of current speed and direction readings.

Figure(s)	Record	Station
5.1 - 5.3	237J6	A
5.4 - 5.6	680K6	B
5.7 - 5.9	594K6	C
5.10 - 5.12	244K6	D
5.13 - 5.15	269K6	E
5.16 - 5.18	260K6	F
5.19 - 5.21	573K5	G
5.22	534K6	H


METER 297
DATE 28 9 76
160 CM/SEC
DAY
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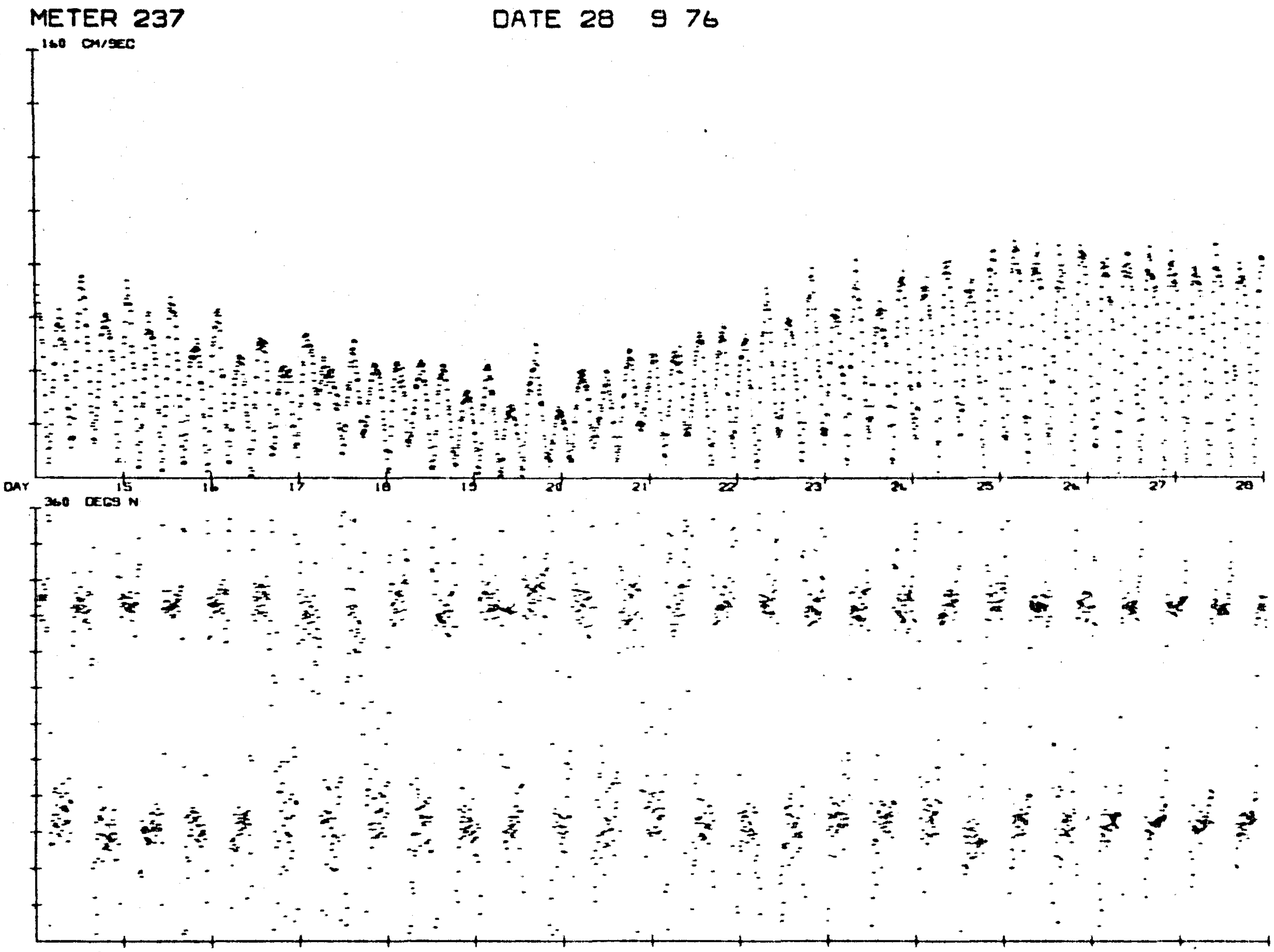
14
360 DEGS N

5.1


METER 237
DATE 28 9 76
160 CM/SEC
DAY
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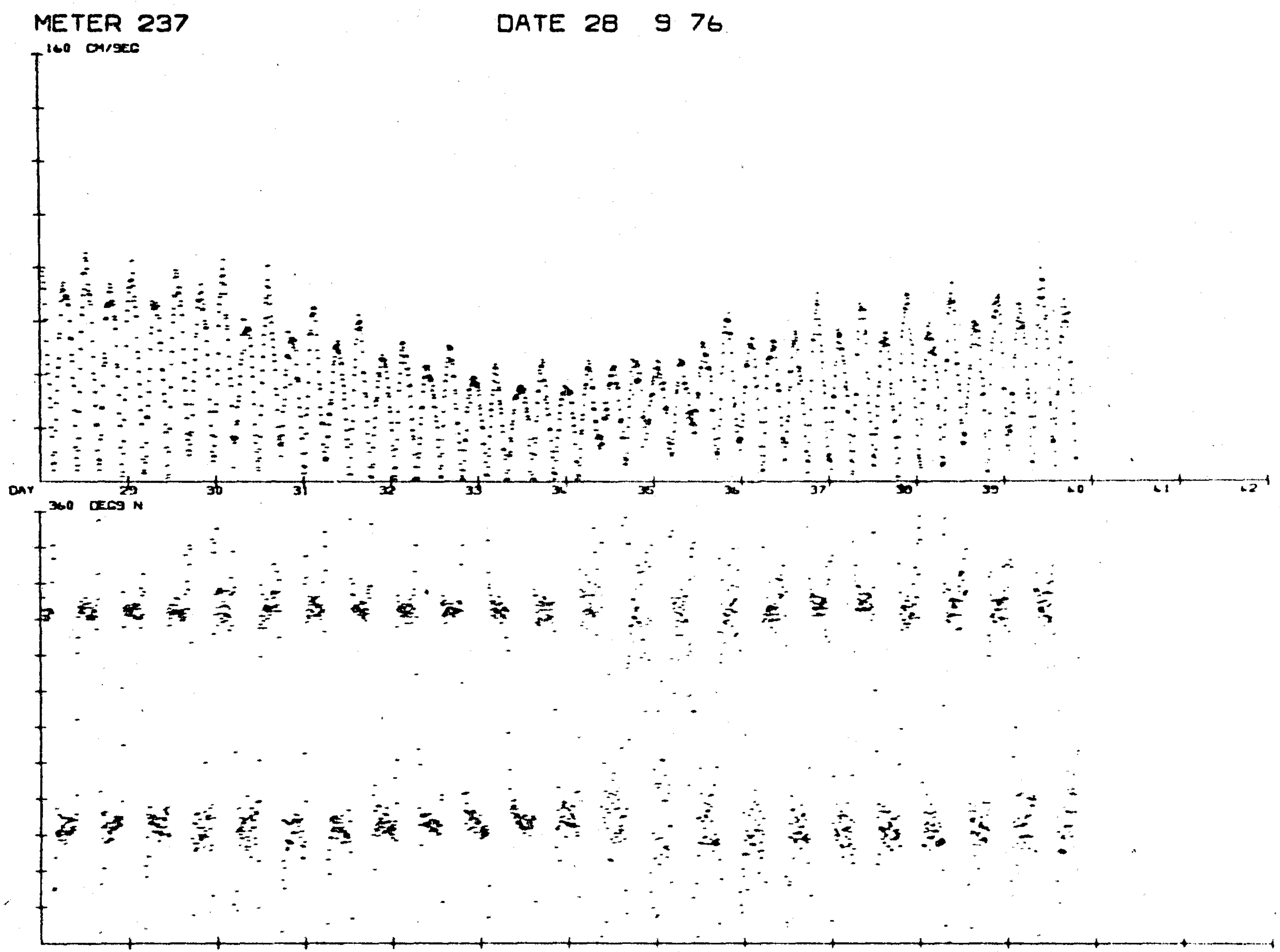
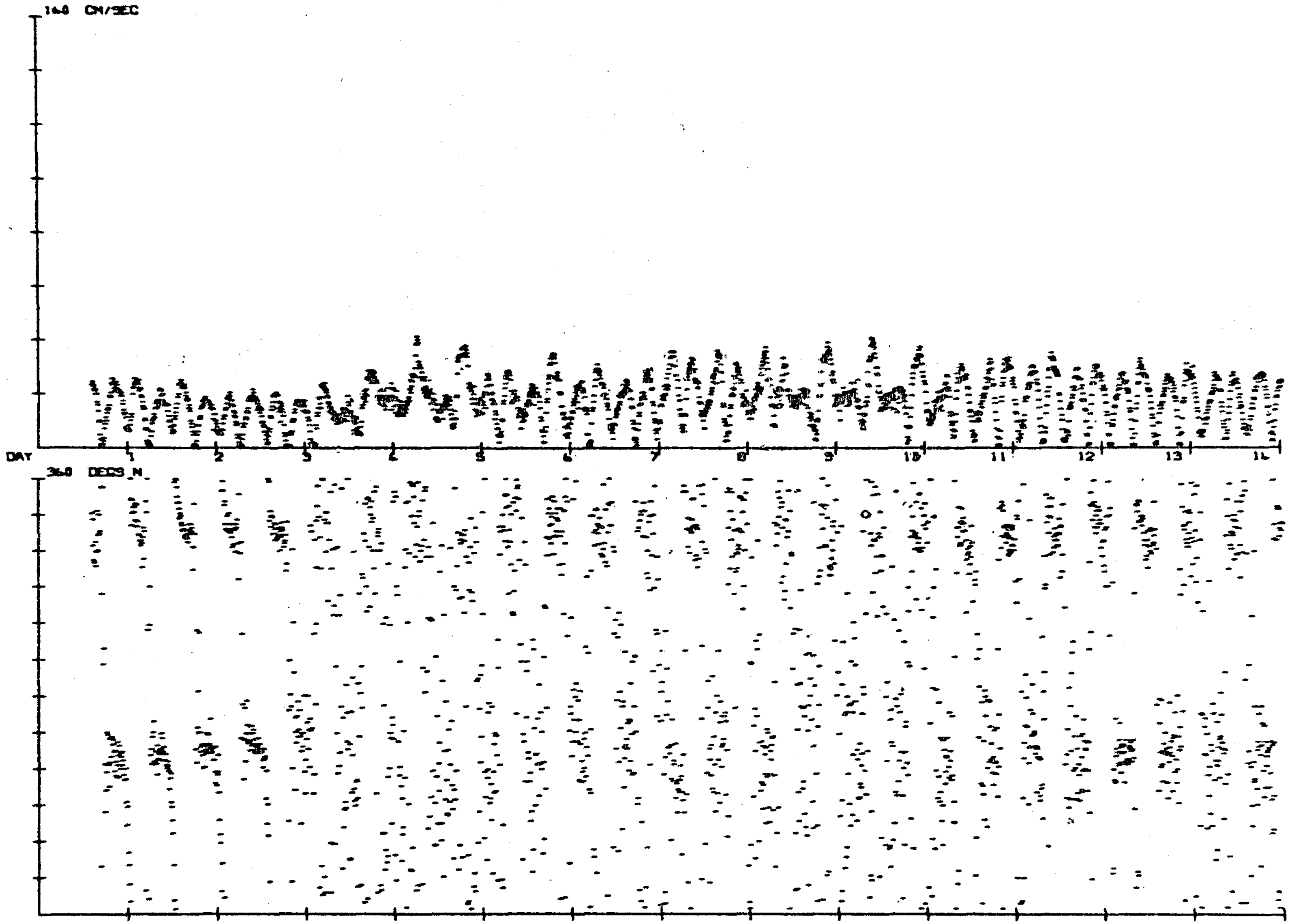
26
27
28
360 DEGS N


METER 237
DATE 28 9 76
160 CM/SEC
DAY
29
30
31
32
33
36
37
39
360 DEGS N

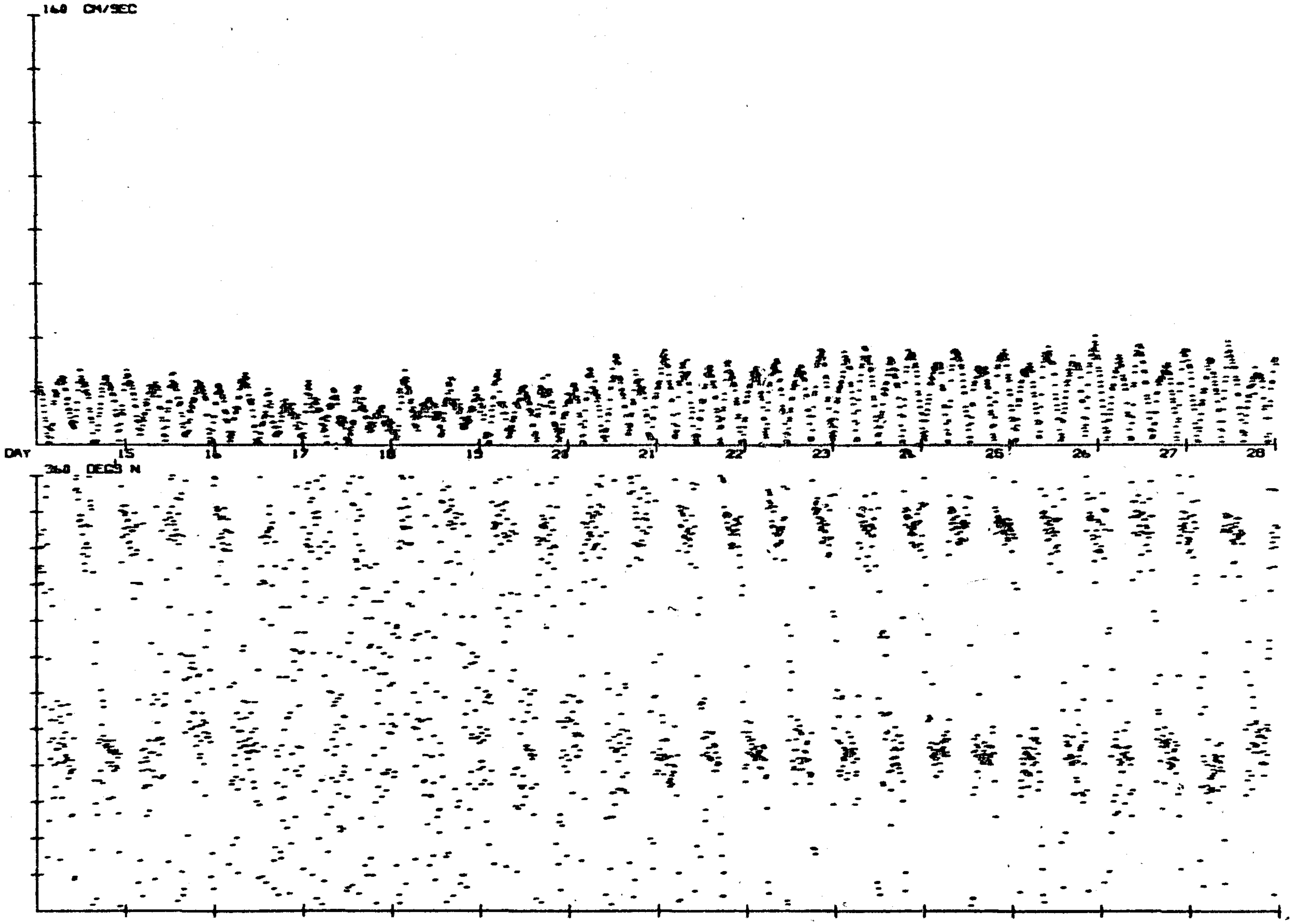
5.3

METER 680 DATE 29 10 76

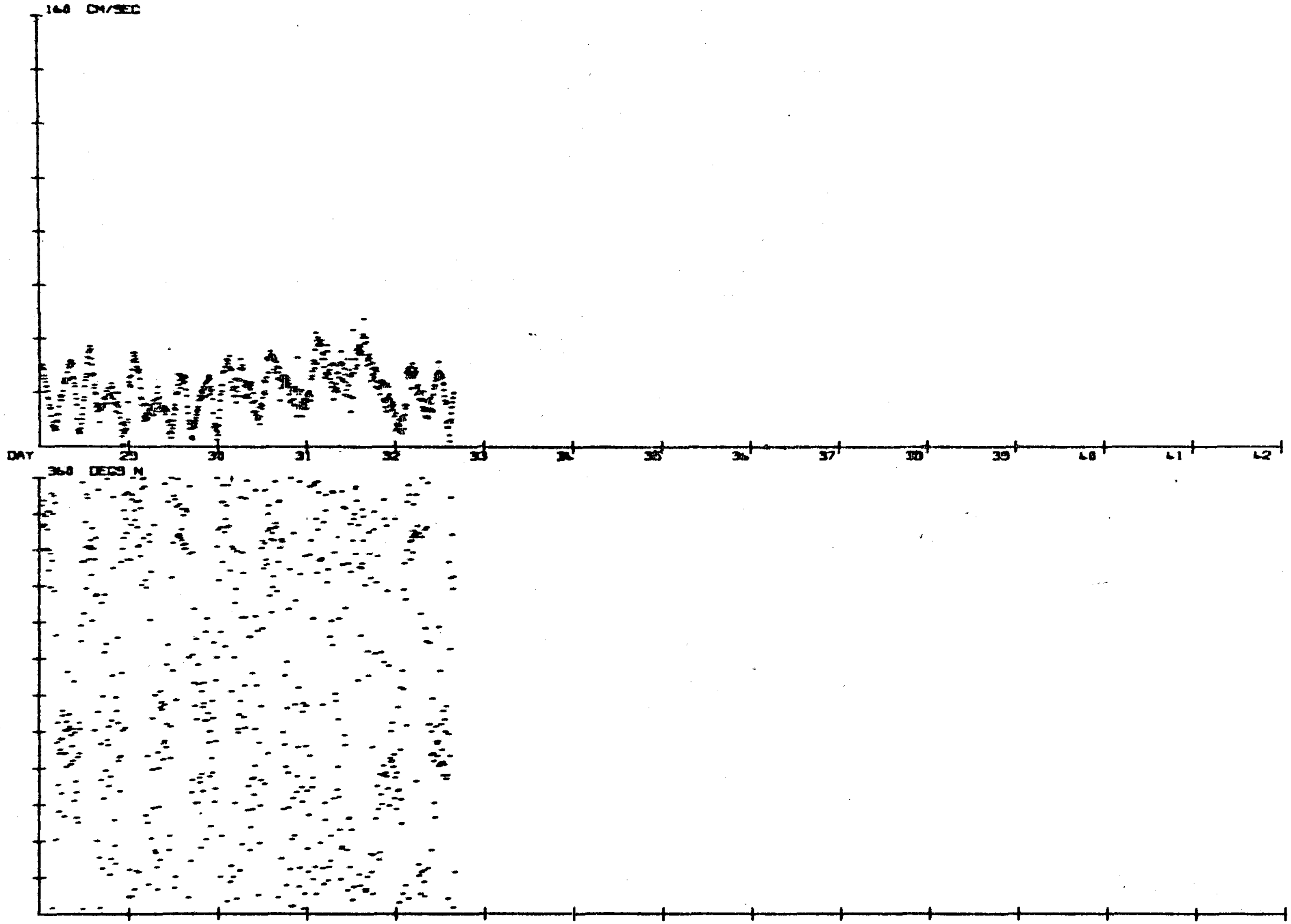


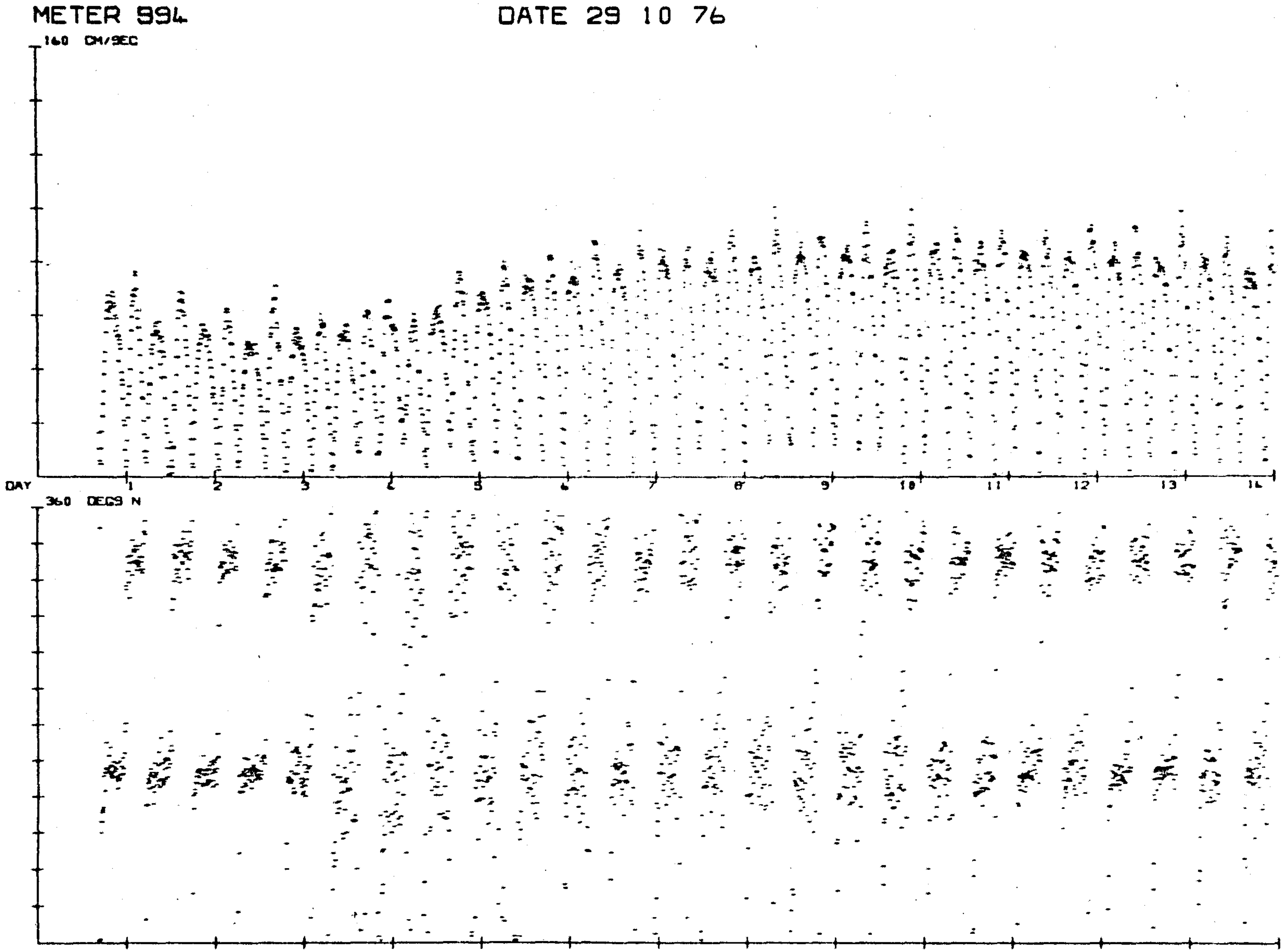
5.4

METER 680 DATE 29 10 76



METER 680 DATE 29 10 76




METER 994
DATE 29 10 76
160 CM/SEC
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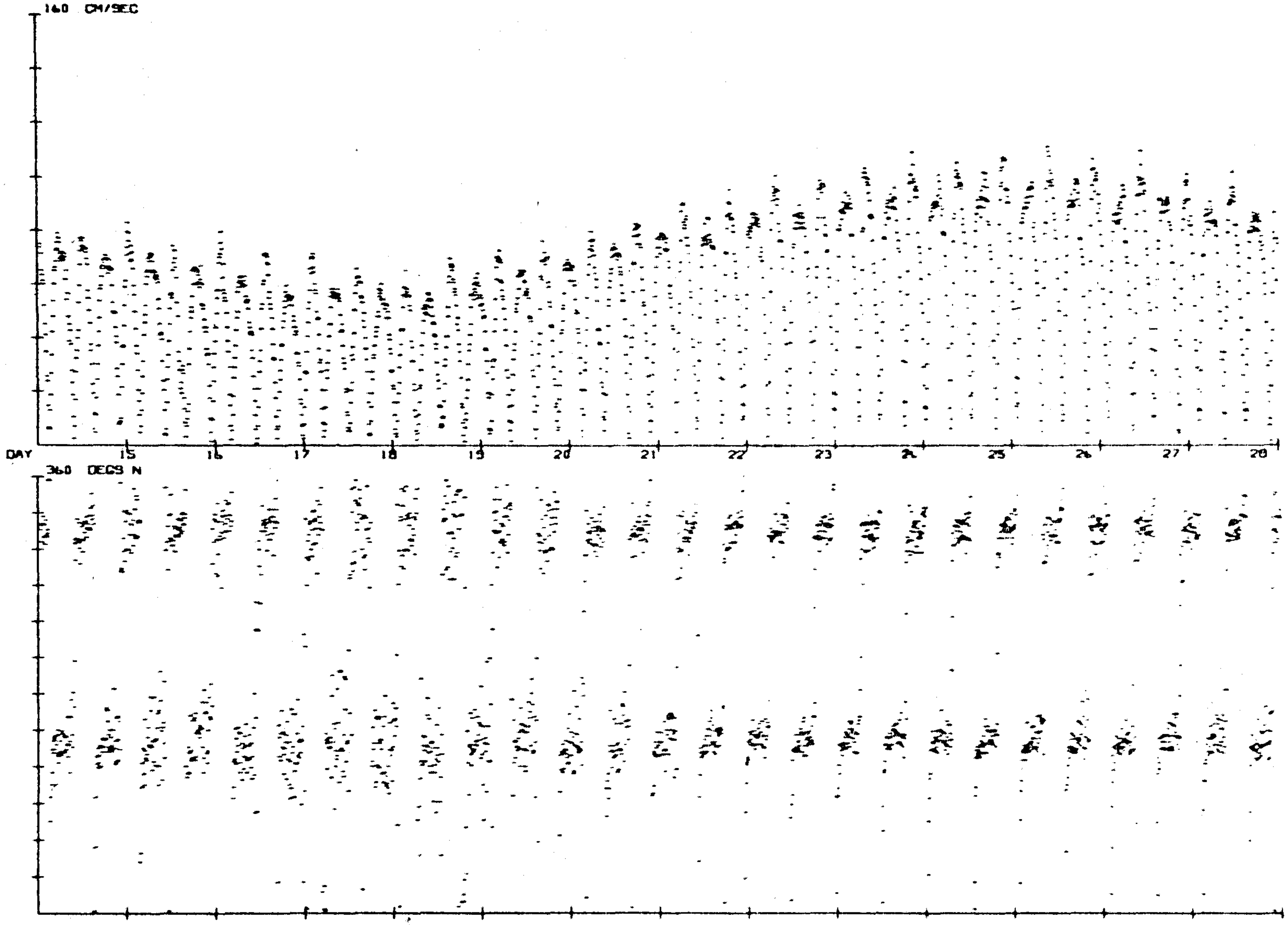
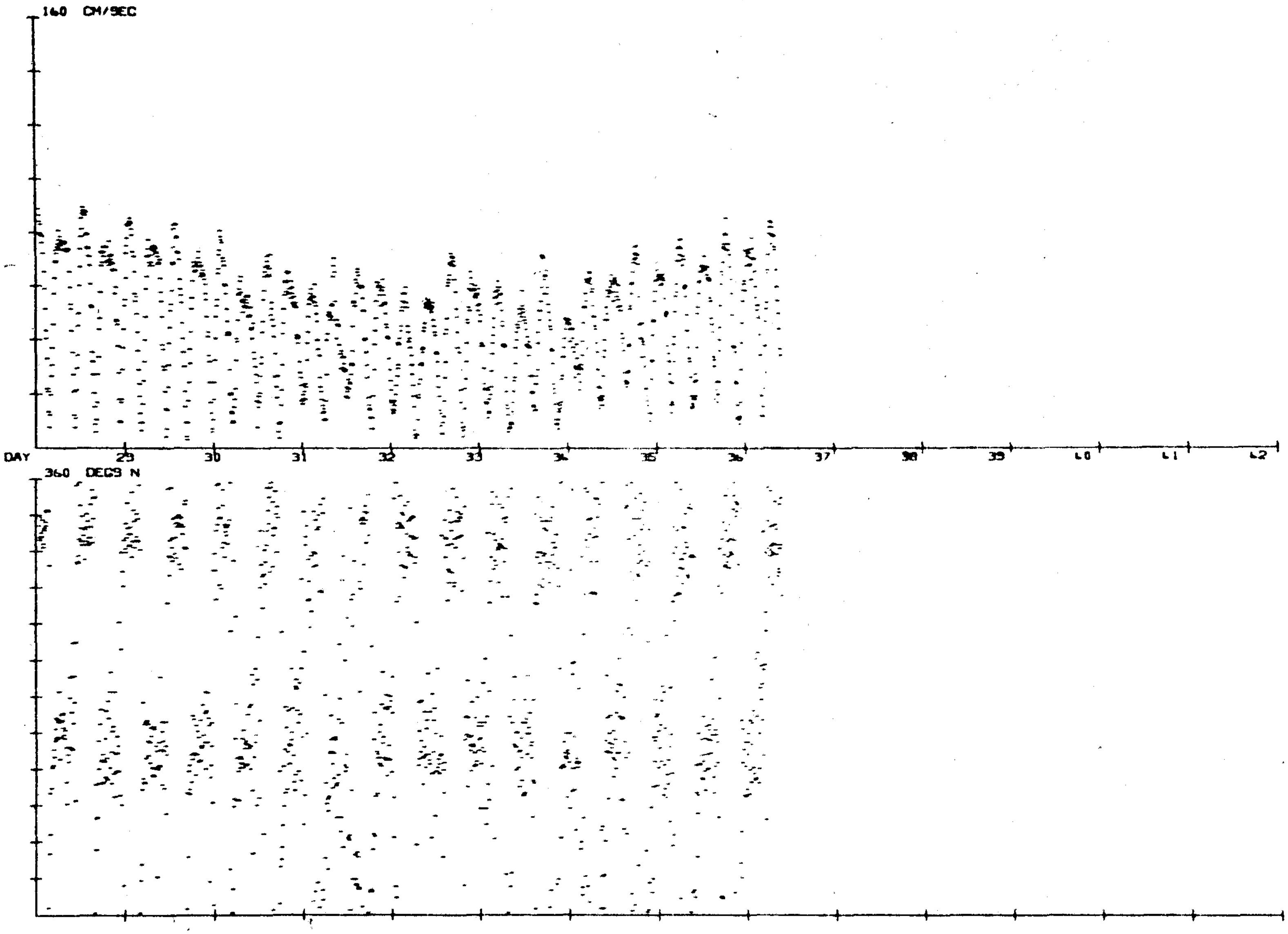
14
360 DEGS N

METER 594 DATE 29 10 76

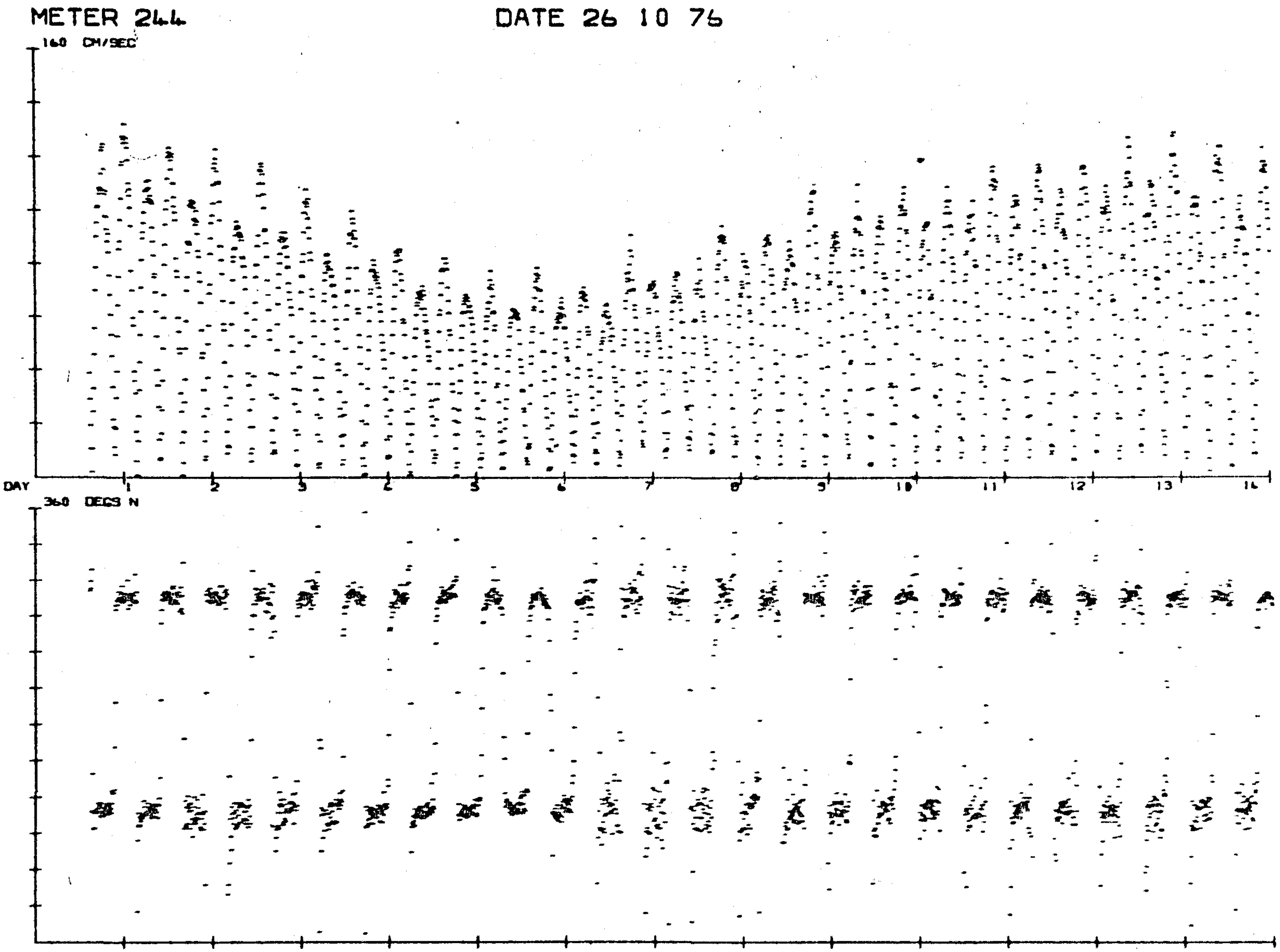


5.8

METER 994 DATE 29 10 76



5.9


METER 244
DATE 26 10 76
160 CM/SEC
DAY
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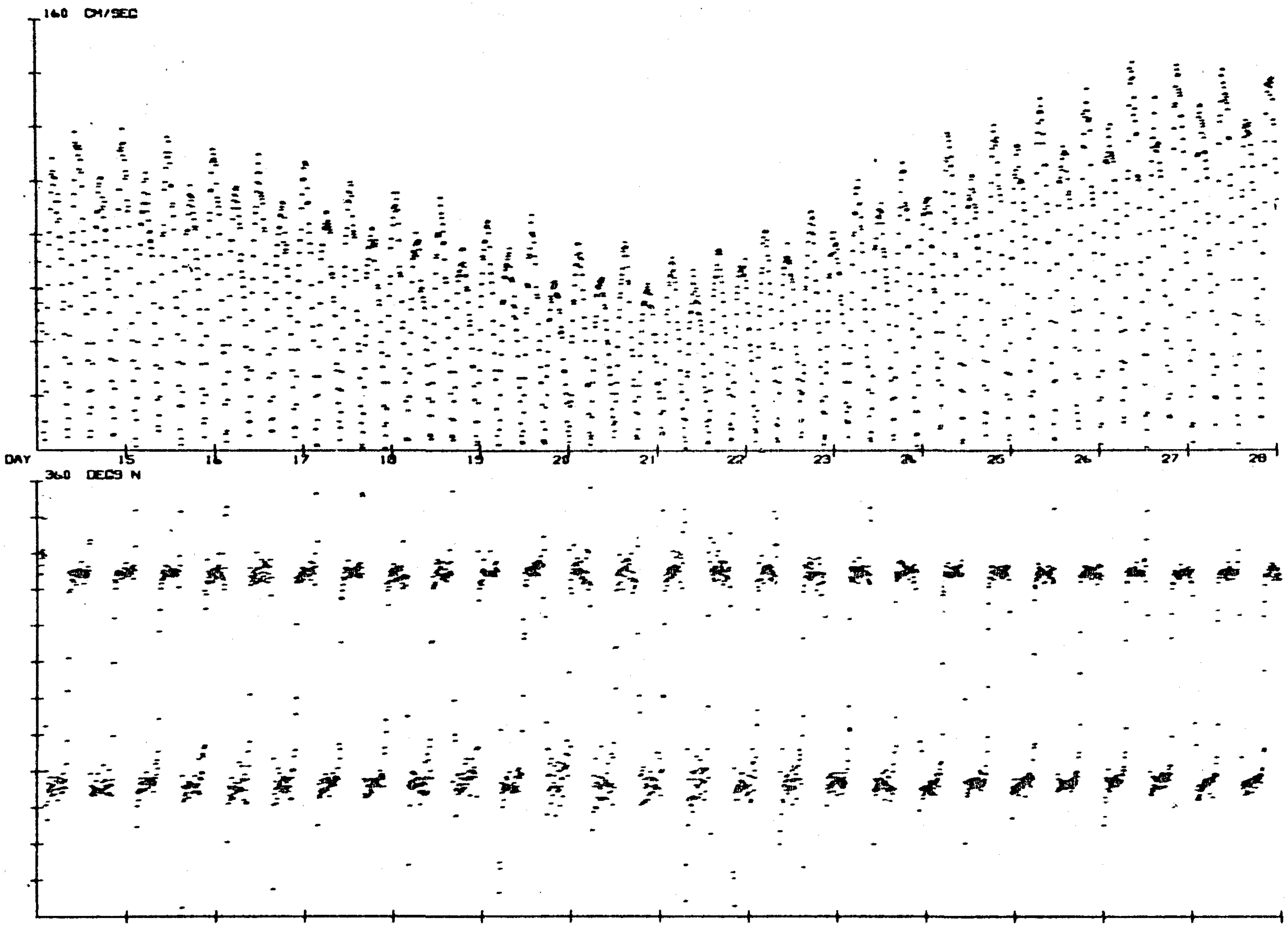
14
360 DEGS N

5.10

METER 244 DATE 26 10 76



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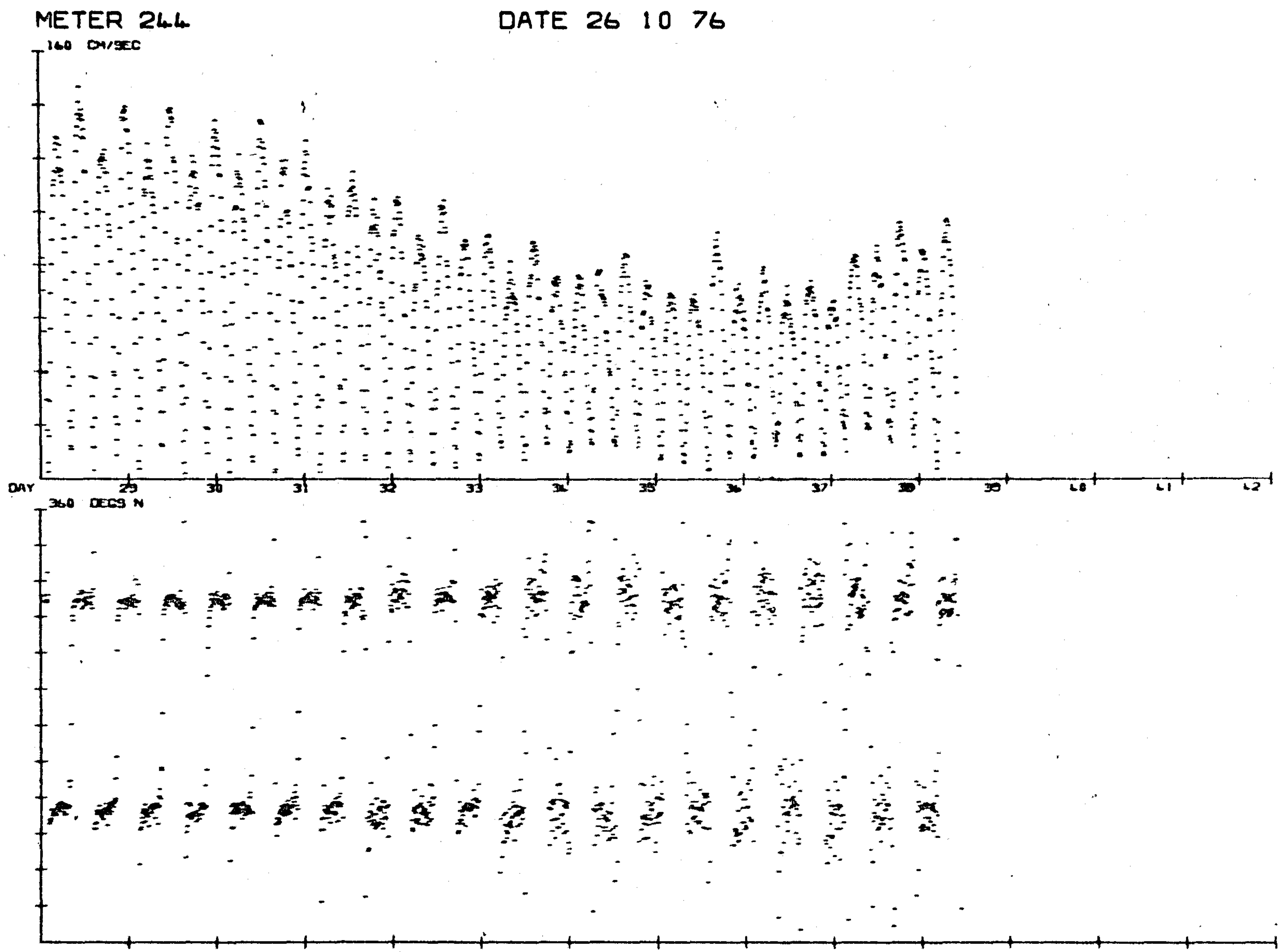
METER 244
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160 CM/SEC
DAY
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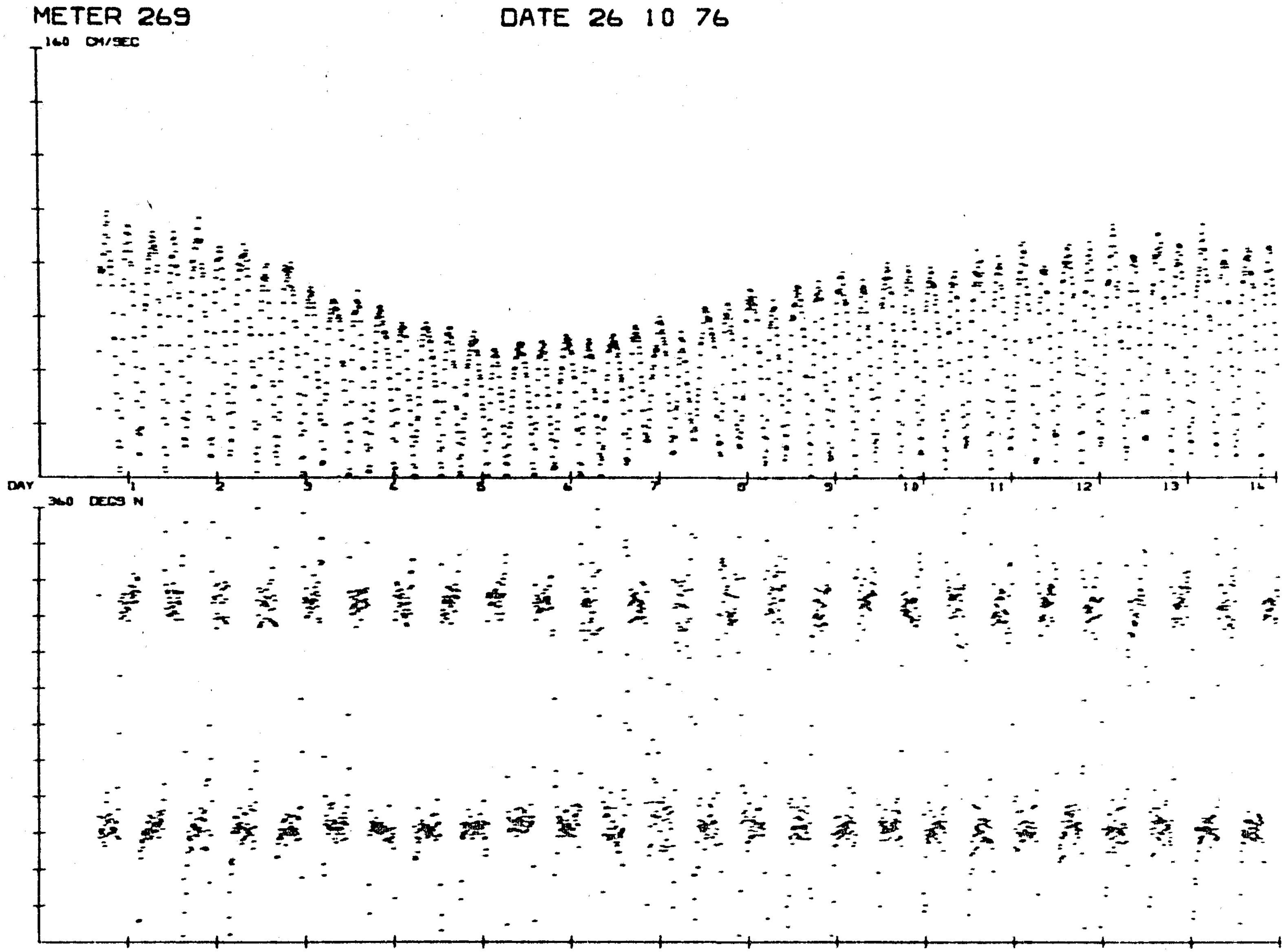
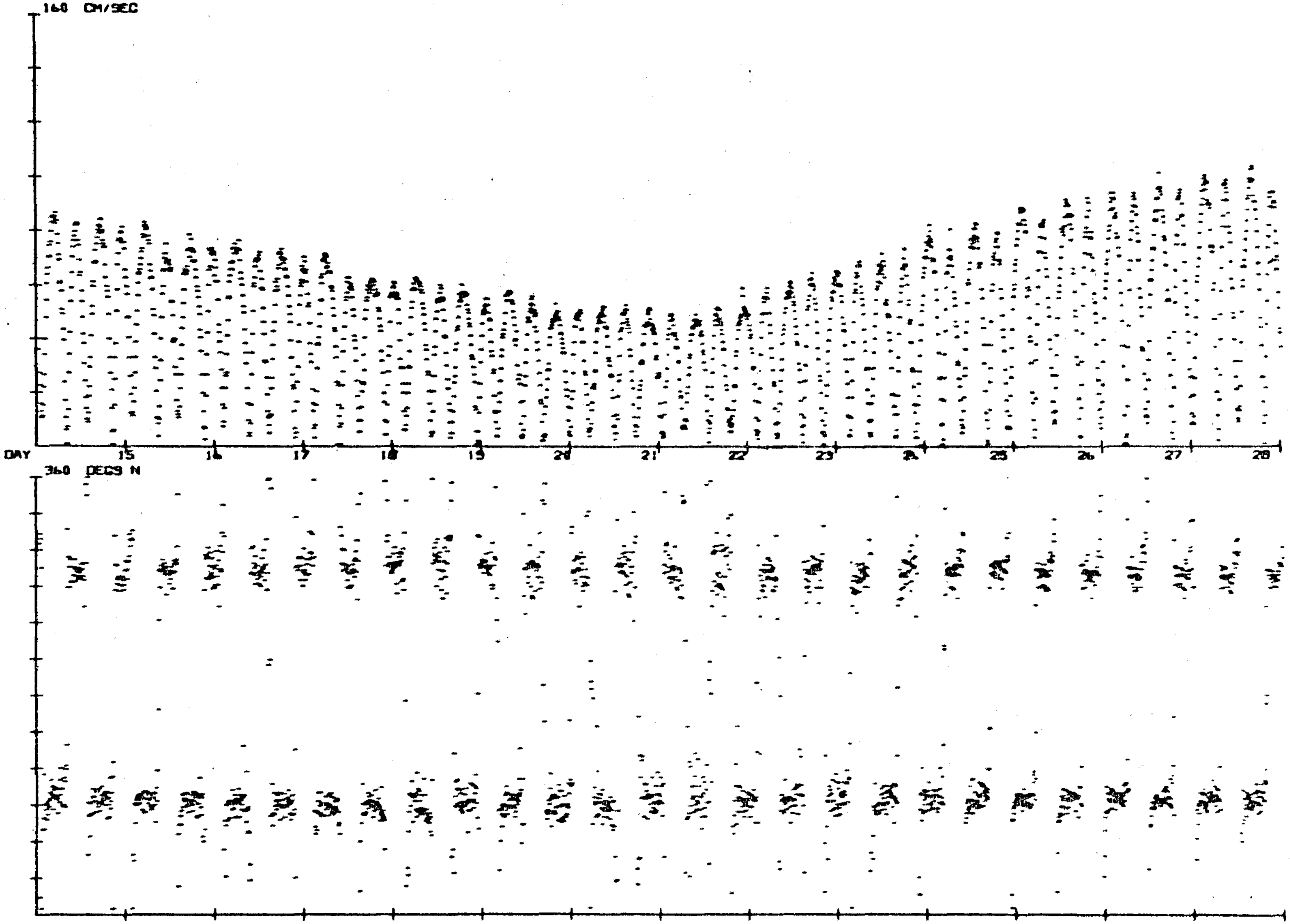
34
35
36
37
38
39
40
41
42
360 DEGS N


METER 269
DATE 26 10 76
160 CM/SEC
DAY
1 2 3 4 5 6 7 8 9 10 11 12 13 14
360 DEGS N

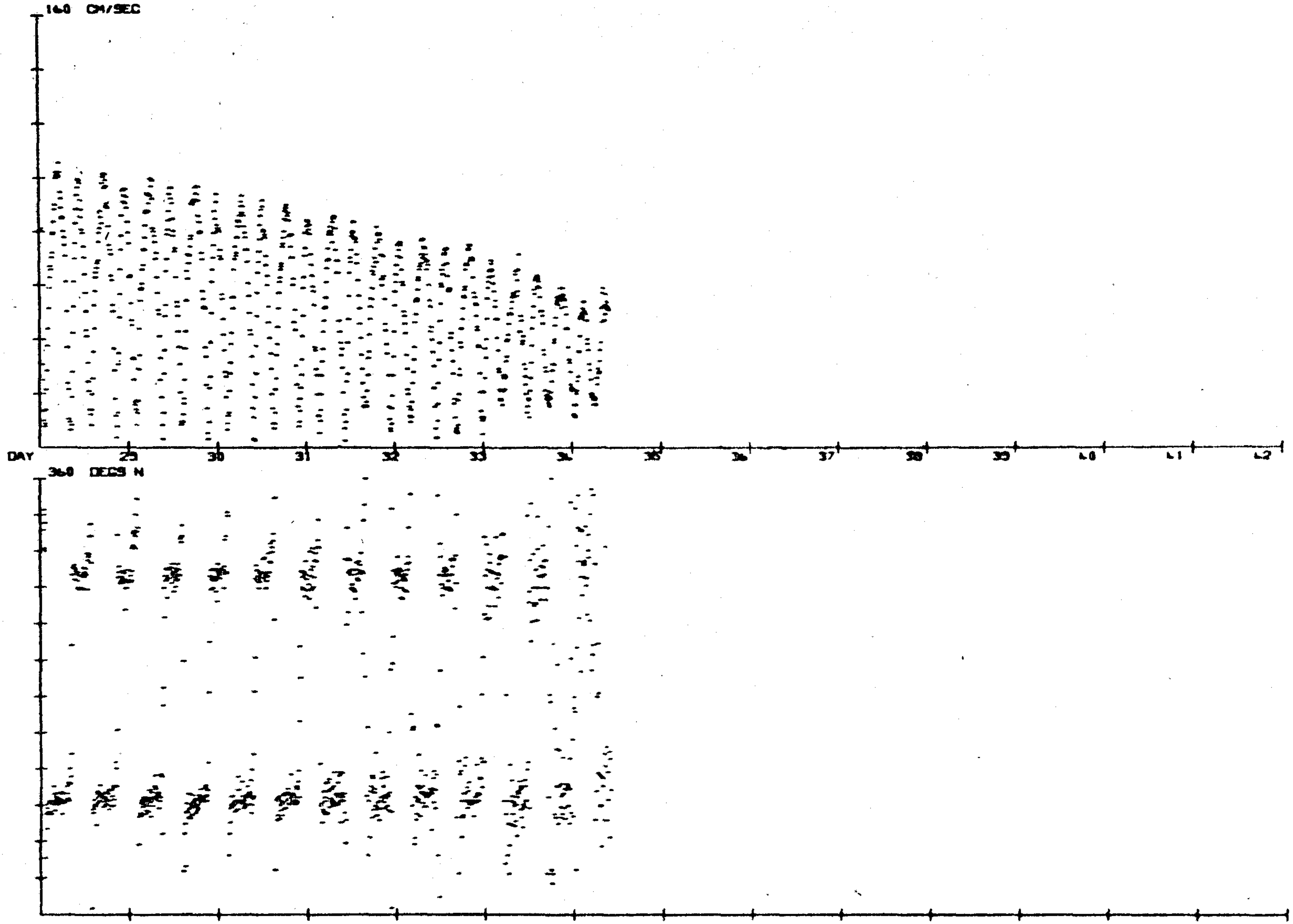
5.13

METER 269 DATE 26 10 76

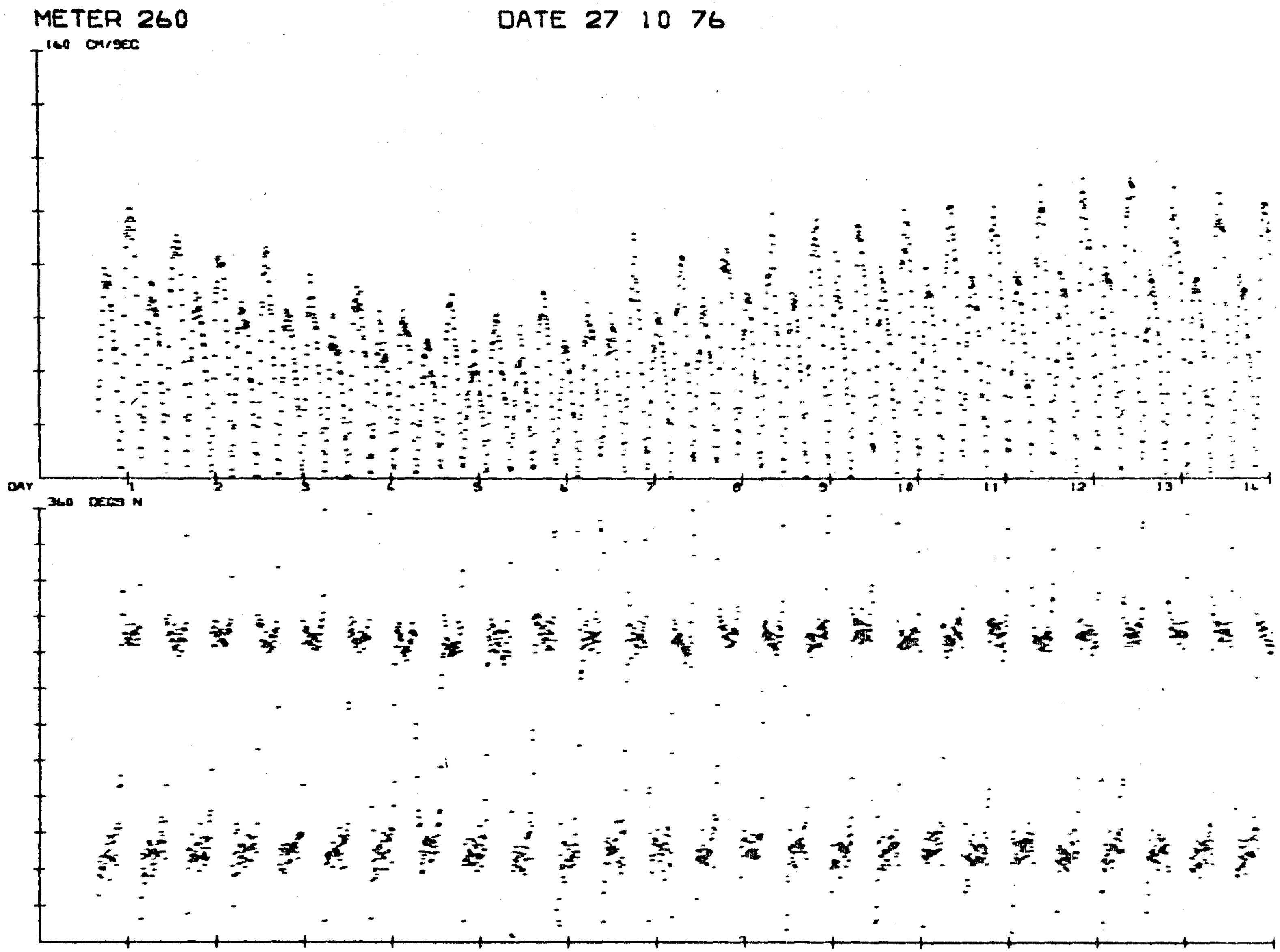


5.14

METER 269 DATE 26 10 76

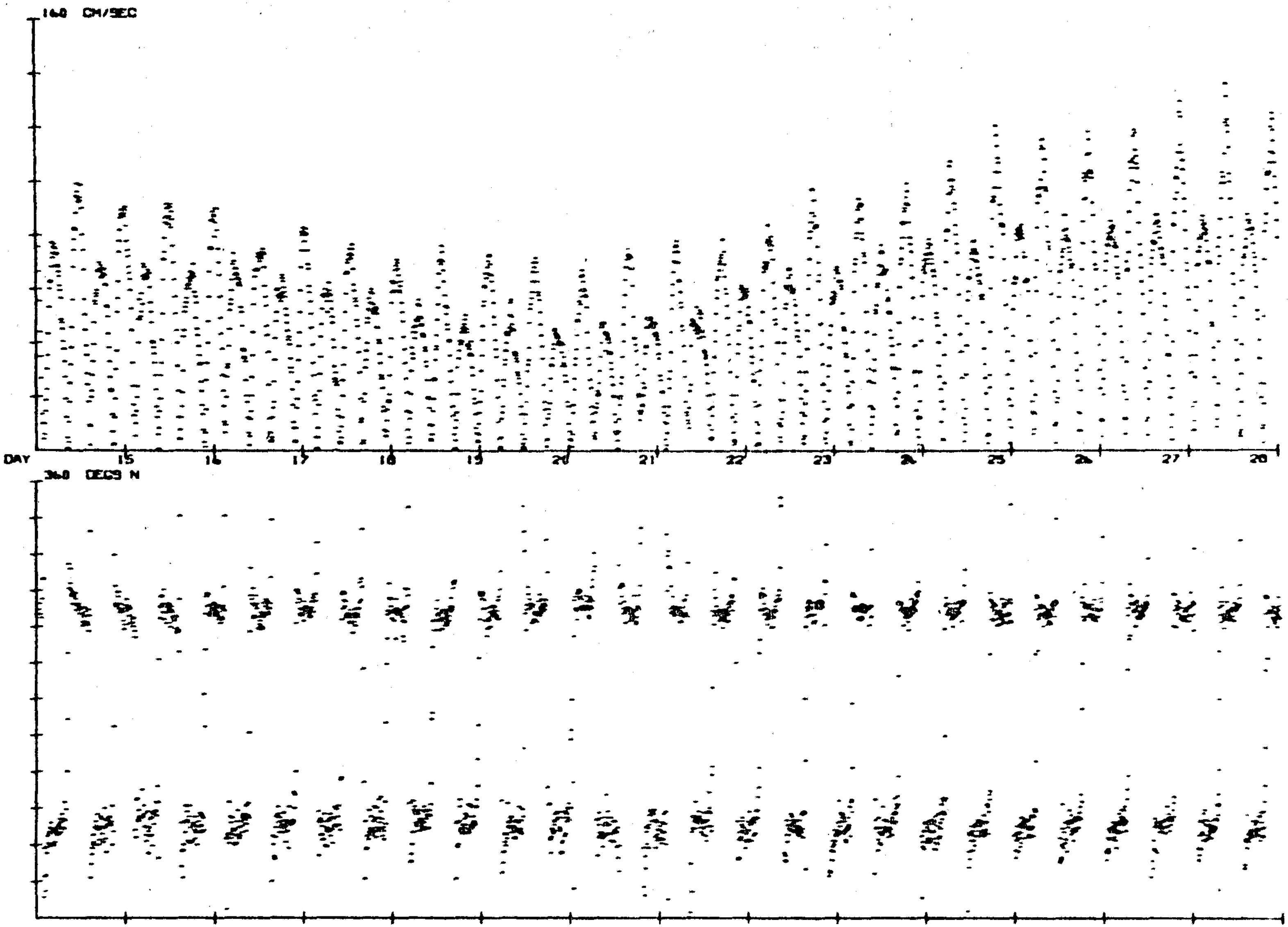


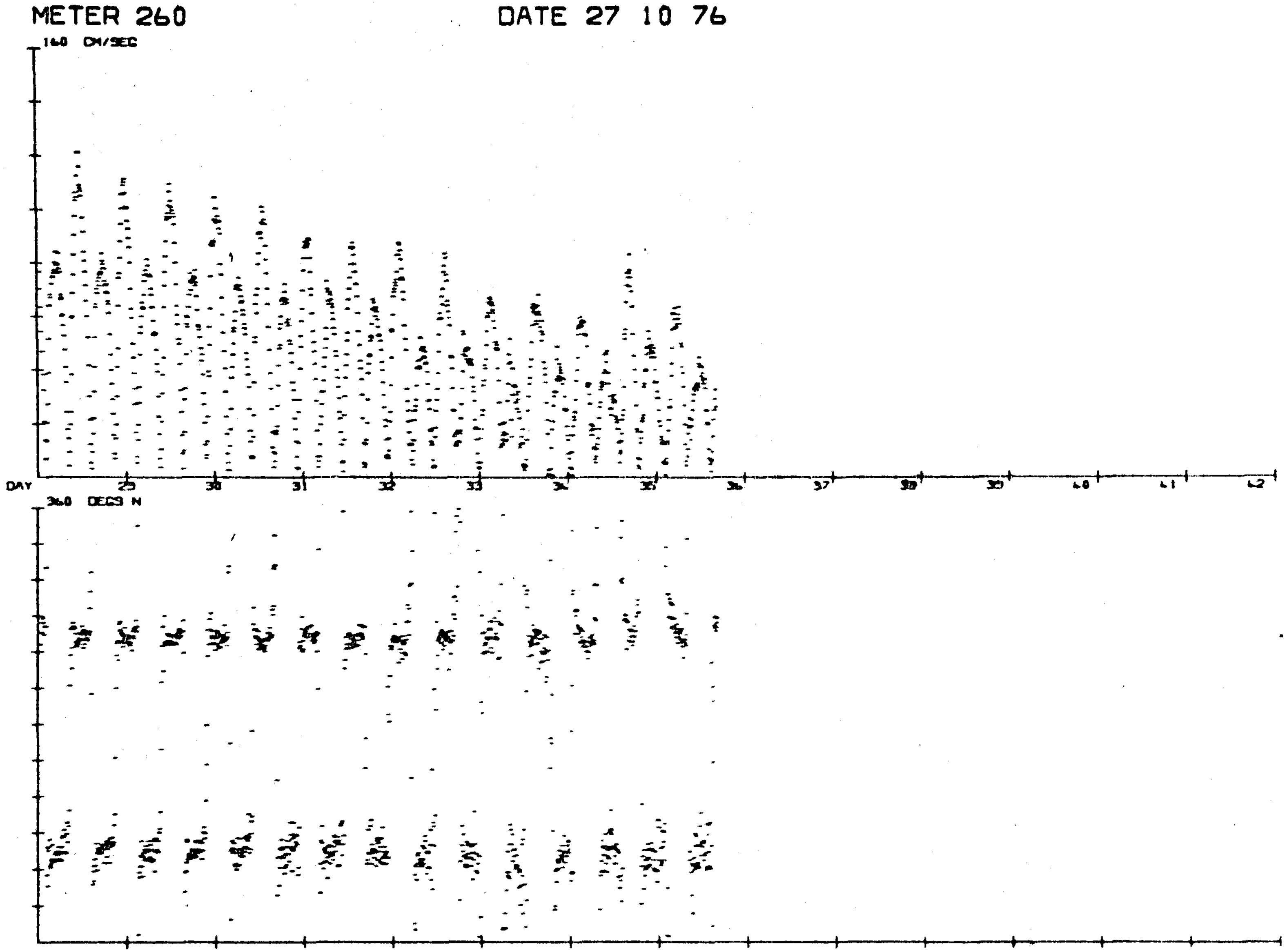
5.15

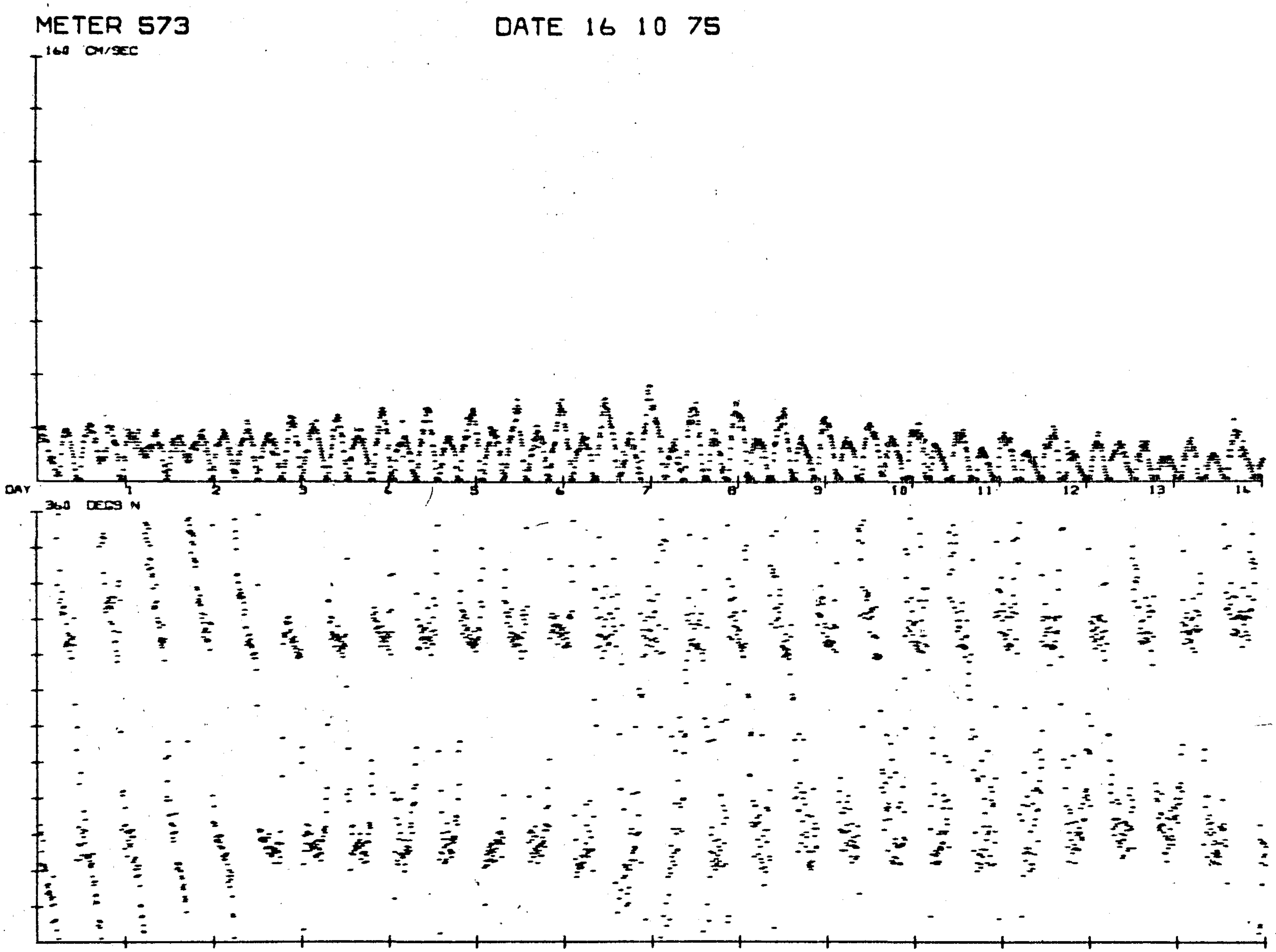

METER 260
DATE 27 10 76
160 CM/SEC
DAY
1 2 3 4 5 6 7 8 9 10 11 12 13 14
360 DEGS N

5.16

METER 260 DATE 27 10 76

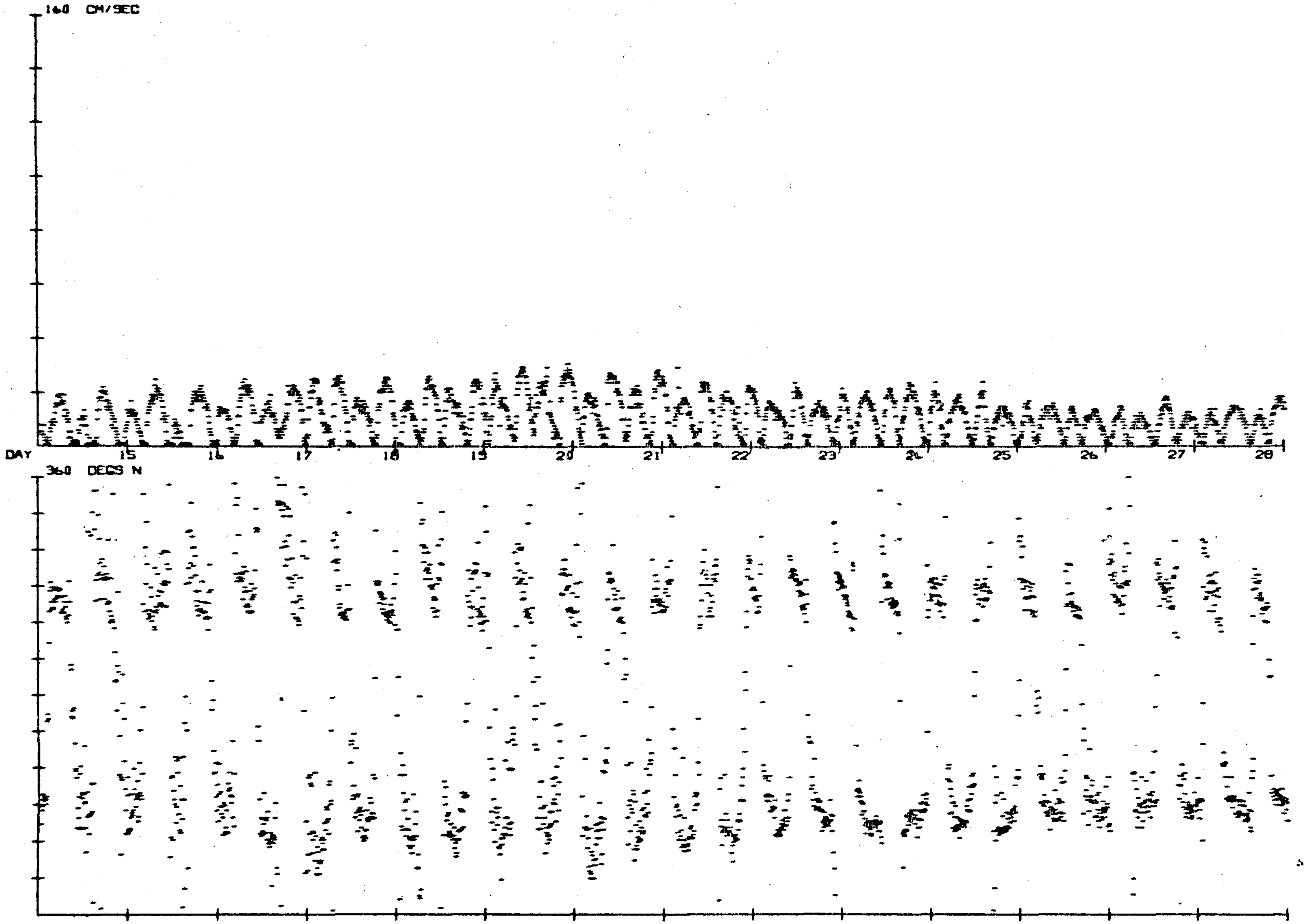


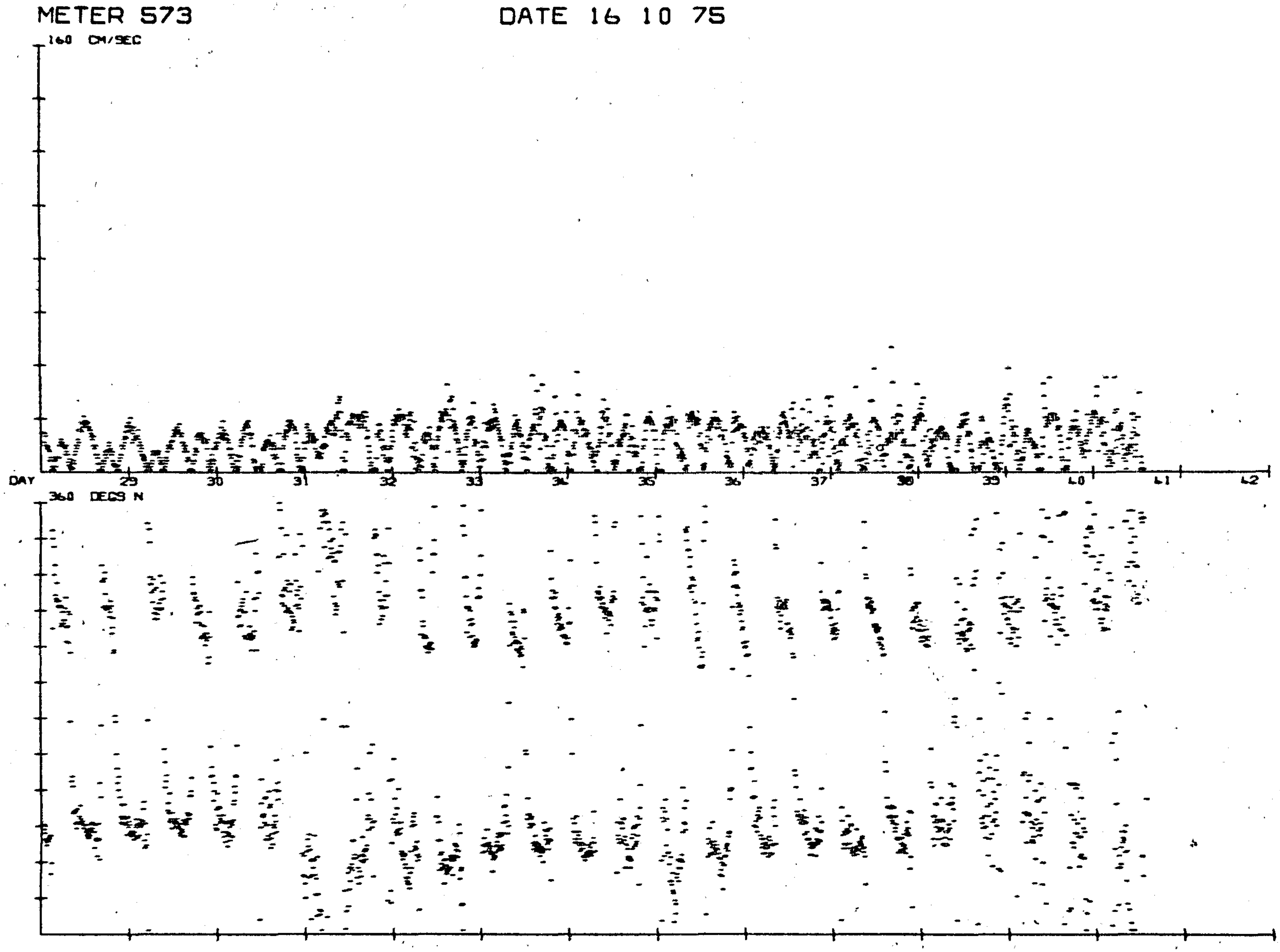

METER 260
DATE 27 10 76
160 CM/SEC
DAY
29
30
31
32
33
360 DEGS N

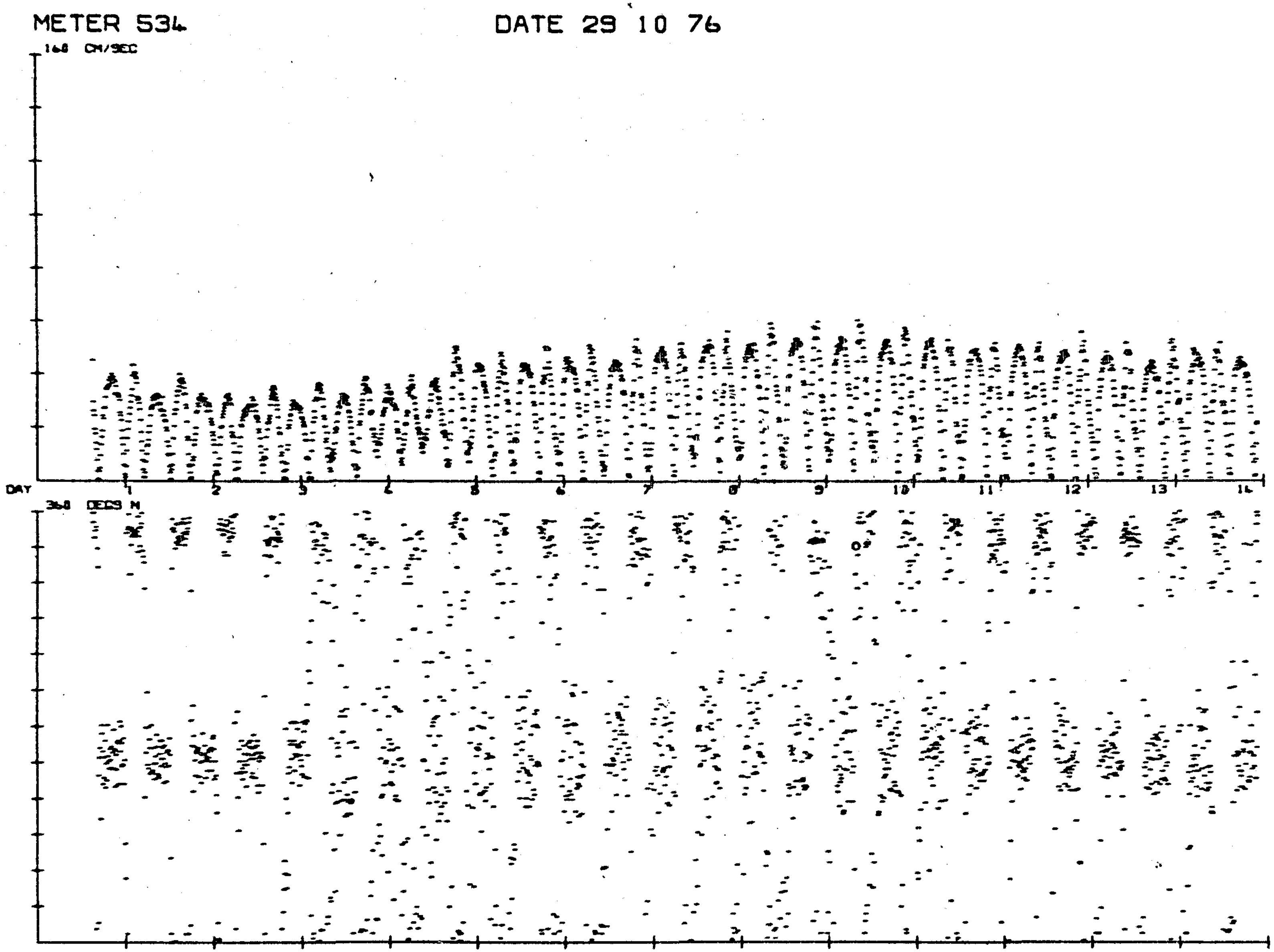

METER 573
DATE 16 10 75
160 CM/SEC
DAY
1 2 3 4 5 6 7 8 9 10 11 12 13 14
360 DEGS N

5.19

METER 573 DATE 16 10 75




METER 573
DATE 16 10 75
160 CM/SEC
DAY
29
30
31
32
33
34
35
36
37
38
39
40
41
42
360 DEGS N



METER 534
DATE 29 10 76
160 CM/SEC
DAY
1 2 3 4 5 6 7 8 9 10 11 12 13 14
360 DEGS M

5.22

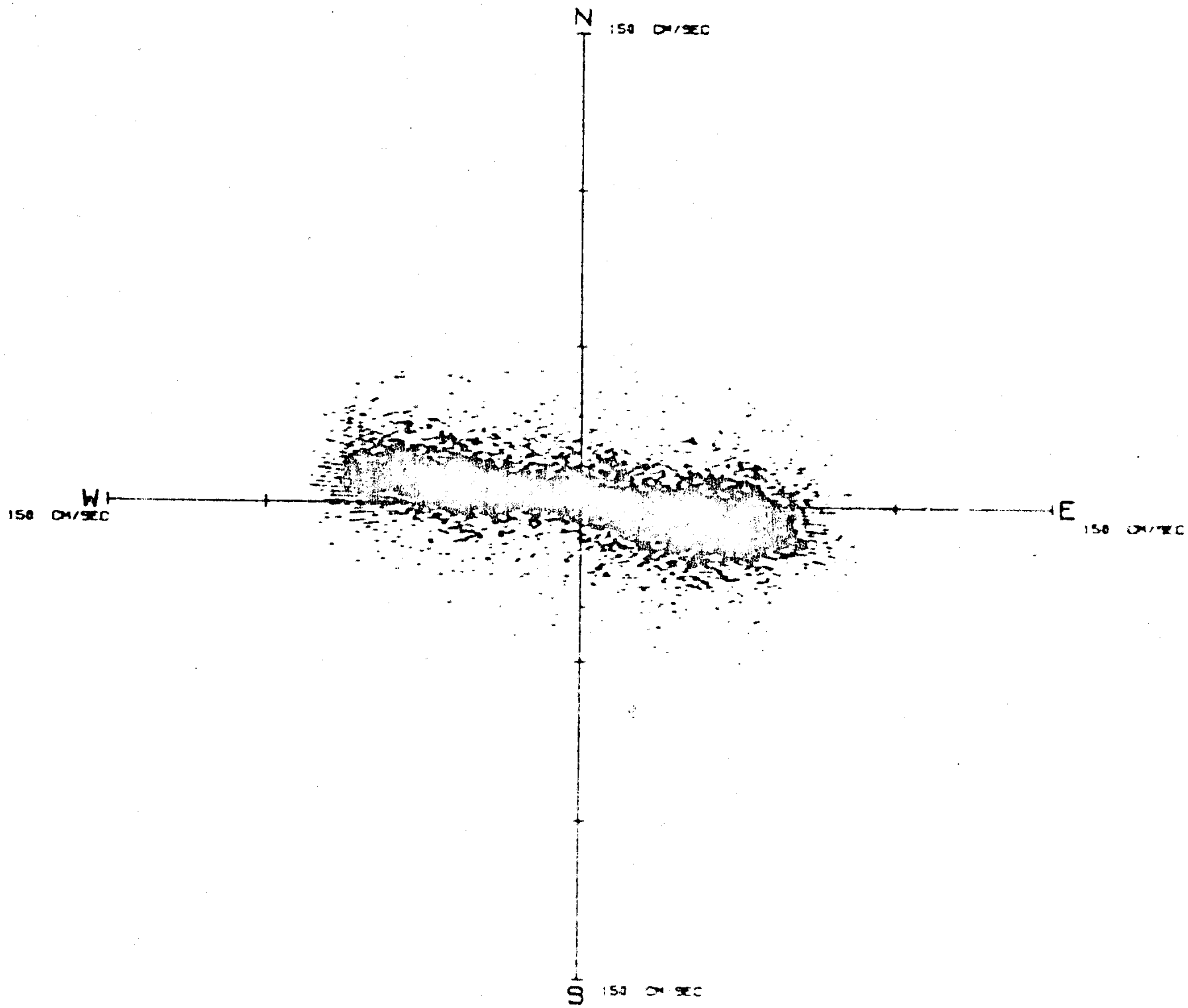
Figures 6.1 - 6.8

Scatter plots of current speed readings

Figure	Record	Station
6.1	237J6	A
6.2	680K6	B
6.3	594K6	C
6.4	244K6	D
6.5	269K6	E
6.6	260K6	F
6.7	573K5	G
6.8	534K6	H

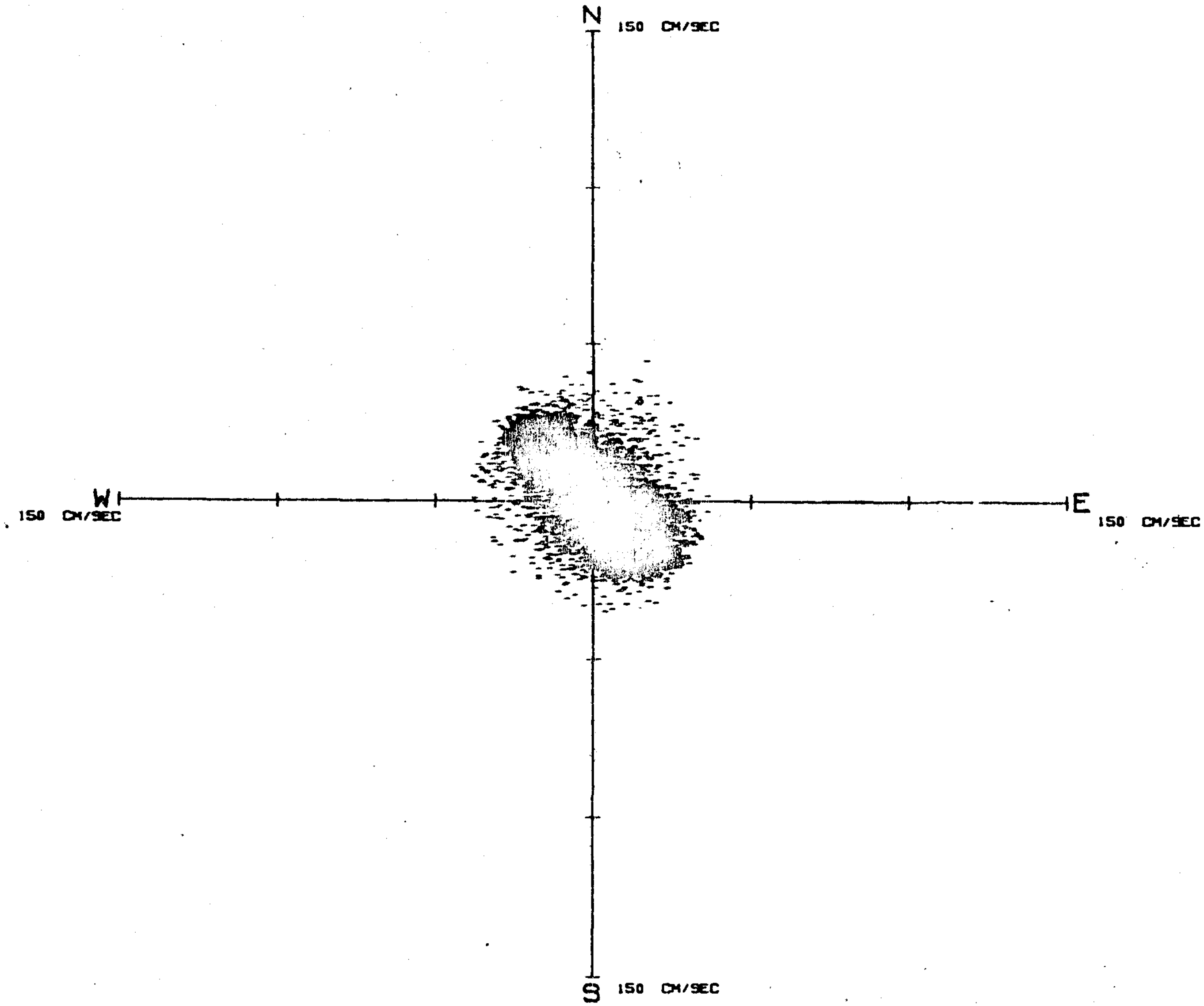
METER 237

DATE 28 9 76



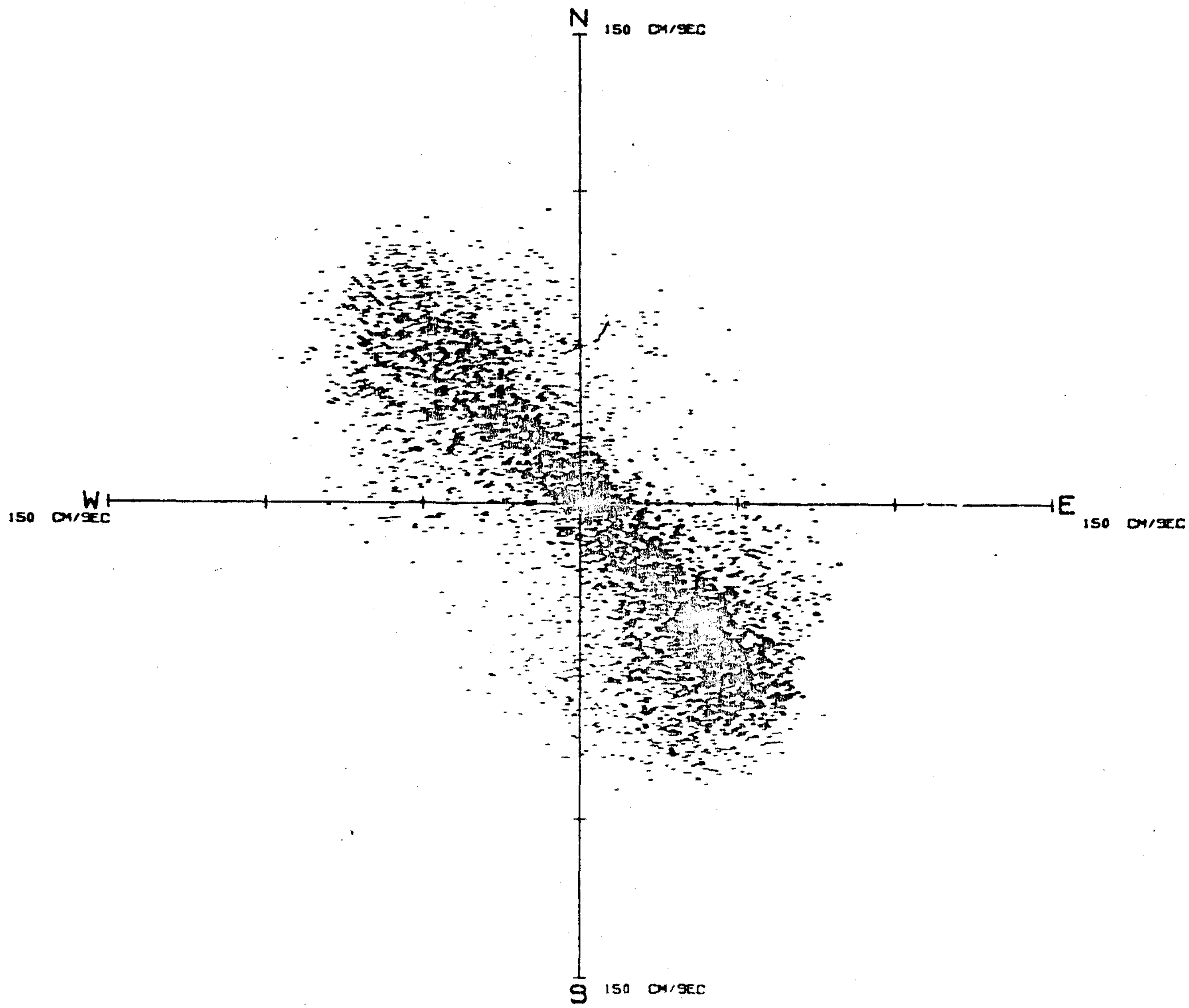
6.1

METER 680 DATE 29 10 76

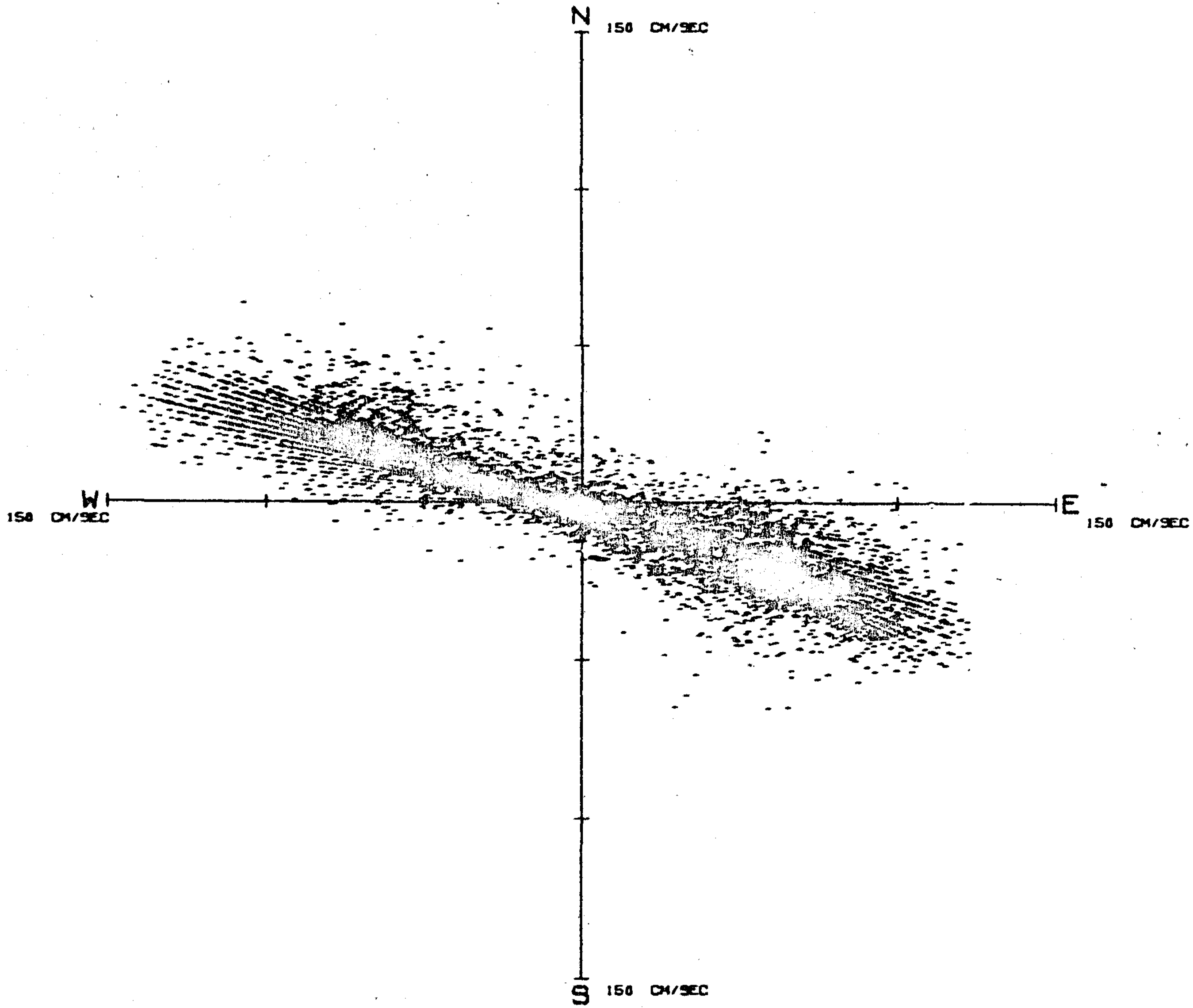


6.2

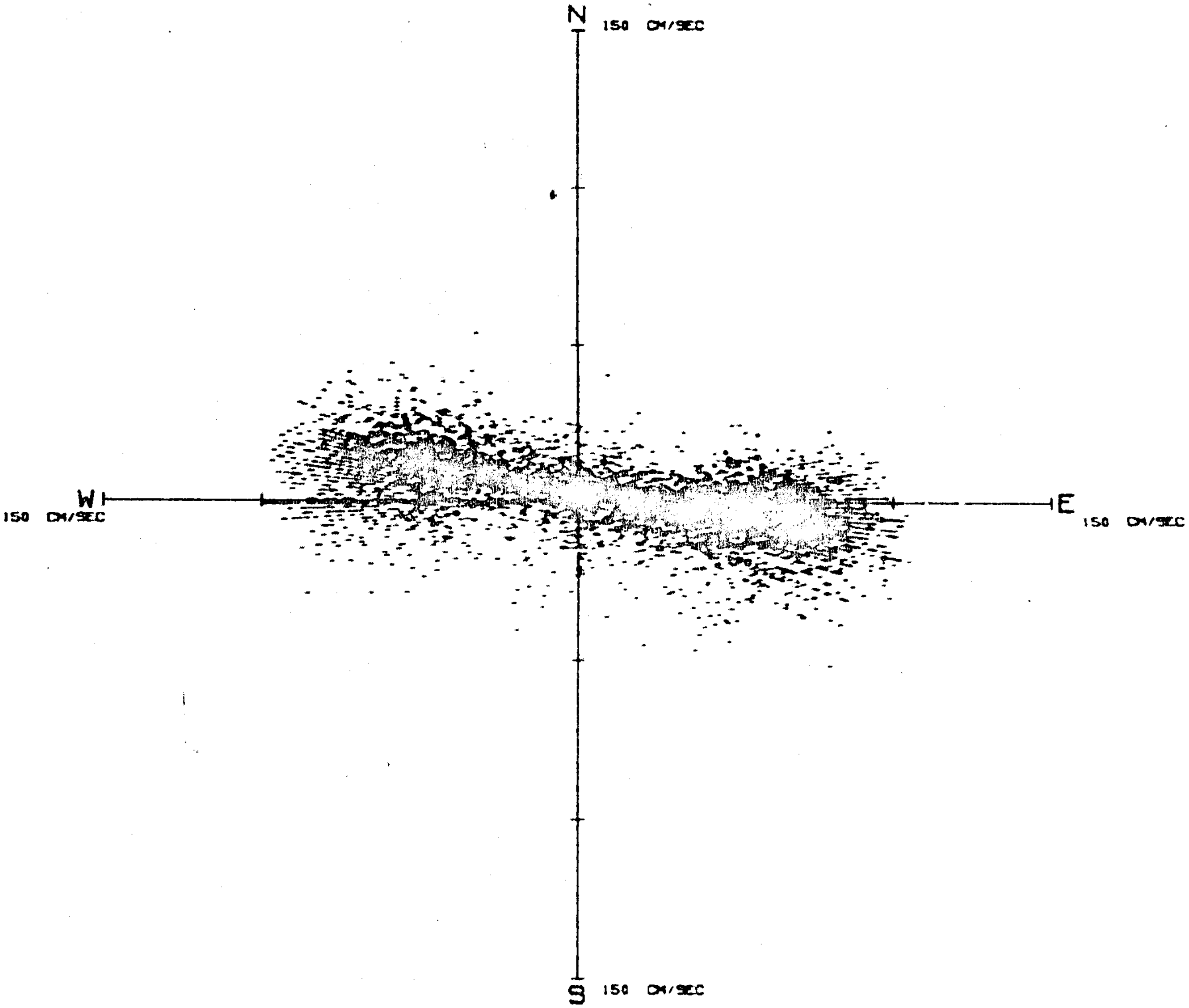
METER 994 DATE 29 10 76



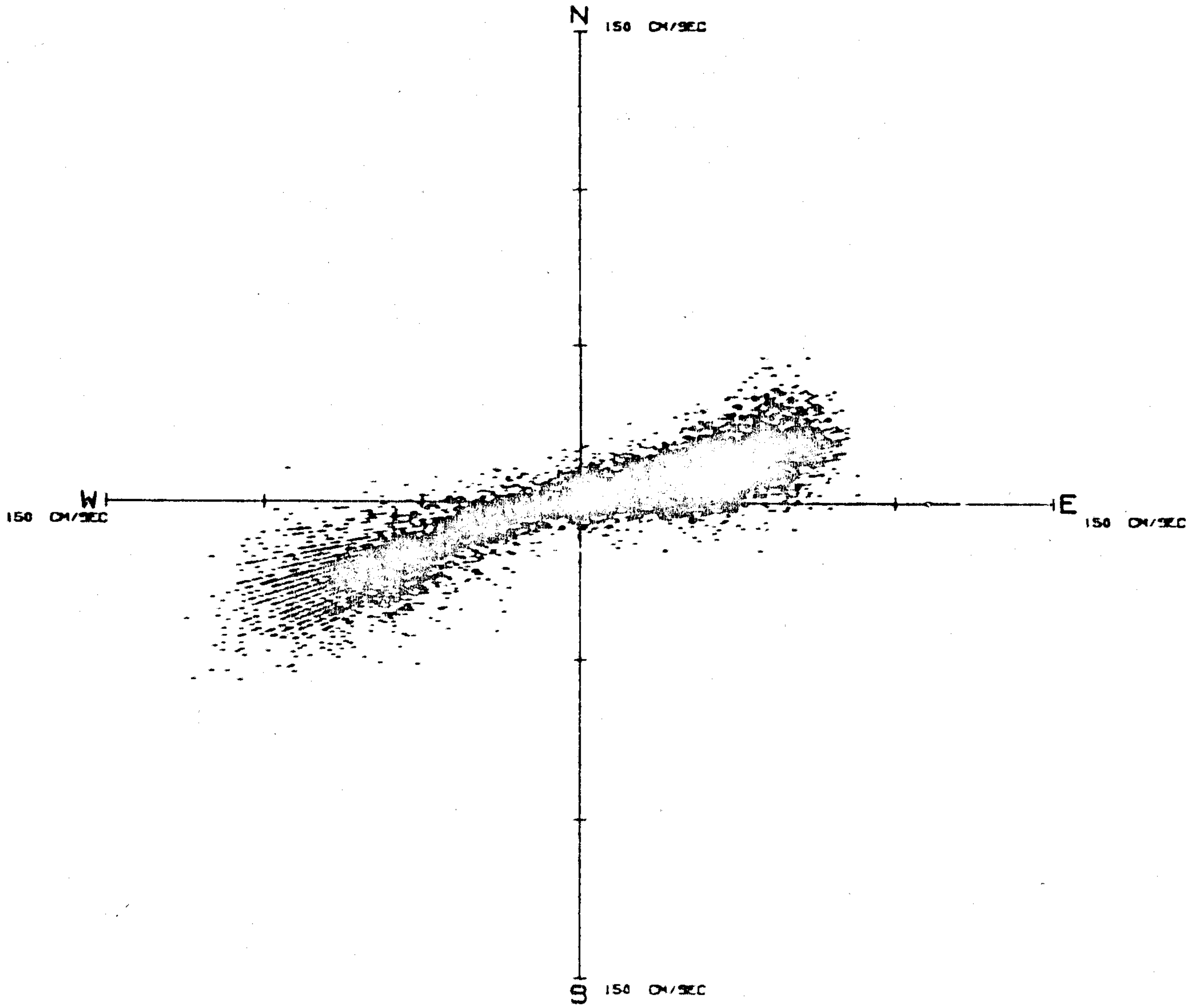
METER 244 DATE 26 10 76



METER 269 DATE 26 10 76

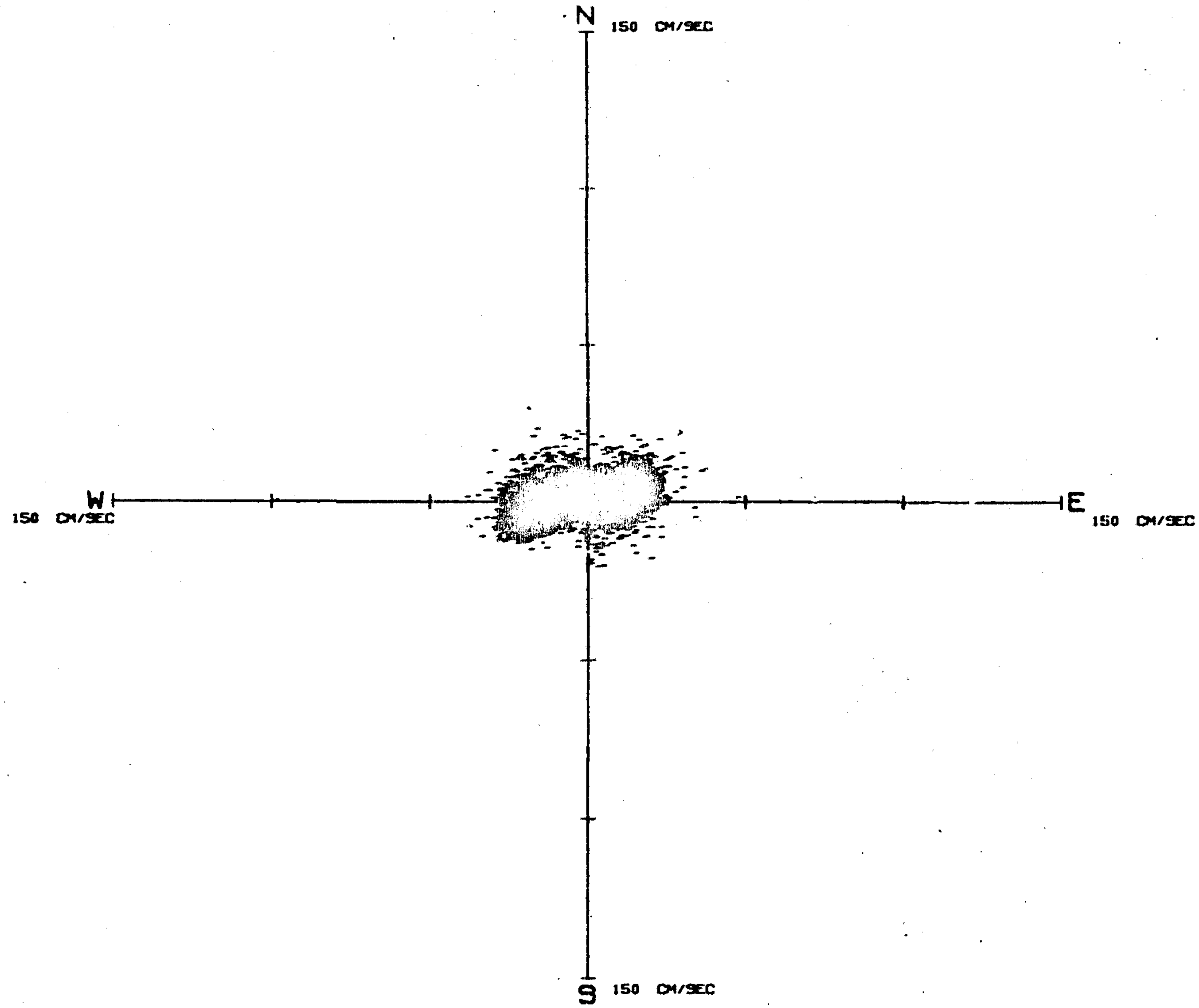


METER 260 DATE 27 10 76

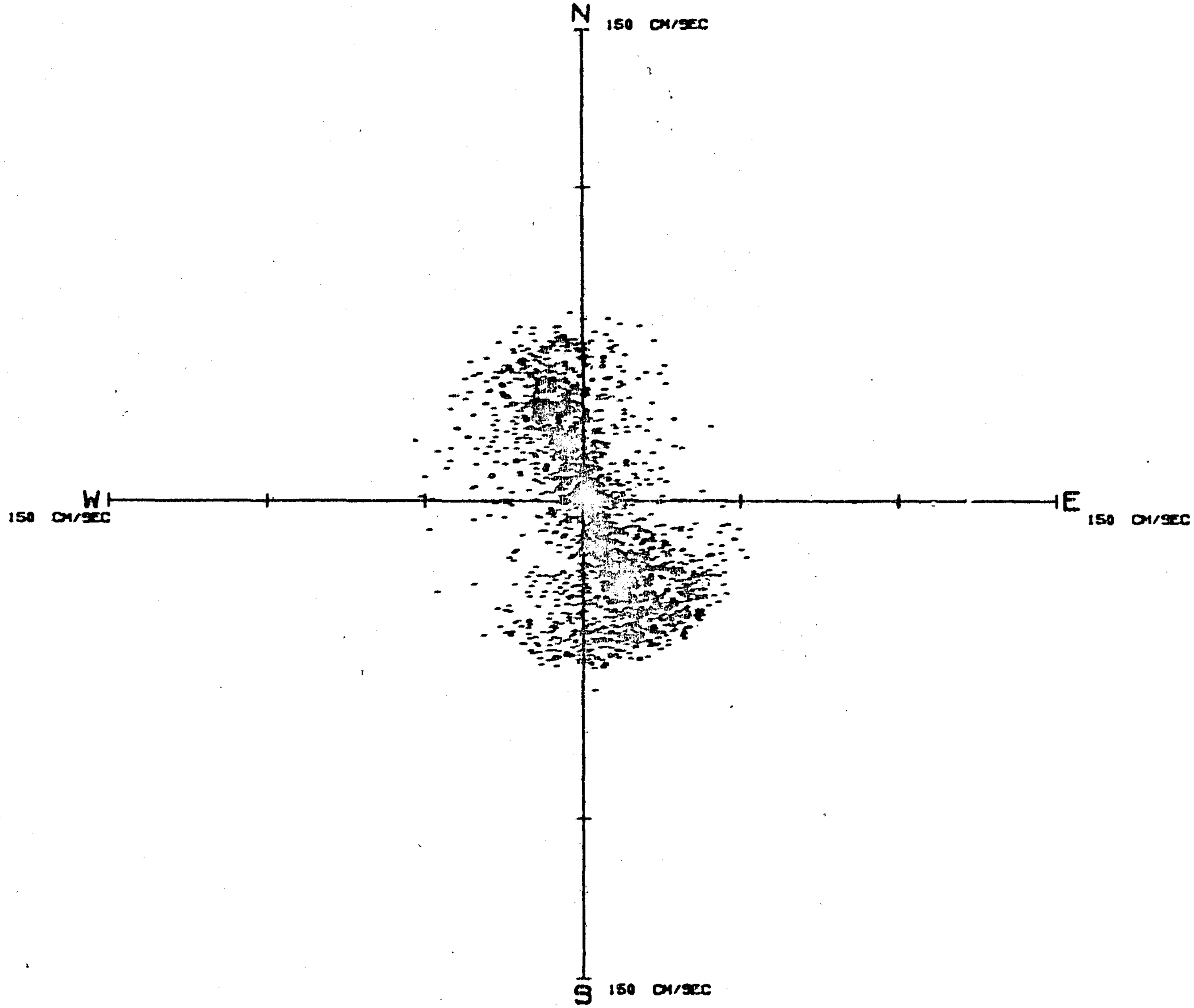


6.9

METER 573 DATE 16 10 75



METER 534 DATE 29 10 76

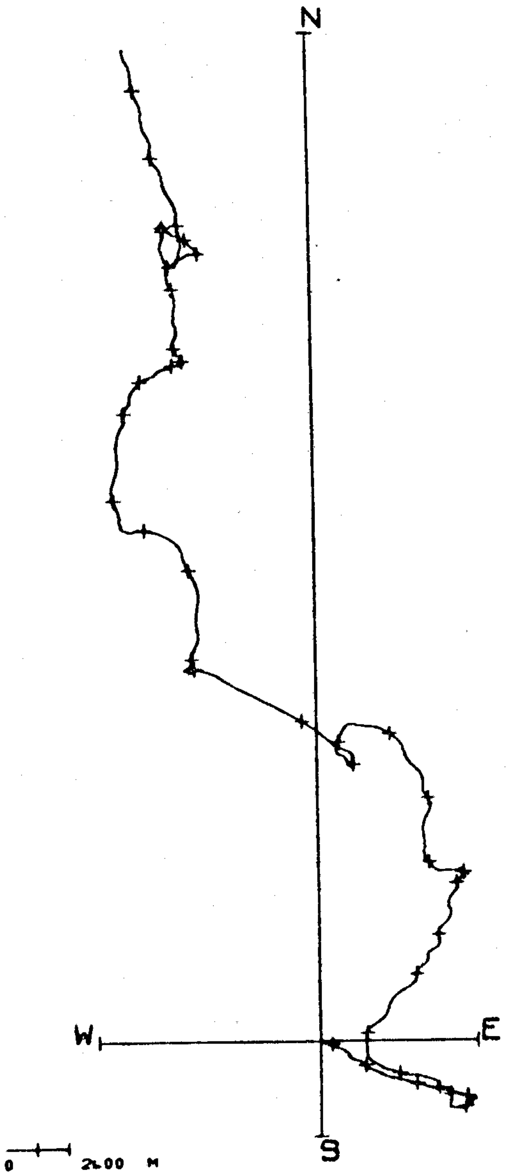


Figures 7.1 - 7.16

Smoothed and unsmoothed progressive vector plots

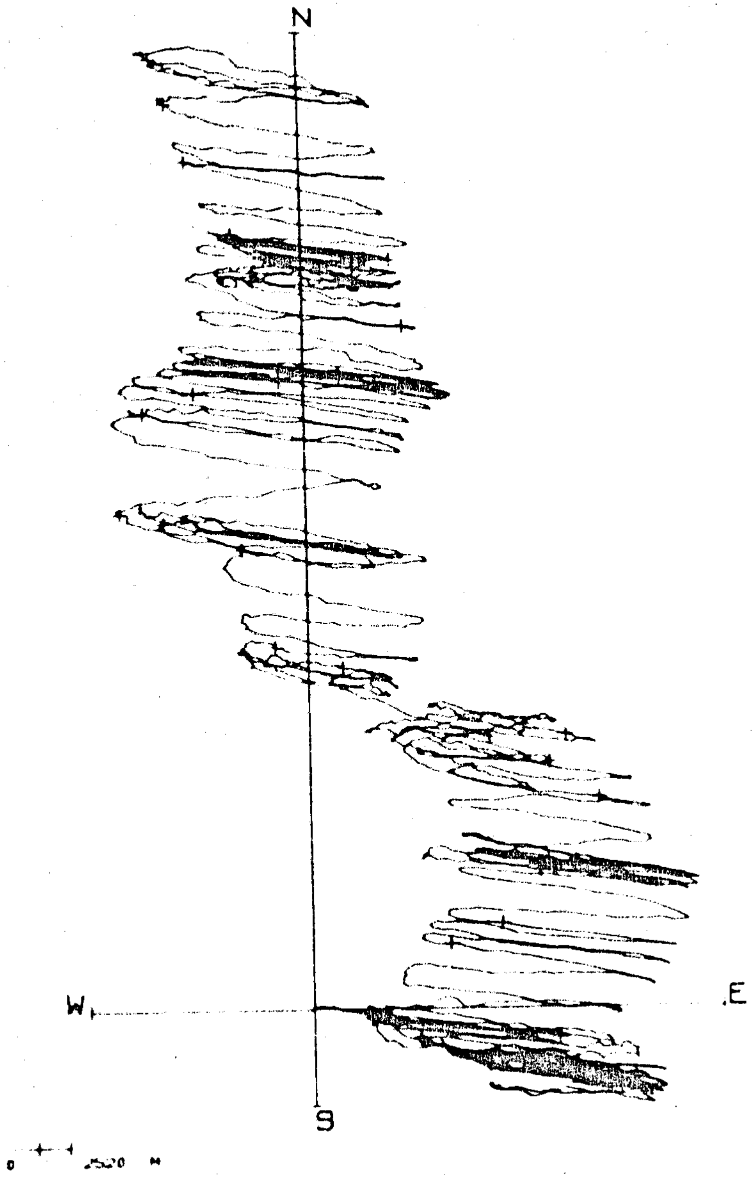
Figure	Record	Station
7.1 - 7.2	237J6	A
7.3 - 7.4	680K6	B
7.5 - 7.6	594K6	C
7.7 - 7.8	244K6	D
7.9 - 7.10	269K6	E
7.11 - 7.12	260K6	F
7.13 - 7.14	573K5	G
7.15 - 7.16	534K6	H

METER 237 DATE 29 9 76

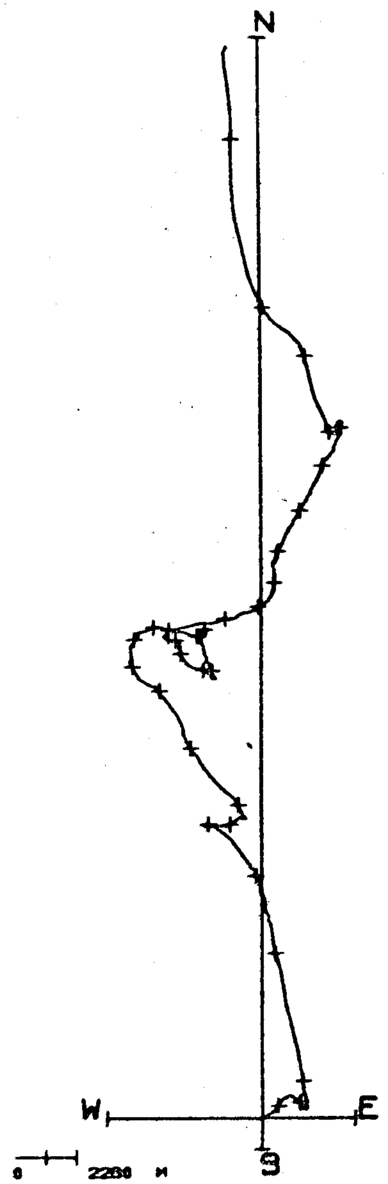


7.1

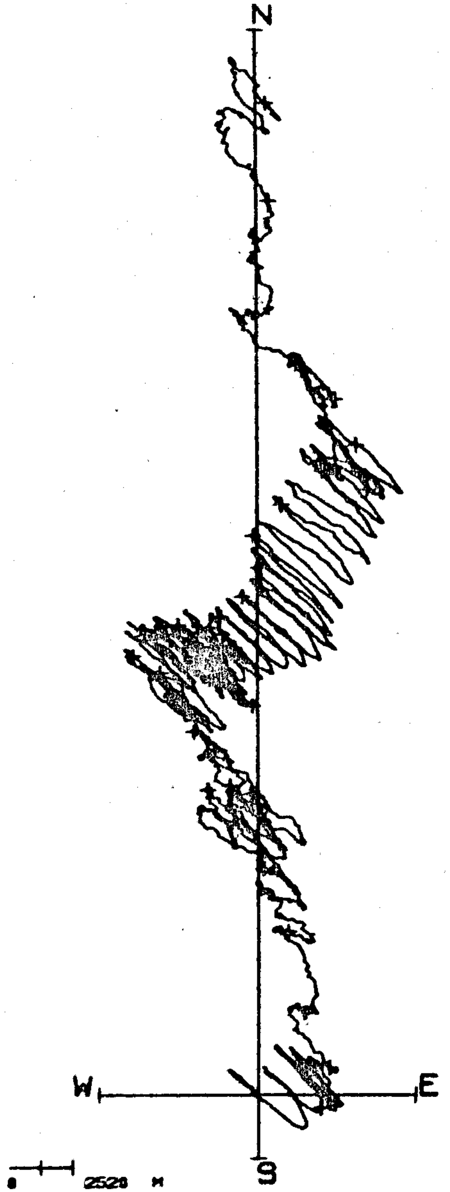
METER 237 DATE 28 9 76



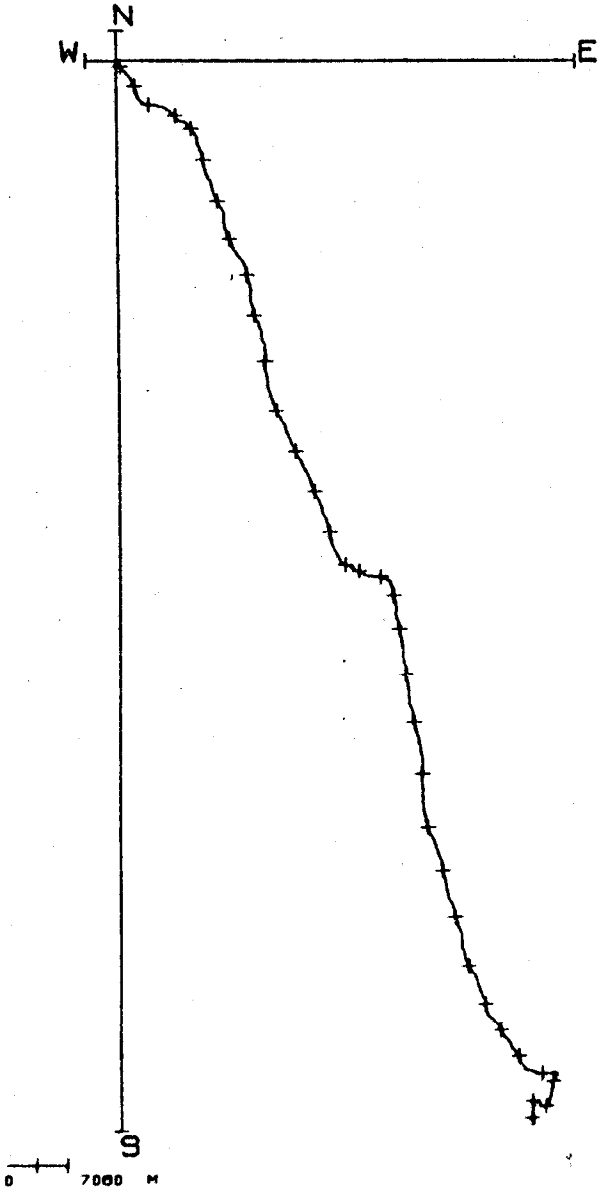
METER 680 DATE 30 10 76



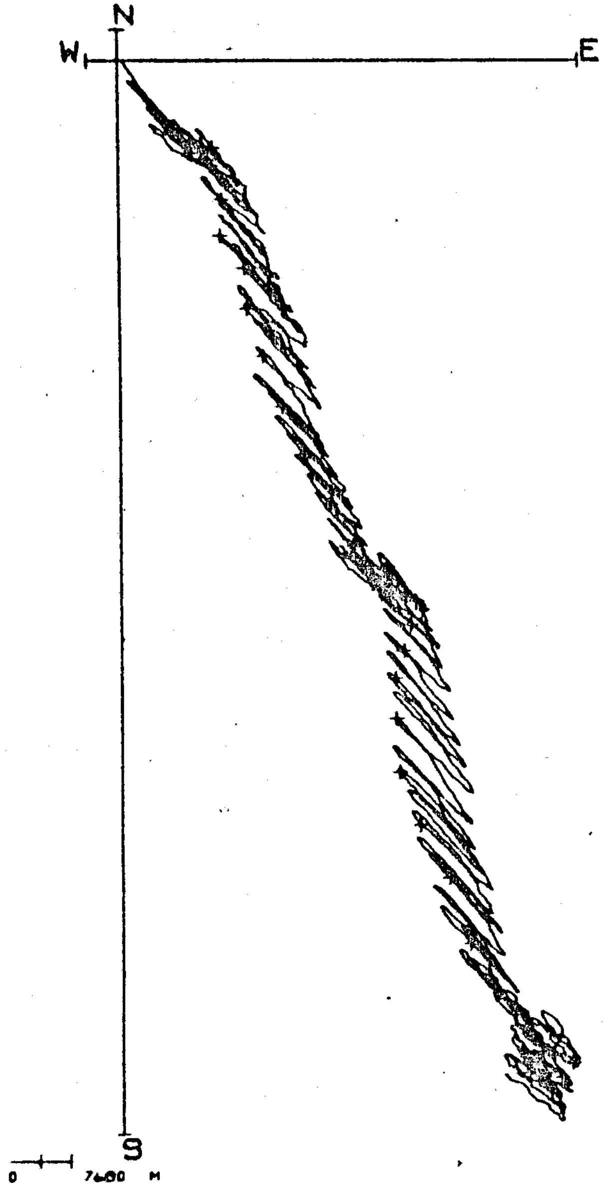
METER 680 DATE 29 10 76



METER 994 DATE 30 10 76

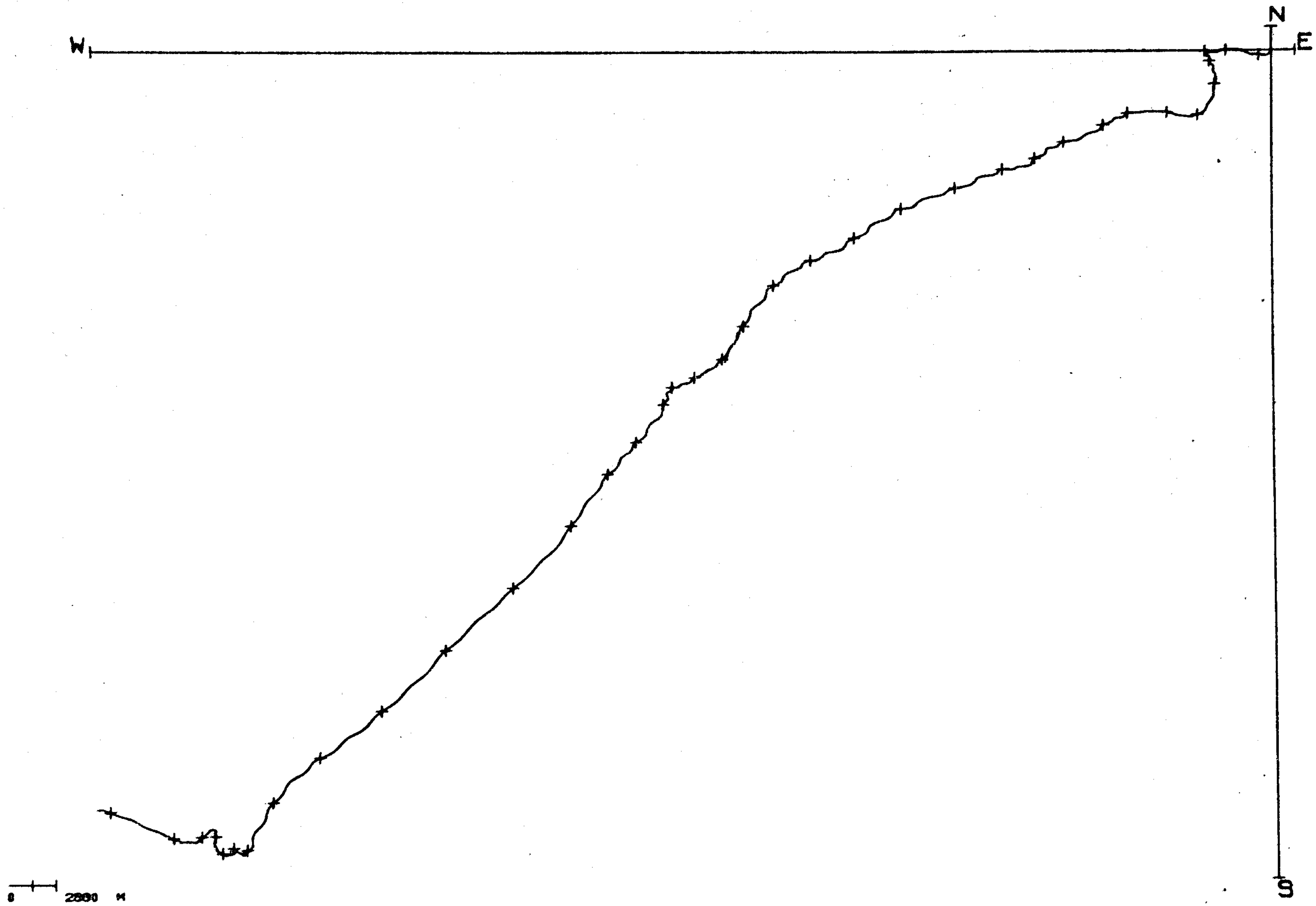


METER 594 DATE 29 10 76

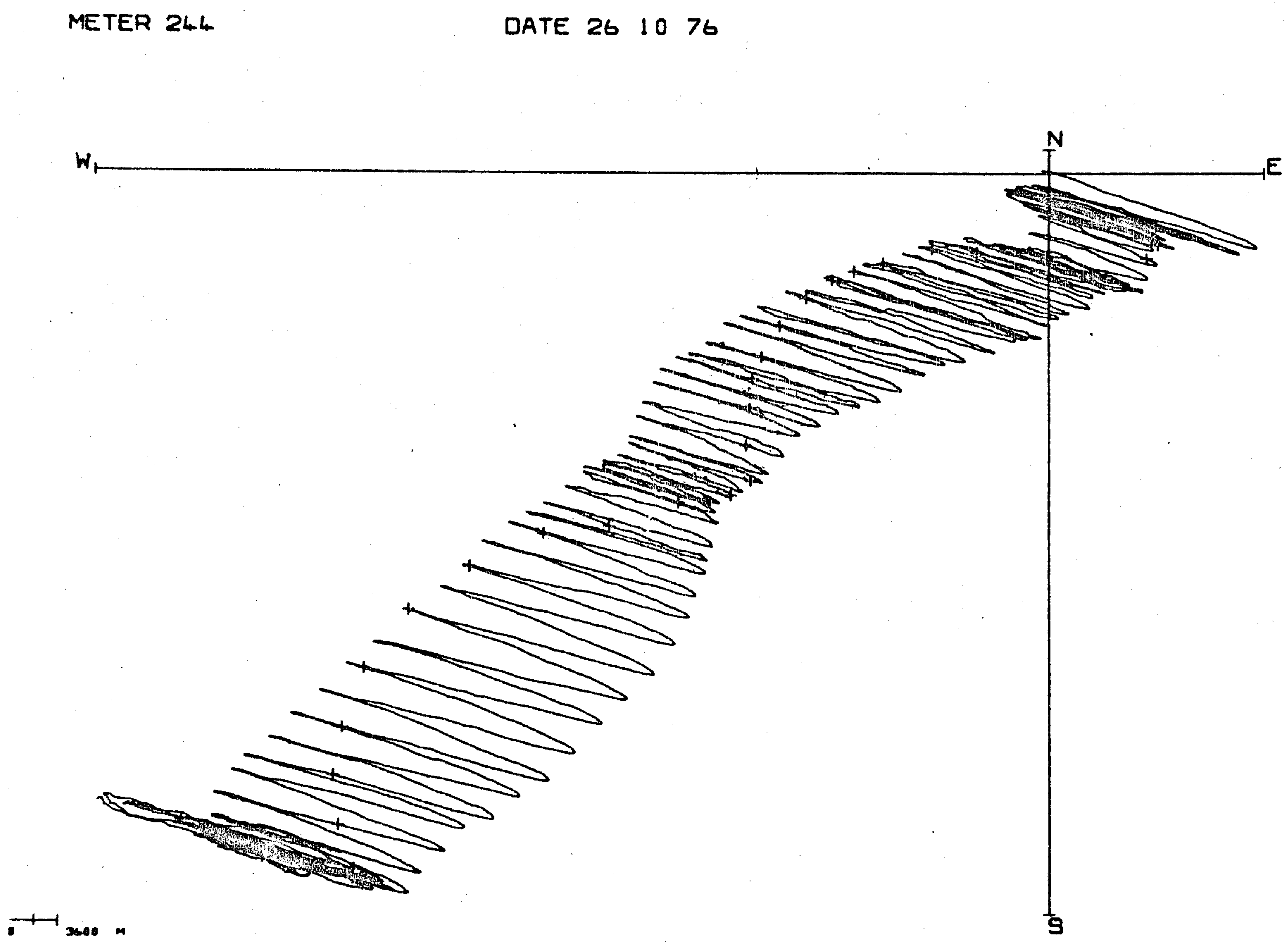


7.6

METER 244 DATE 27 10 76

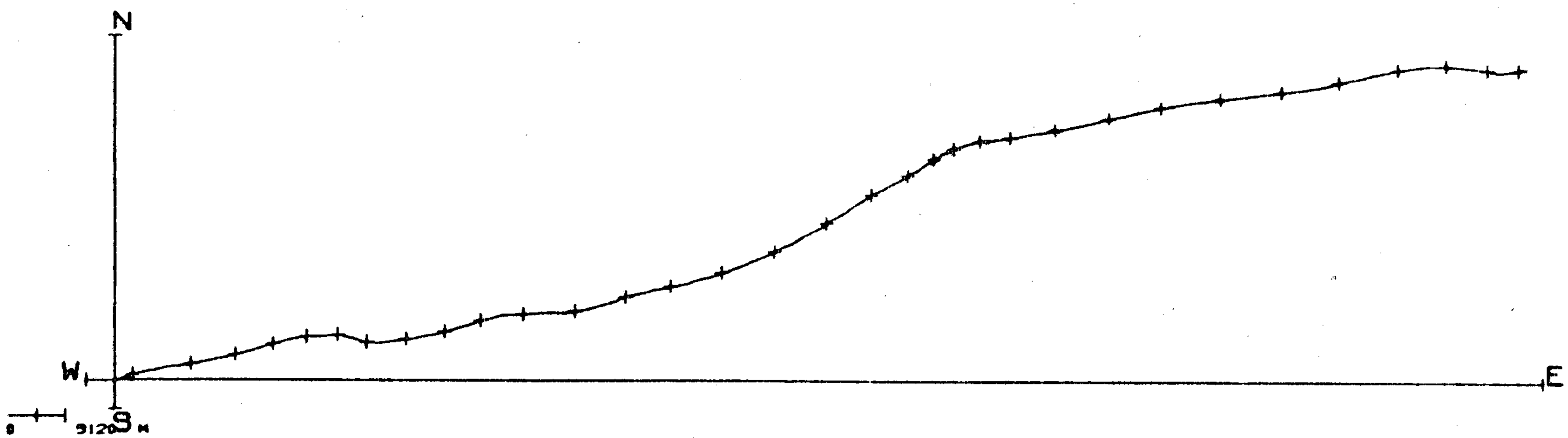


7.7



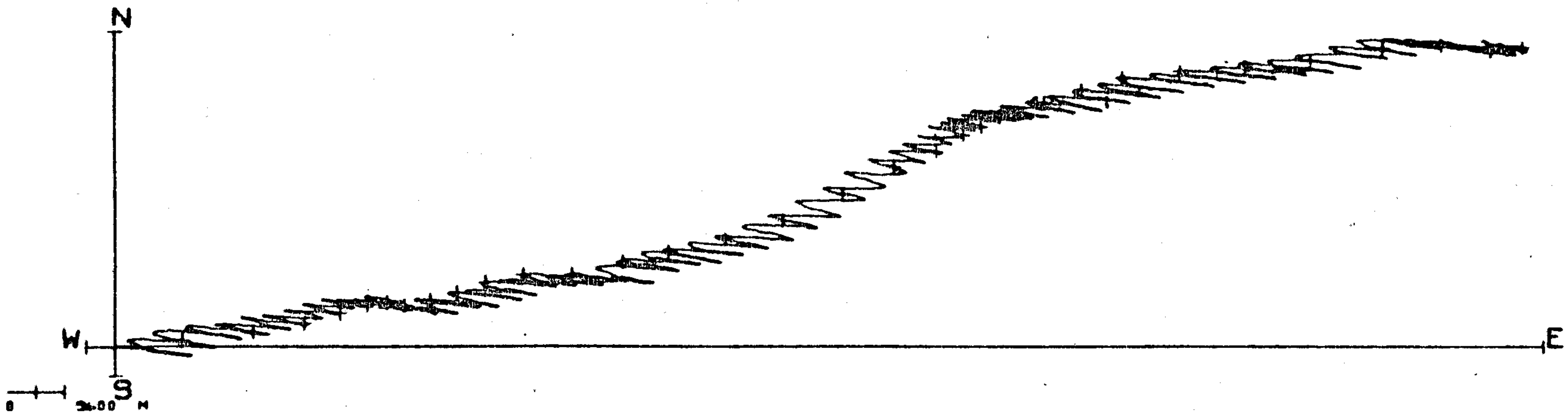
7.8

METER 269 DATE 27 10 76

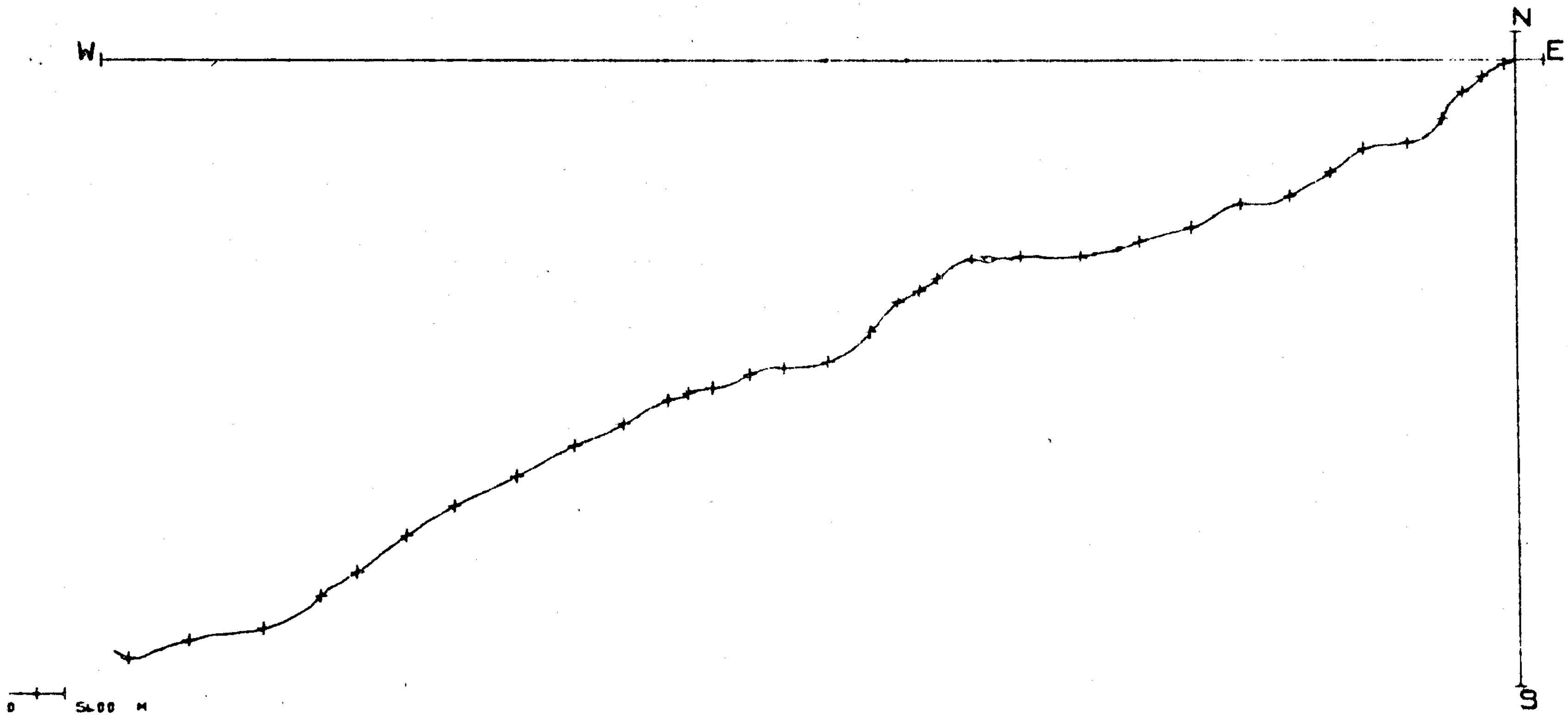


7.9

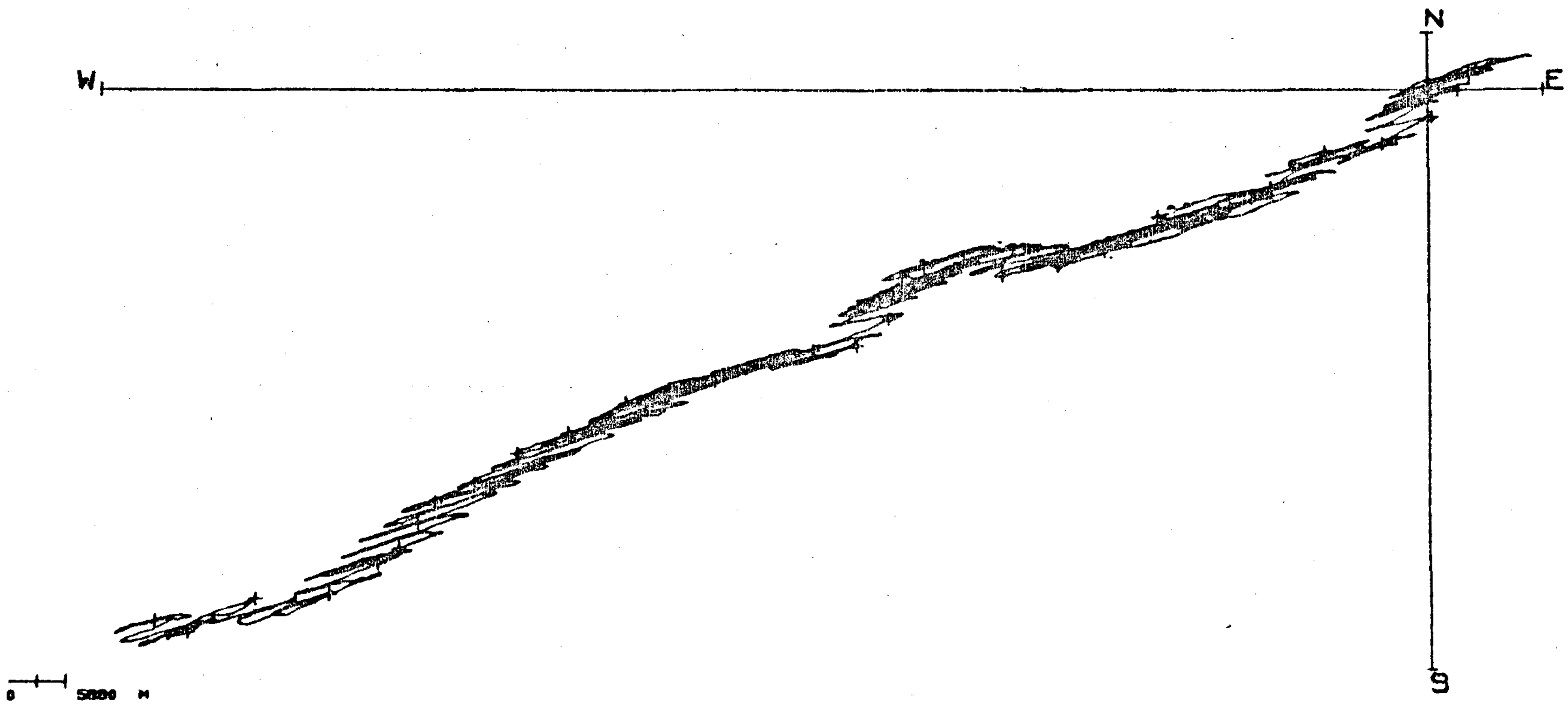
METER 269 DATE 26 10 76



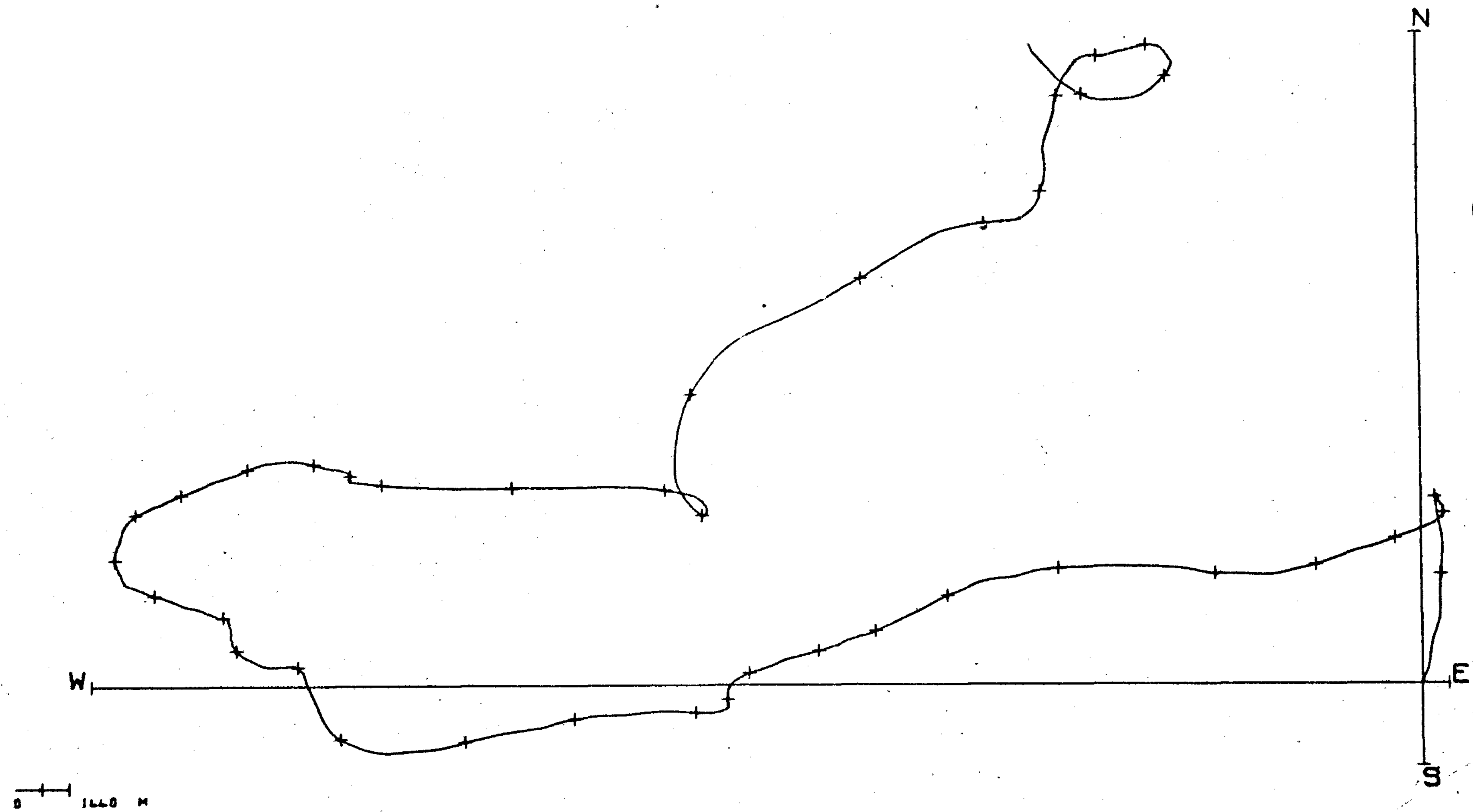
METER 260 DATE 28 10 76



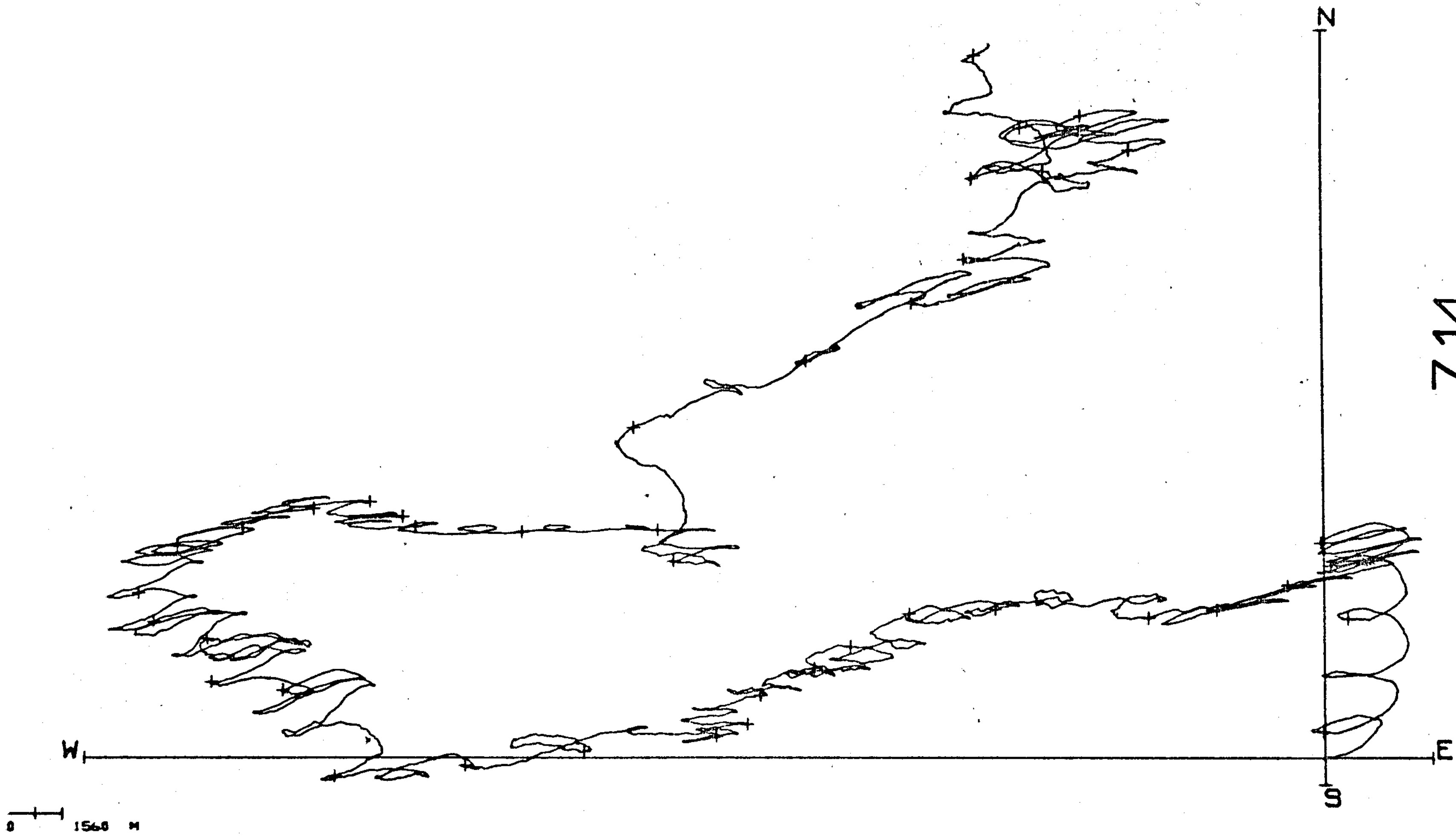
METER 260 DATE 27 10 76



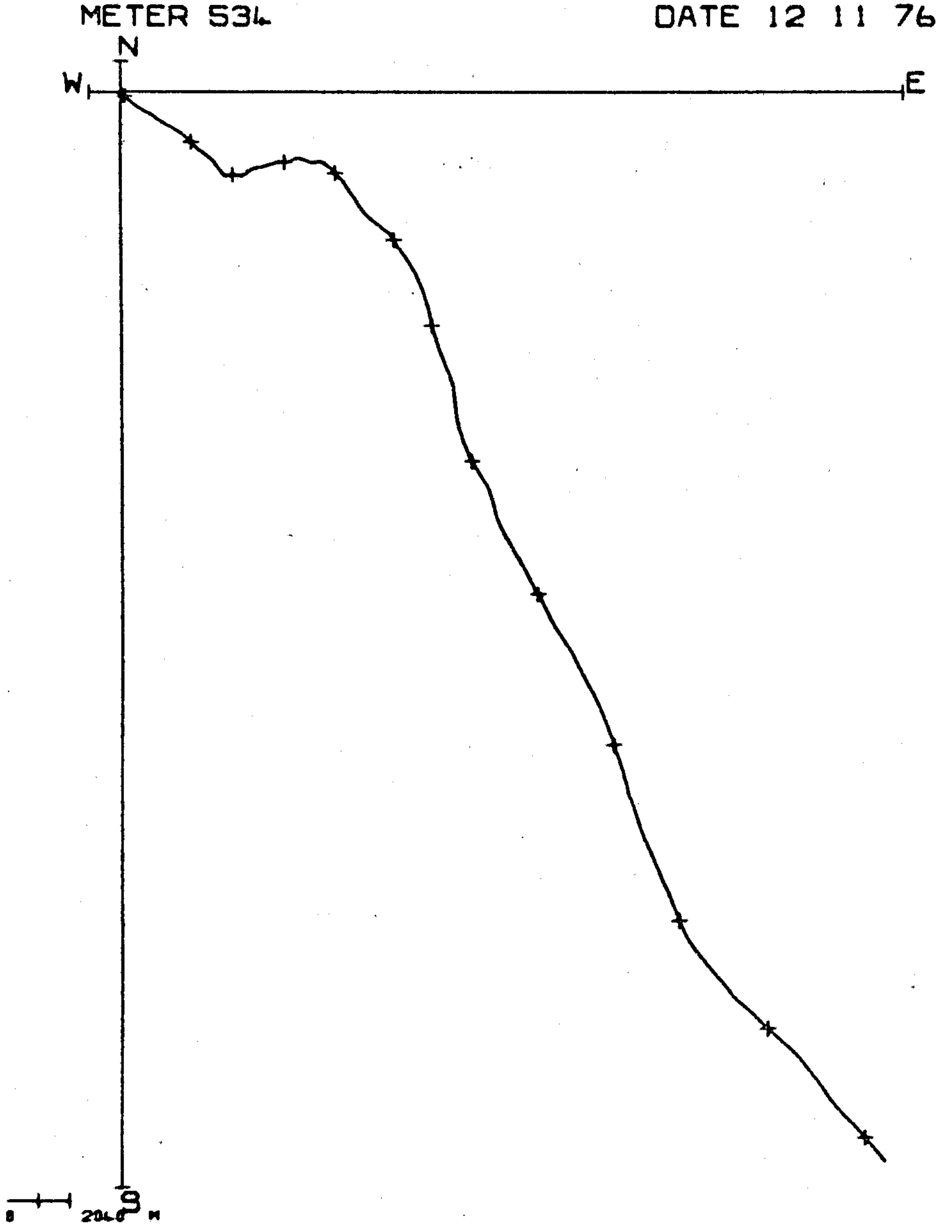
METER 573 DATE 16 10 75



METER 573 DATE 16 10 75

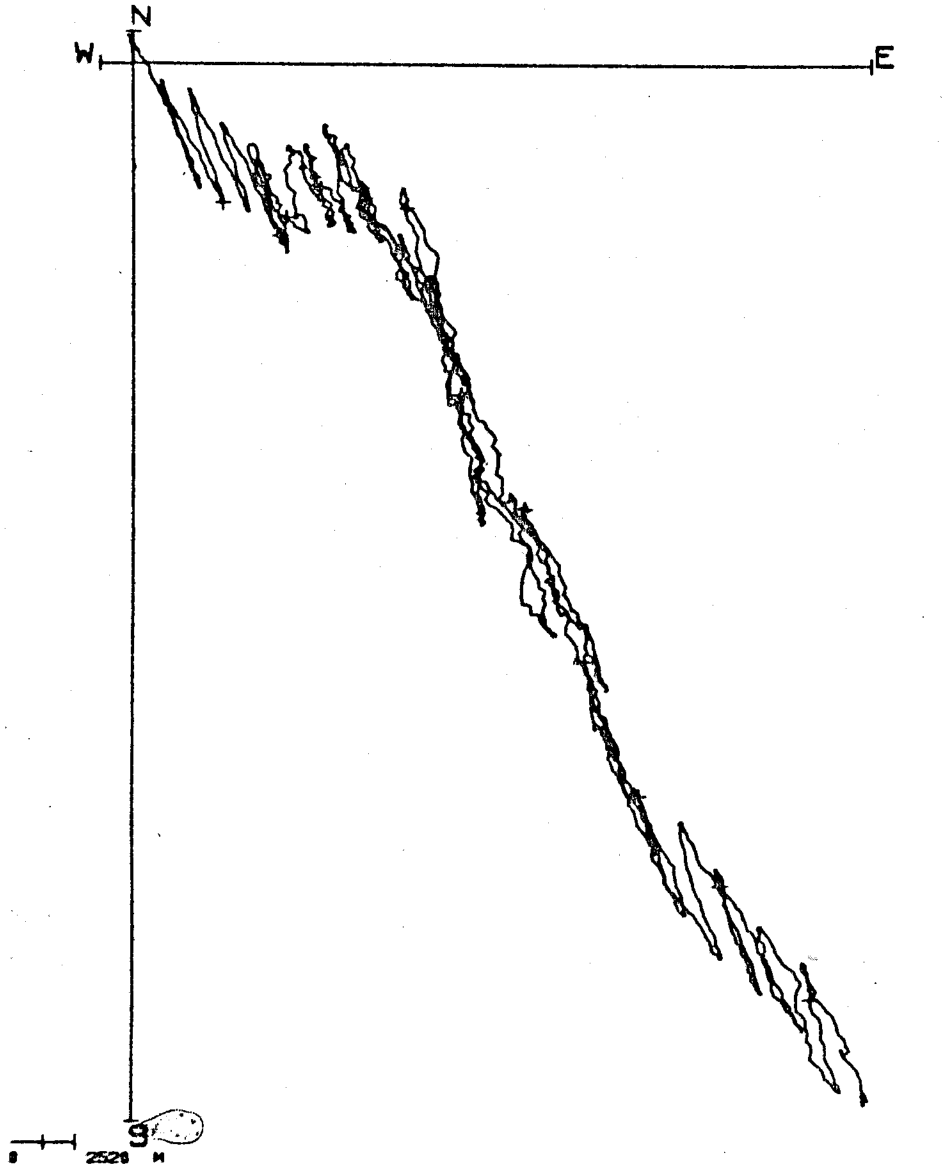


7.14



METER 534
DATE 12 11 76
N
W
E
S
0
2060
M

METER 534 DATE 29 10 76

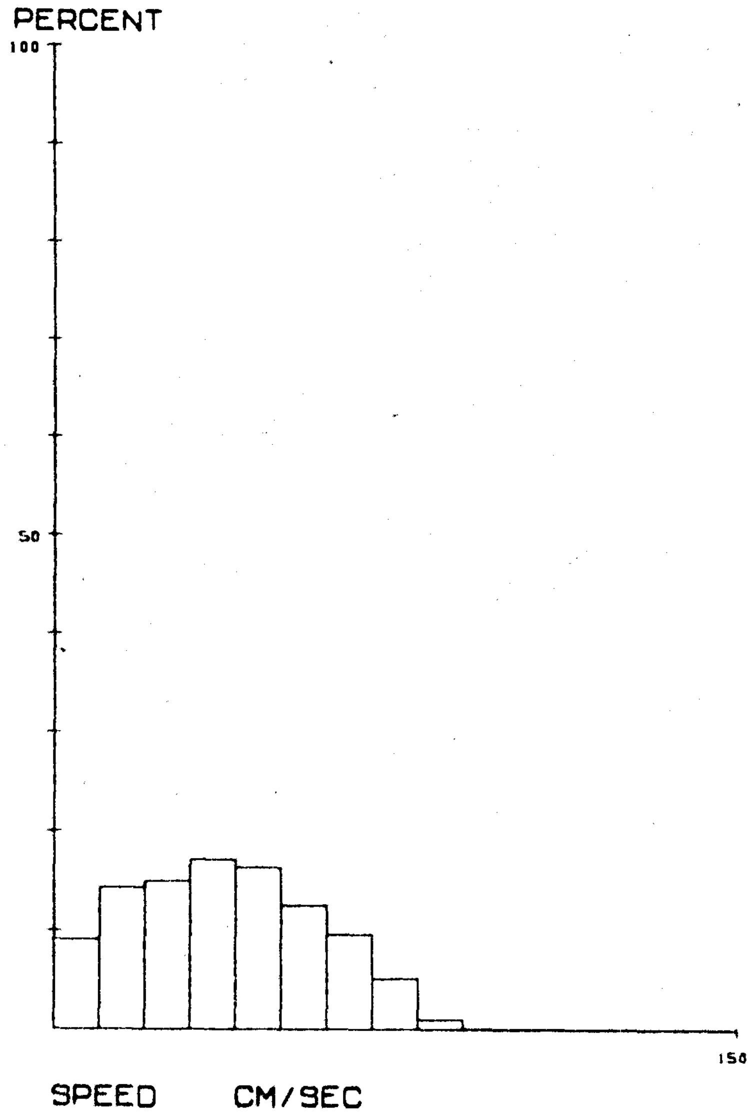


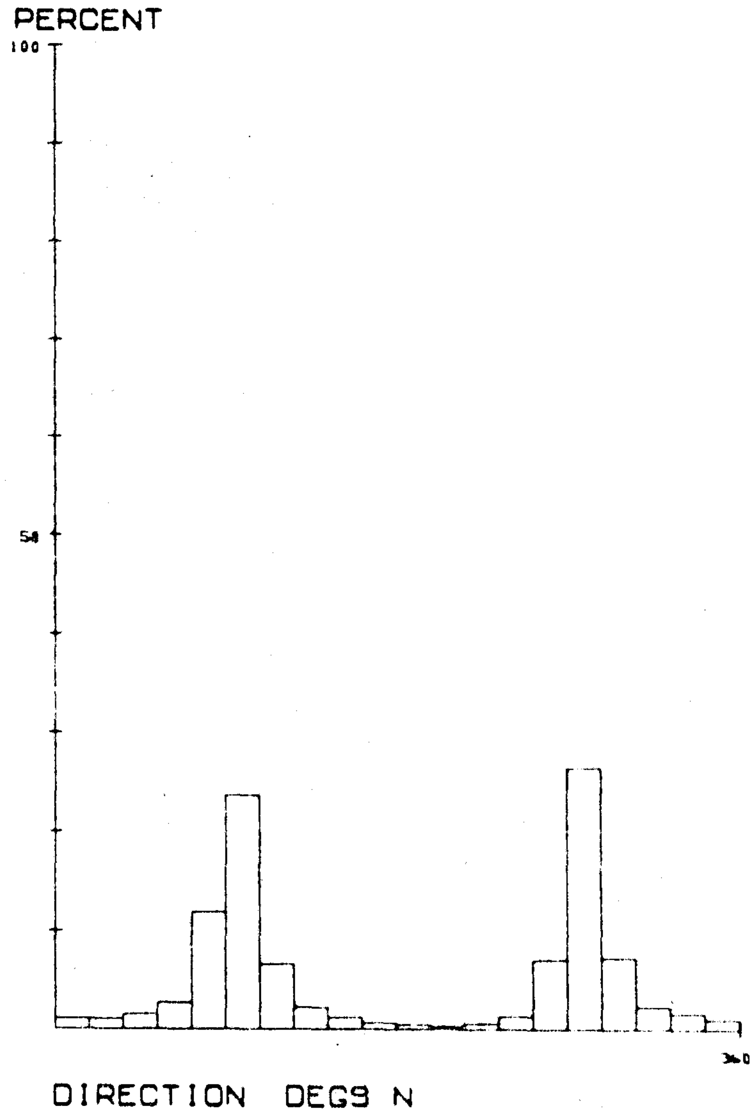
Figures 8.1 - 8.8

Frequency histograms of speed and direction readings

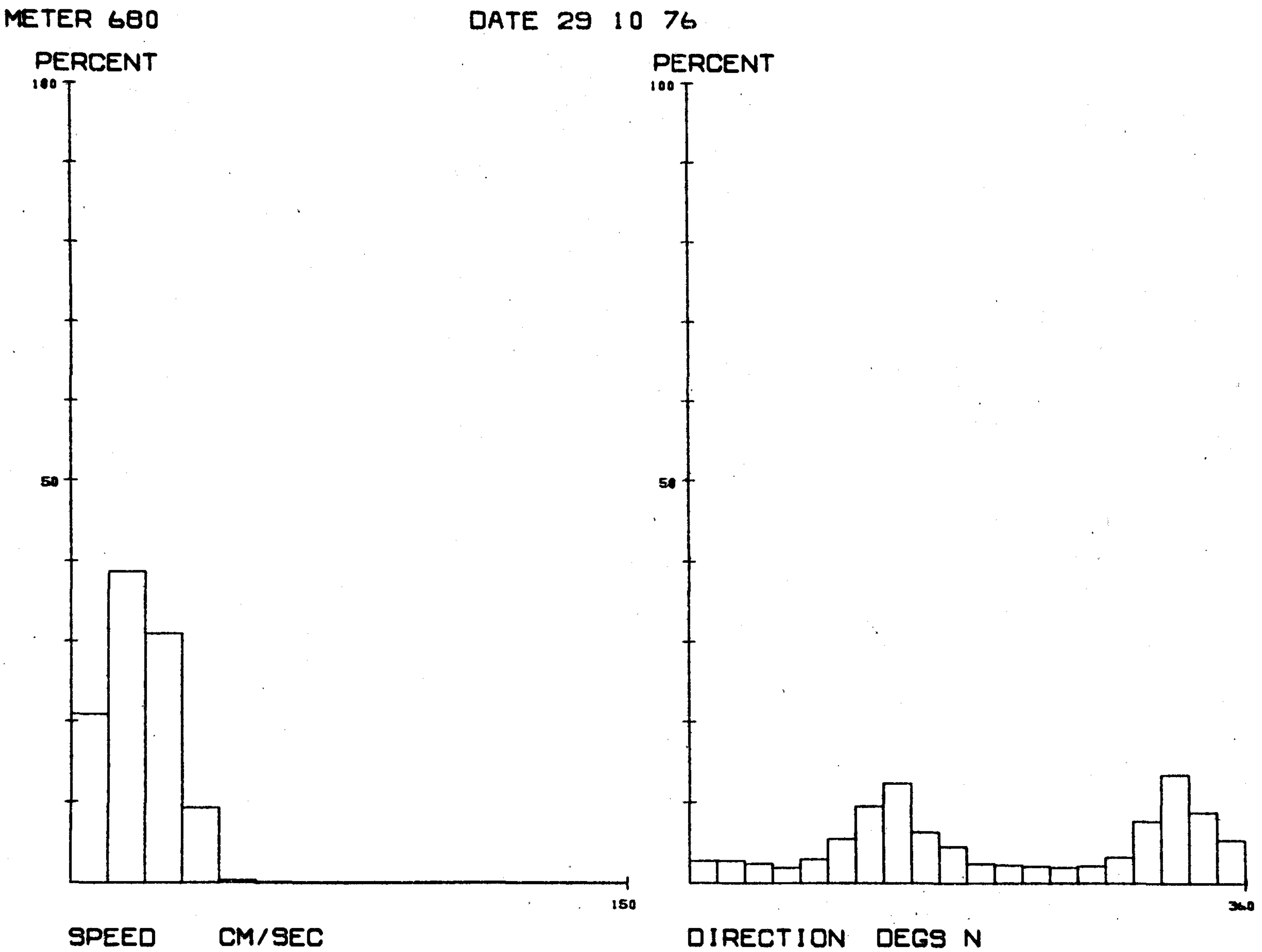
Figure	Record	Station
8.1	237J6	A
8.2	680K6	B
8.3	594K6	C
8.4	244K6	D
8.5	269K6	E
8.6	260K6	F
8.7	573K5	G
8.8	534K6	H

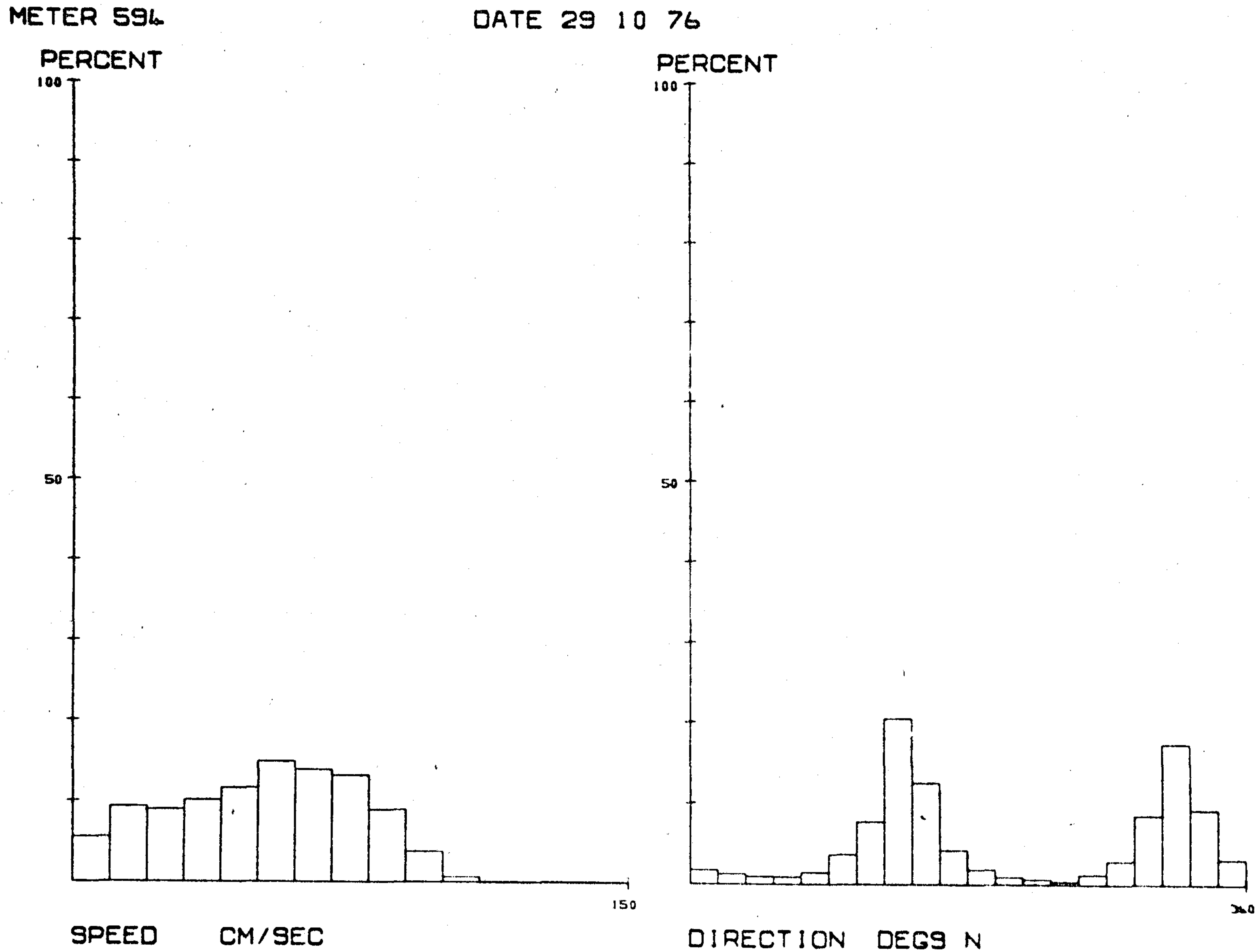
METER 237 DATE 28 9 76





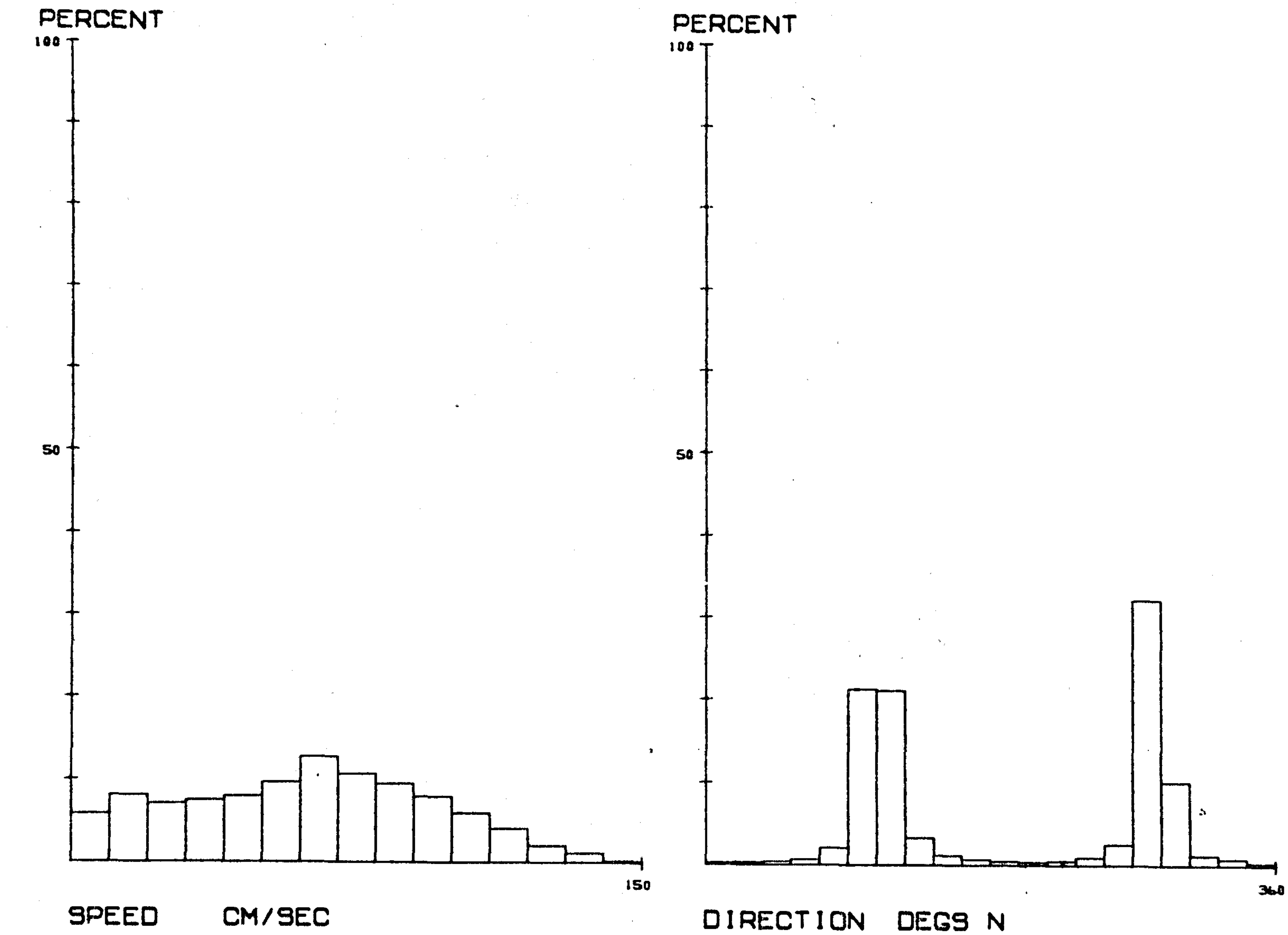
8.1


METER 680
DATE 29 10 76
PERCENT
100
50
SPEED CM/SEC
150
PERCENT
100
50
DIRECTION DEGS N
360

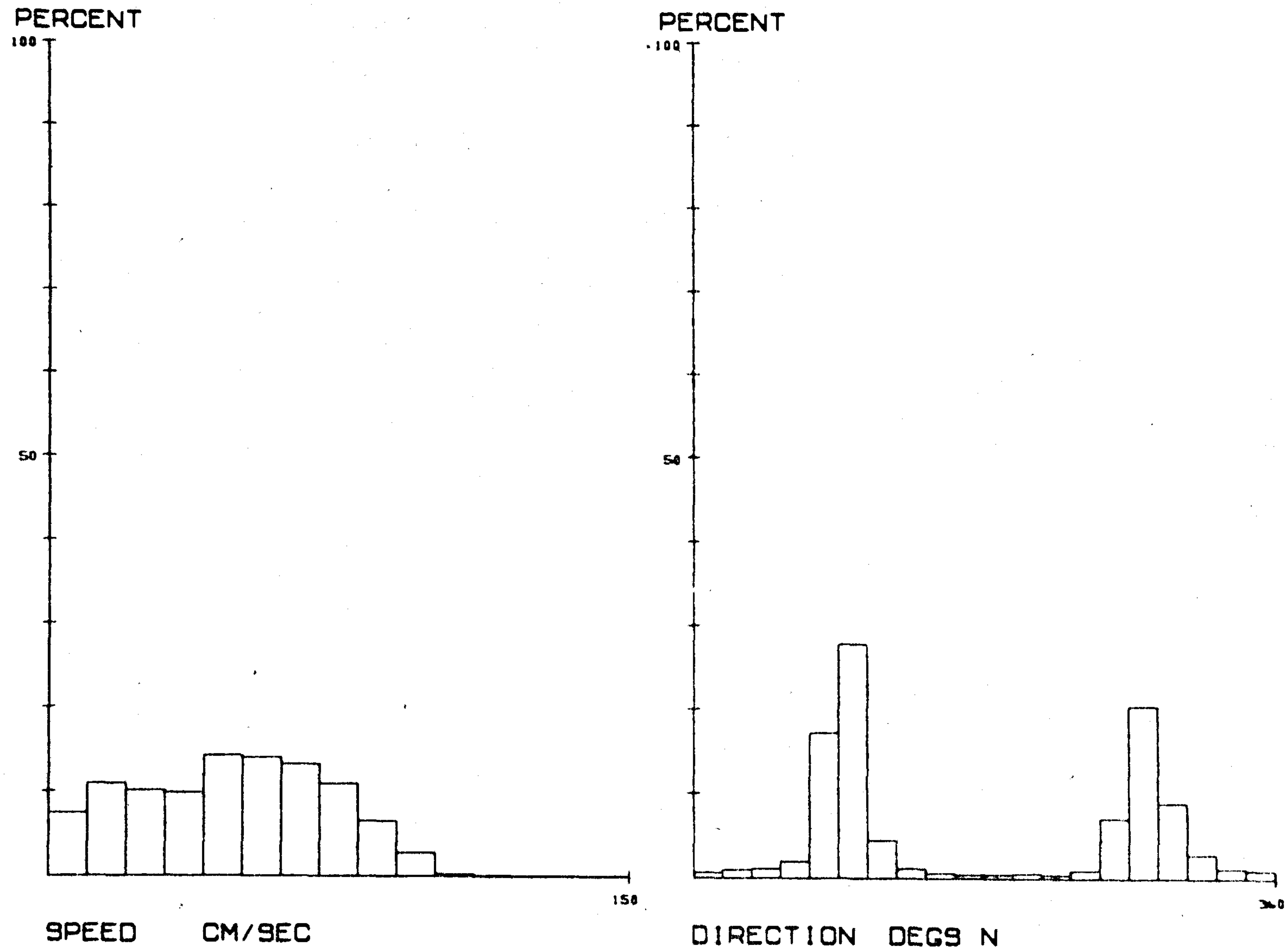

METER 594
DATE 29 10 76
PERCENT
100
50
150
SPEED CM/SEC
PERCENT
100
50
360
DIRECTION DEGS N

8.3

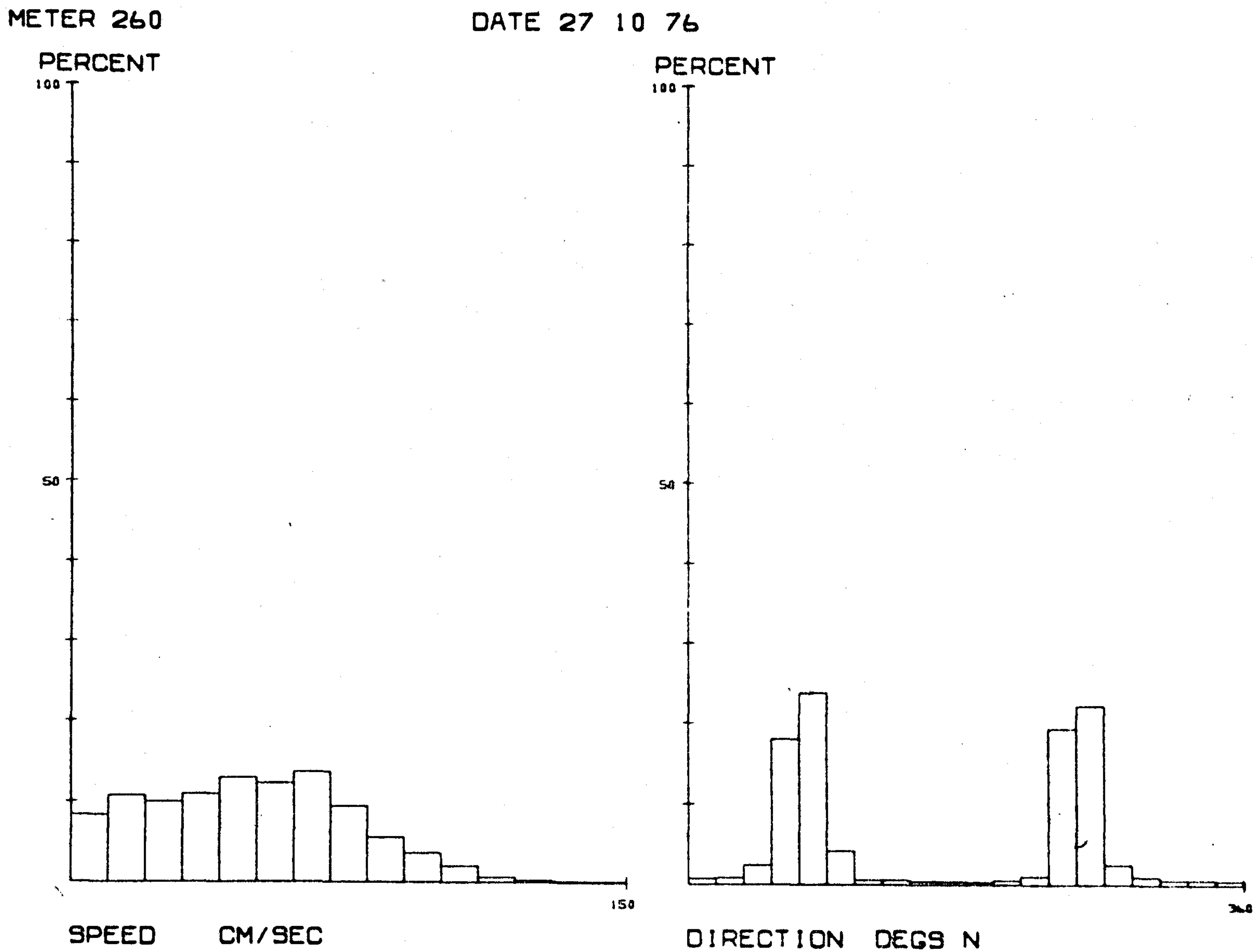
METER 244 DATE 26 10 76



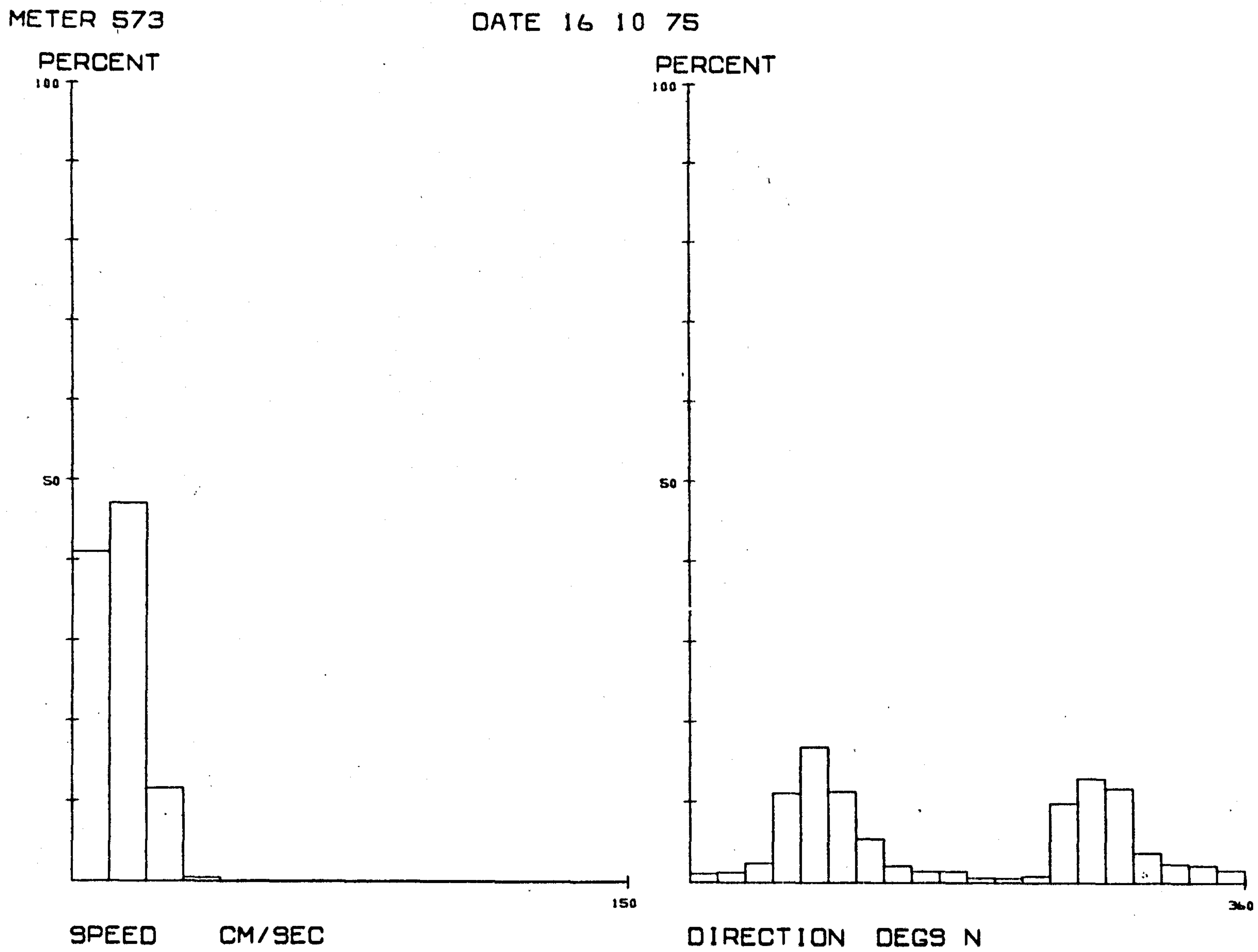
METER 269 DATE 26 10 76



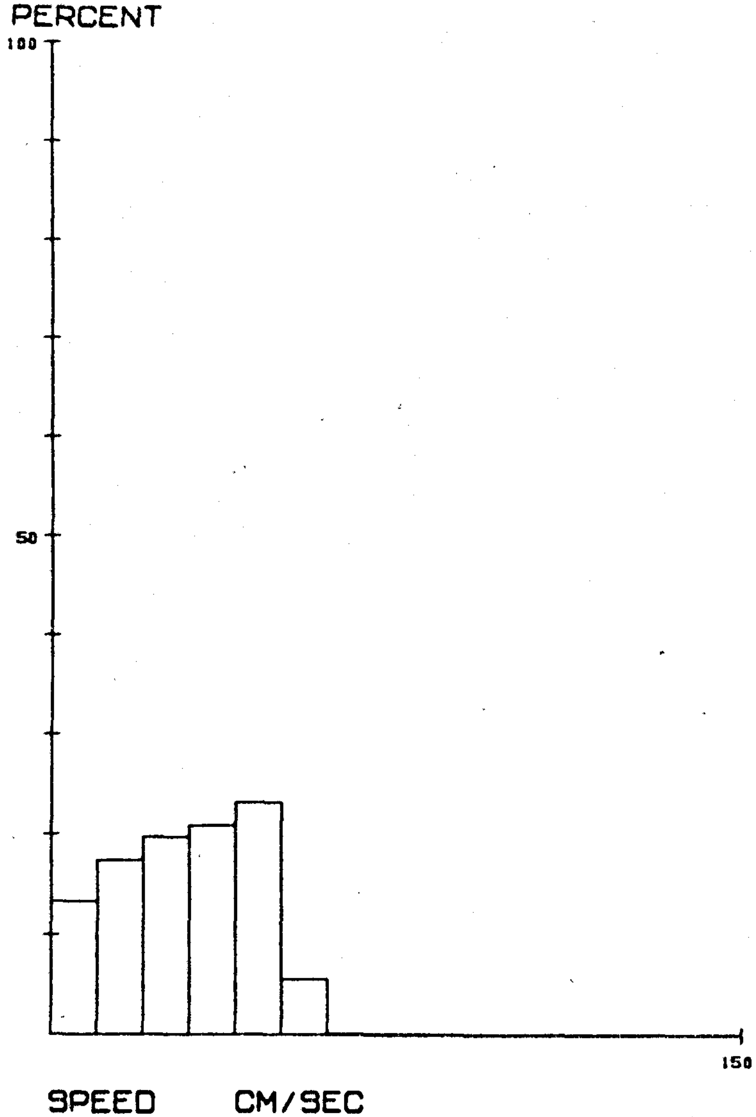
8.5

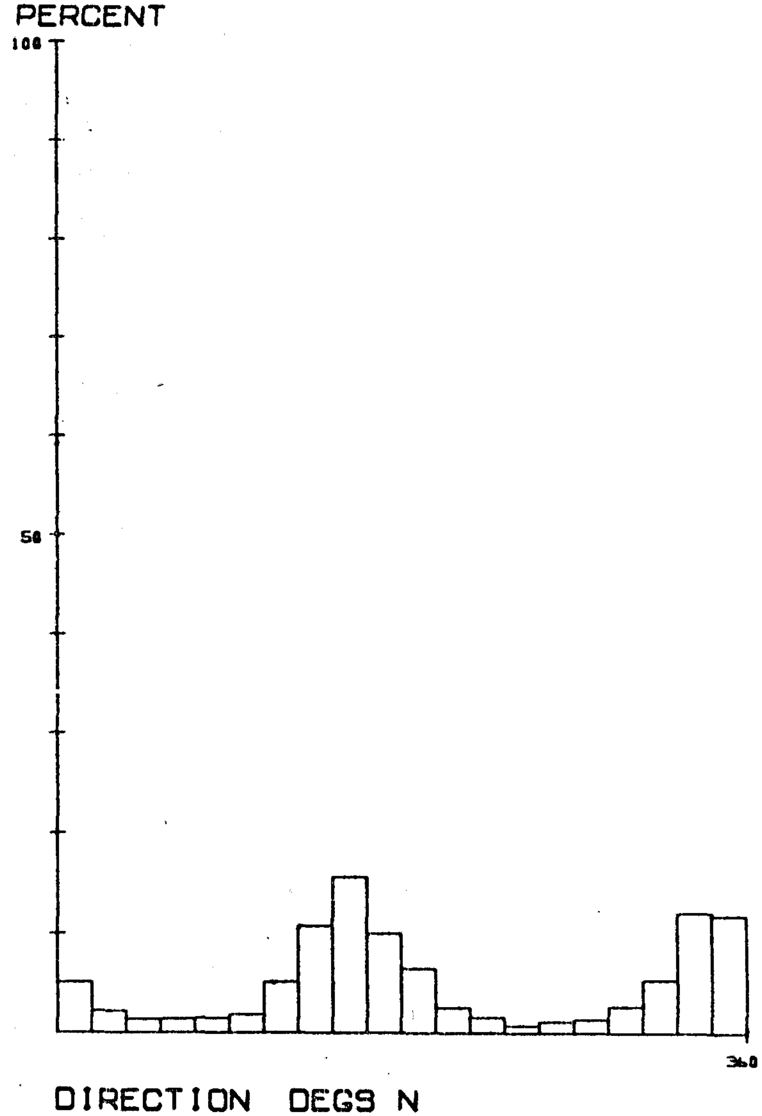

METER 260
DATE 27 10 76
PERCENT
100
50
150
SPEED CM/SEC
PERCENT
100
50
360
DIRECTION DEGS N

8.6

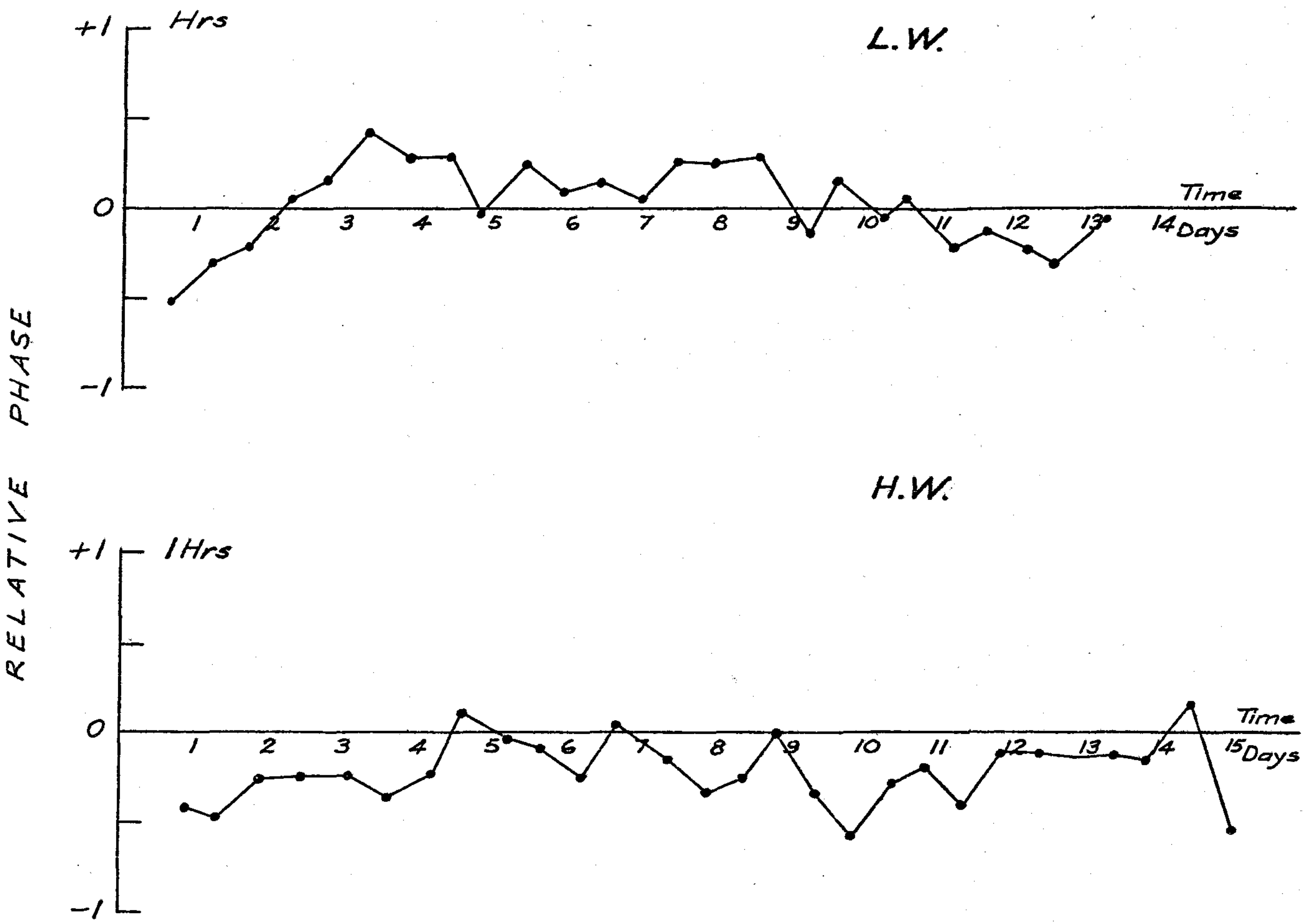

METER 573
DATE 16 10 75
PERCENT
100
50
150
SPEED CM/SEC
PERCENT
100
50
360
DIRECTION DEGS N

METER 534 DATE 29 10 76



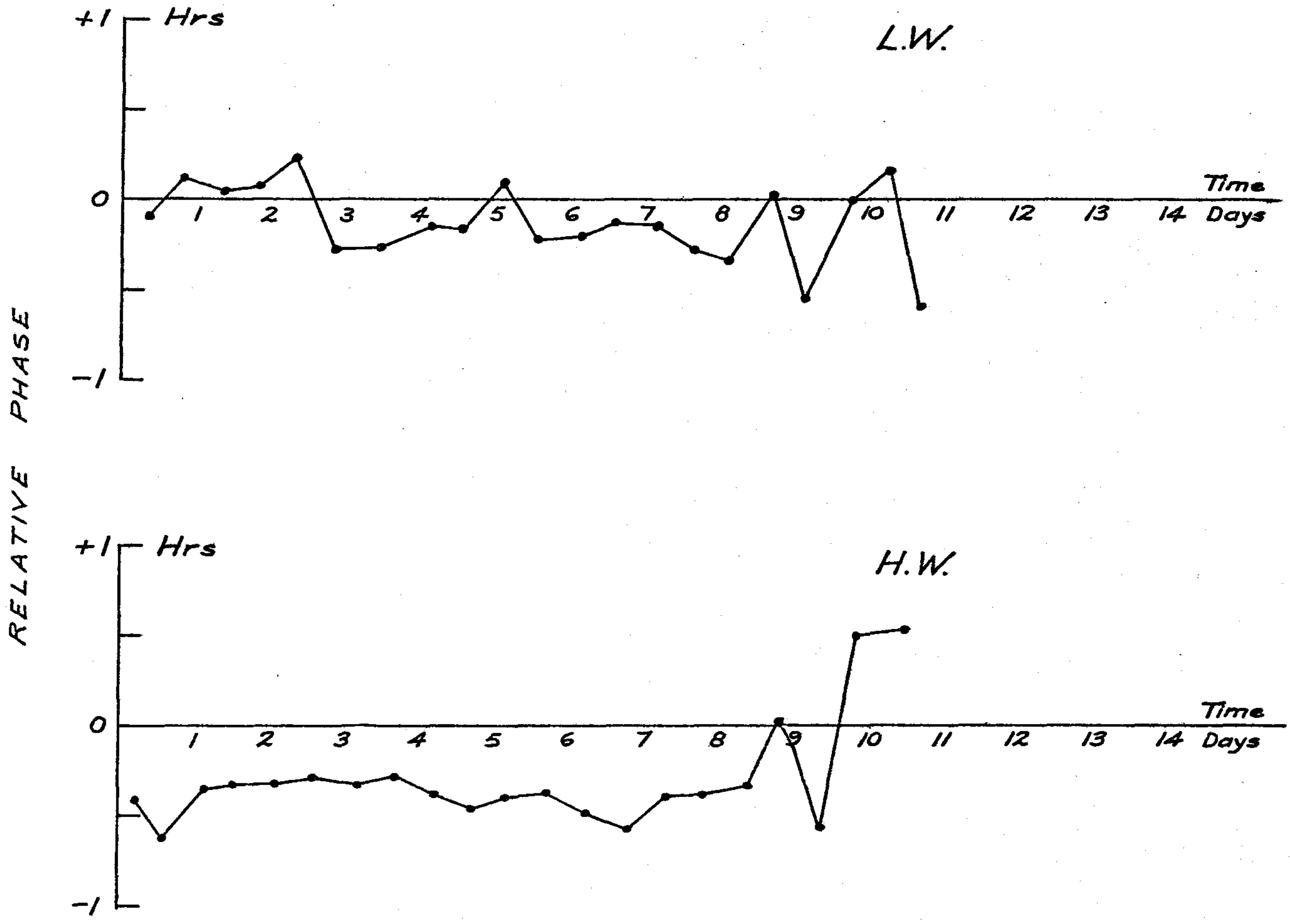


88



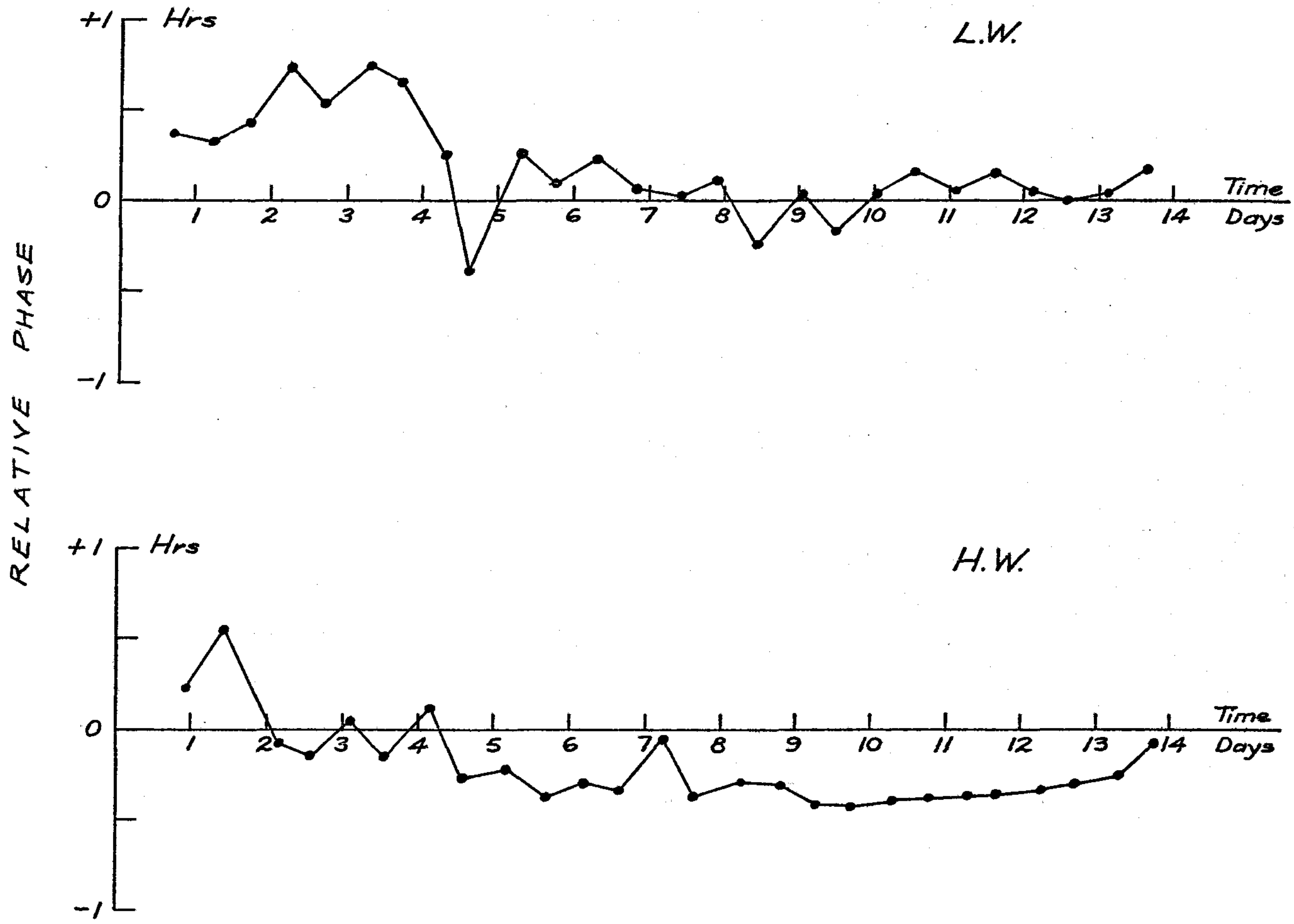
Phase of slackwater at Stn. A (Record 237 J6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·1



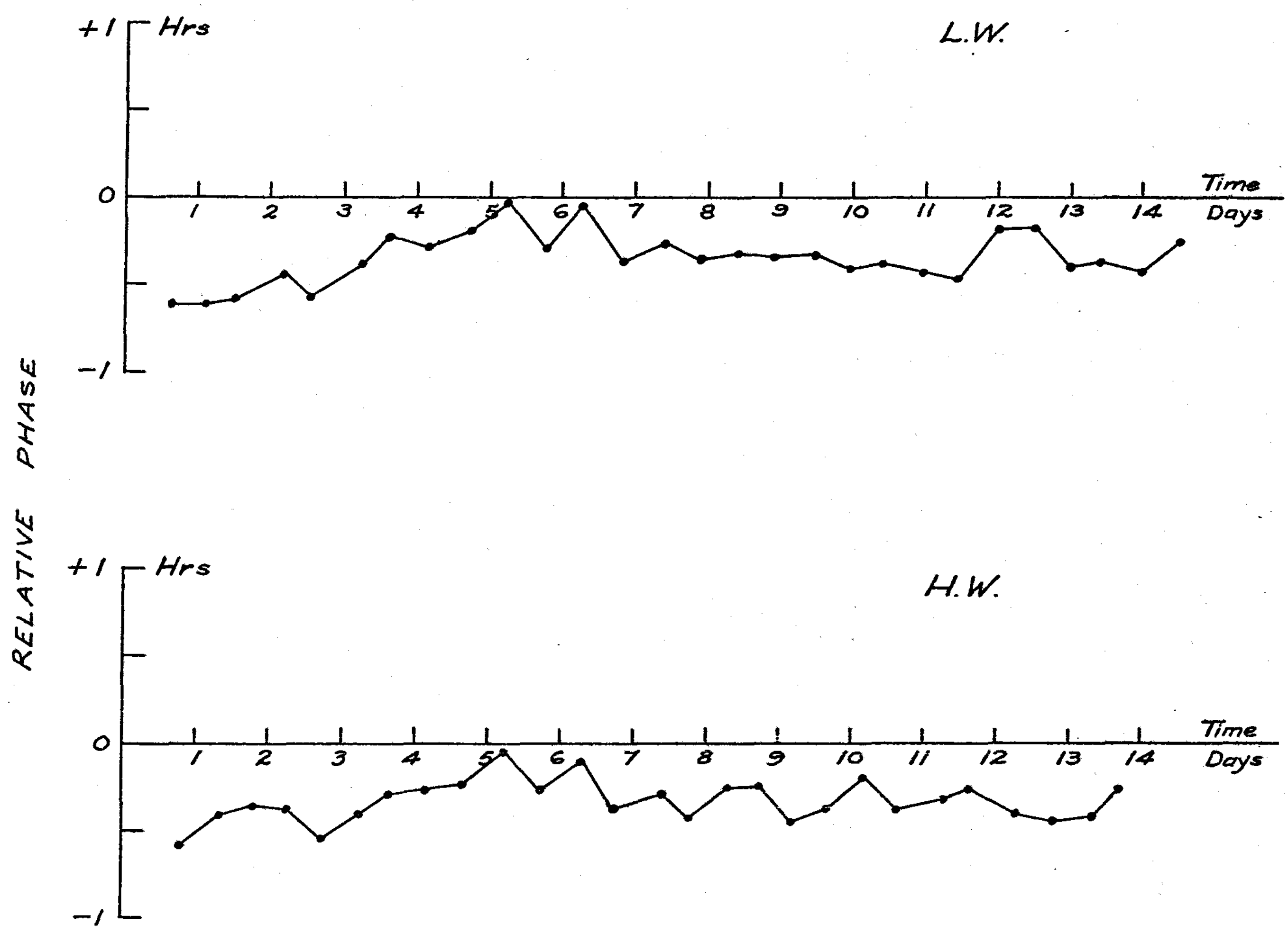
Phase of slackwater at Stn. B (Record 680K6) relative to predicted LW (top) and HW (bottom) Swansea. First 11 days of good data only. (Interpretation not possible beyond 11 days).

Fig. 9·2



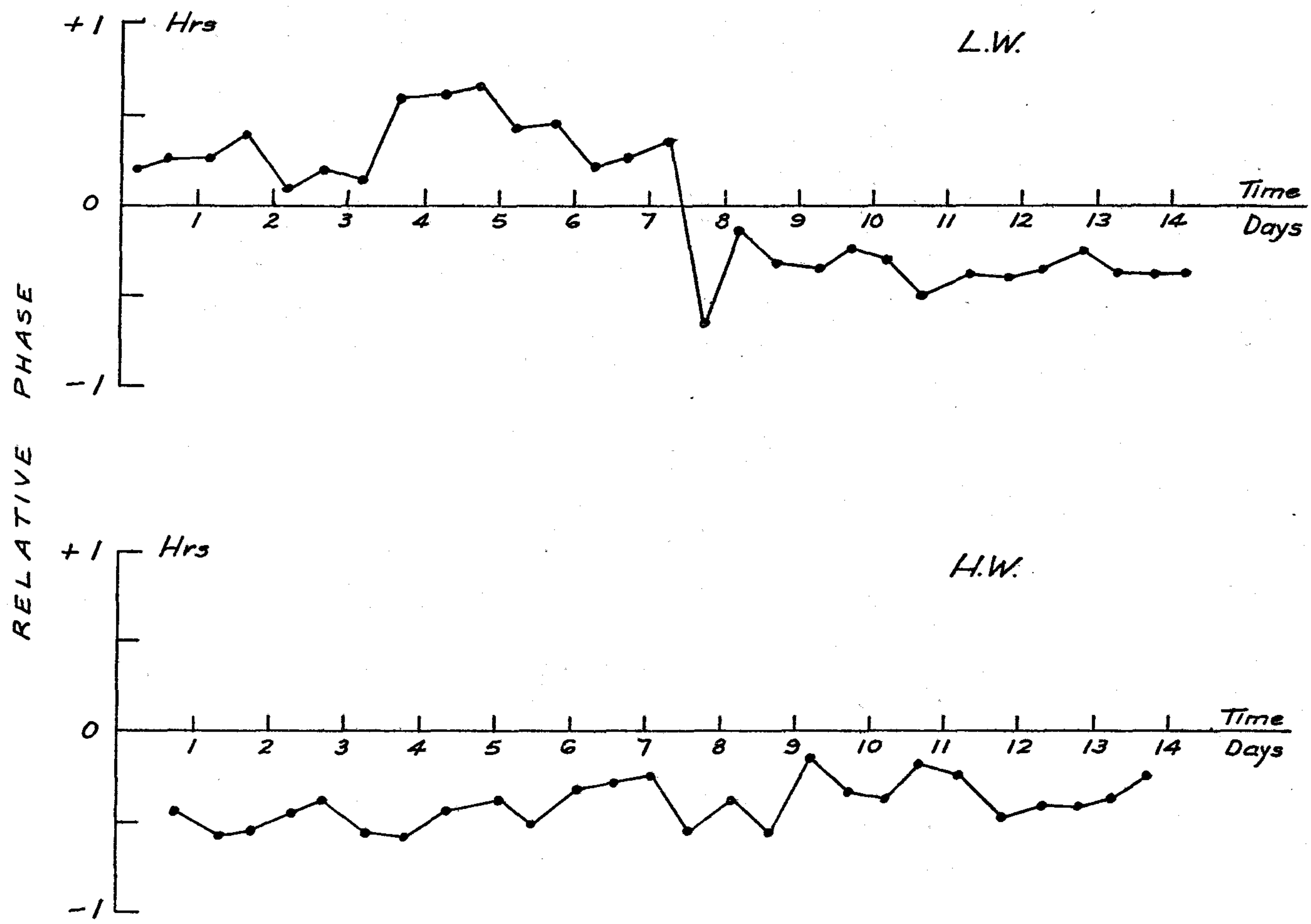
Phase of slackwater at Stn. C (Record 594K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·3



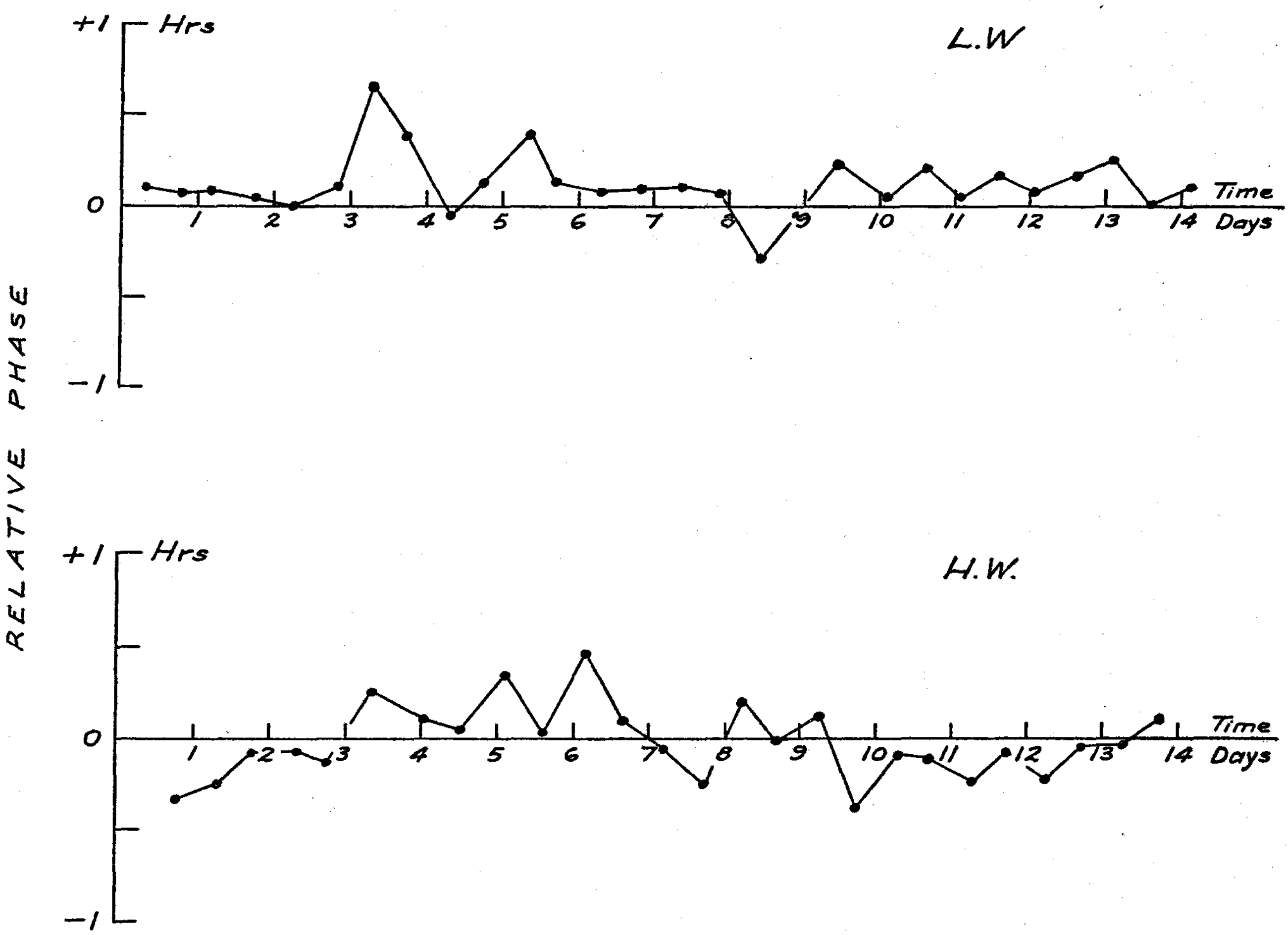
Phase of slackwater at Stn. D (Record 244K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·4



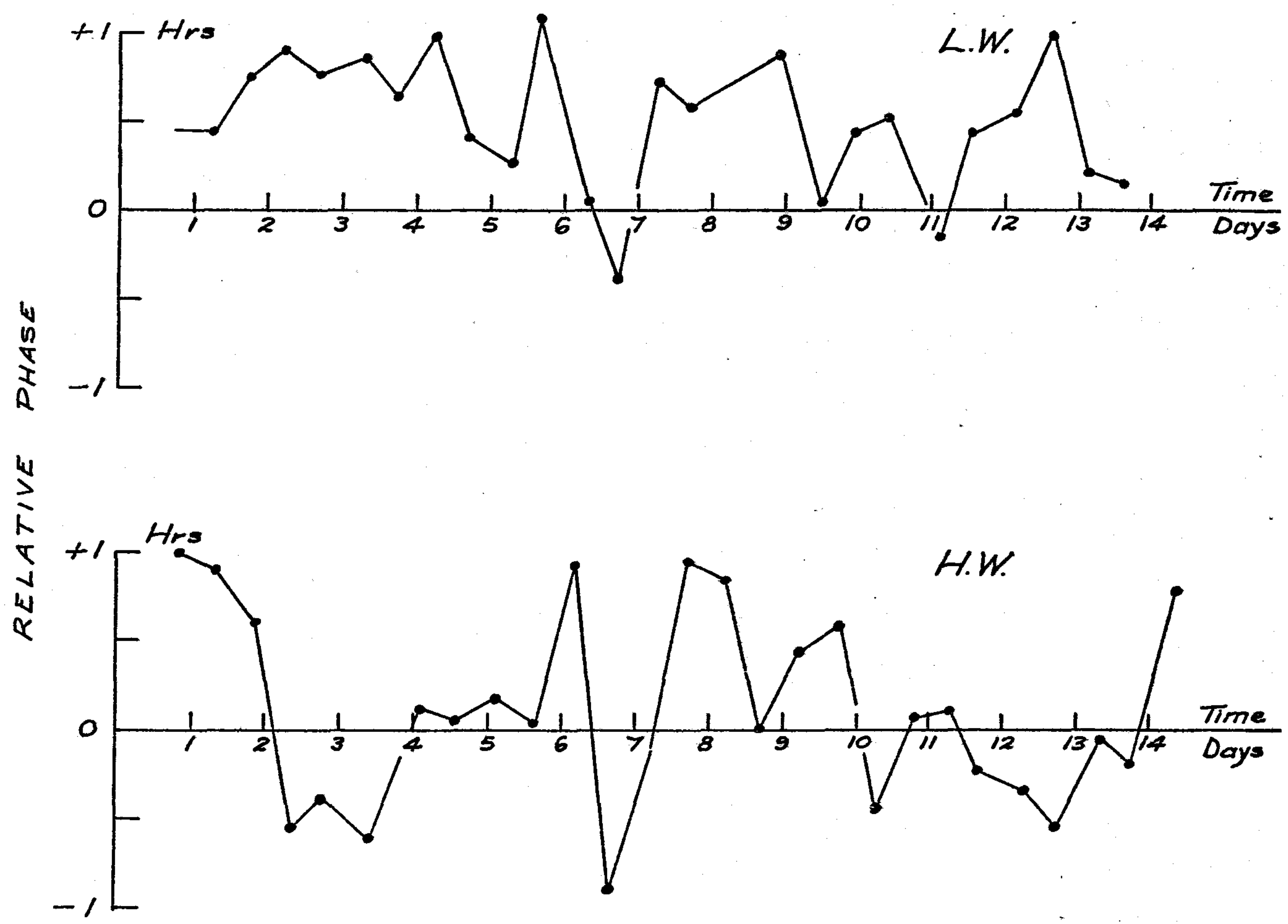
Phase of slackwater at Stn. E (Record 269K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·5



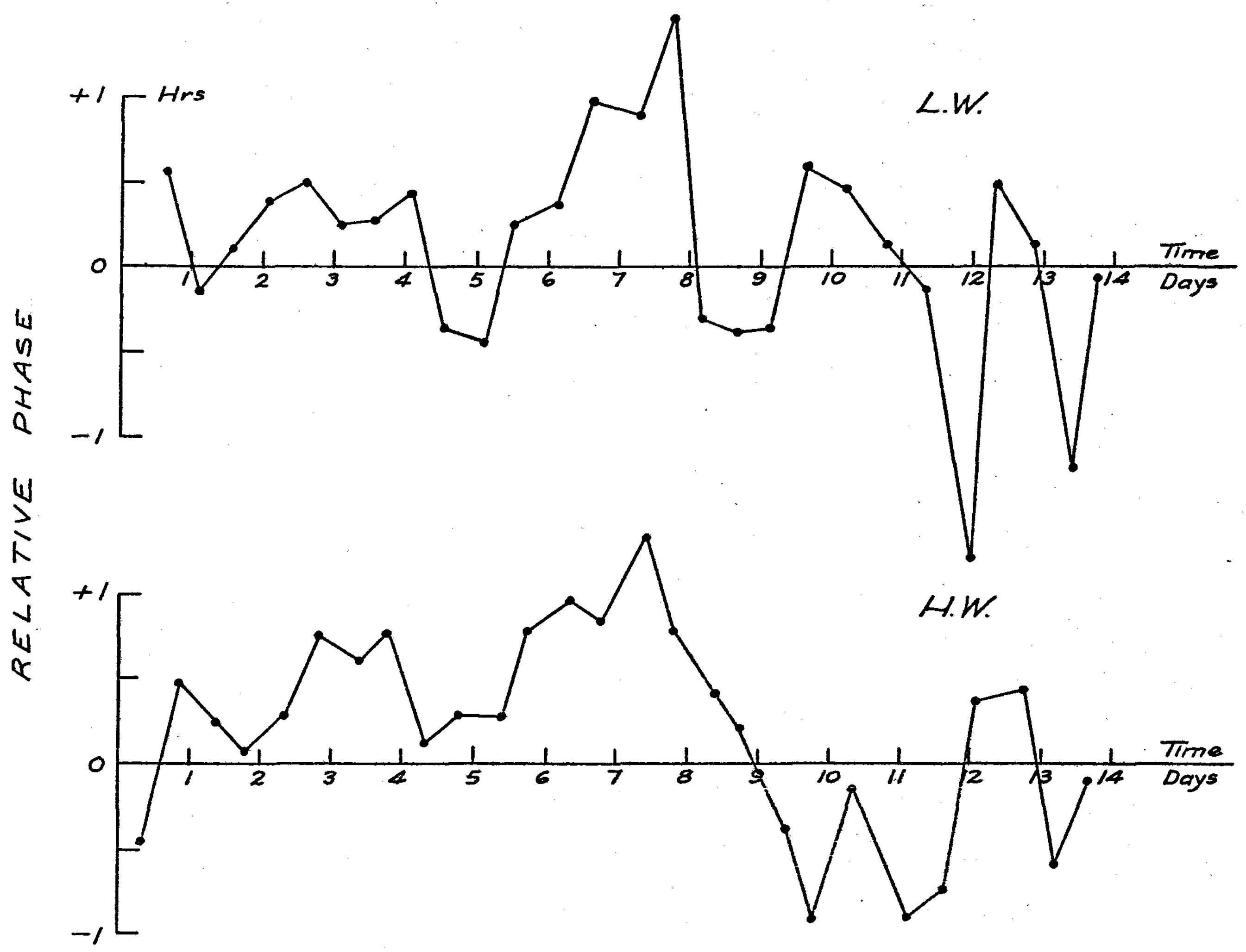
Phase of slackwater at Stn. F (Record 260K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·6



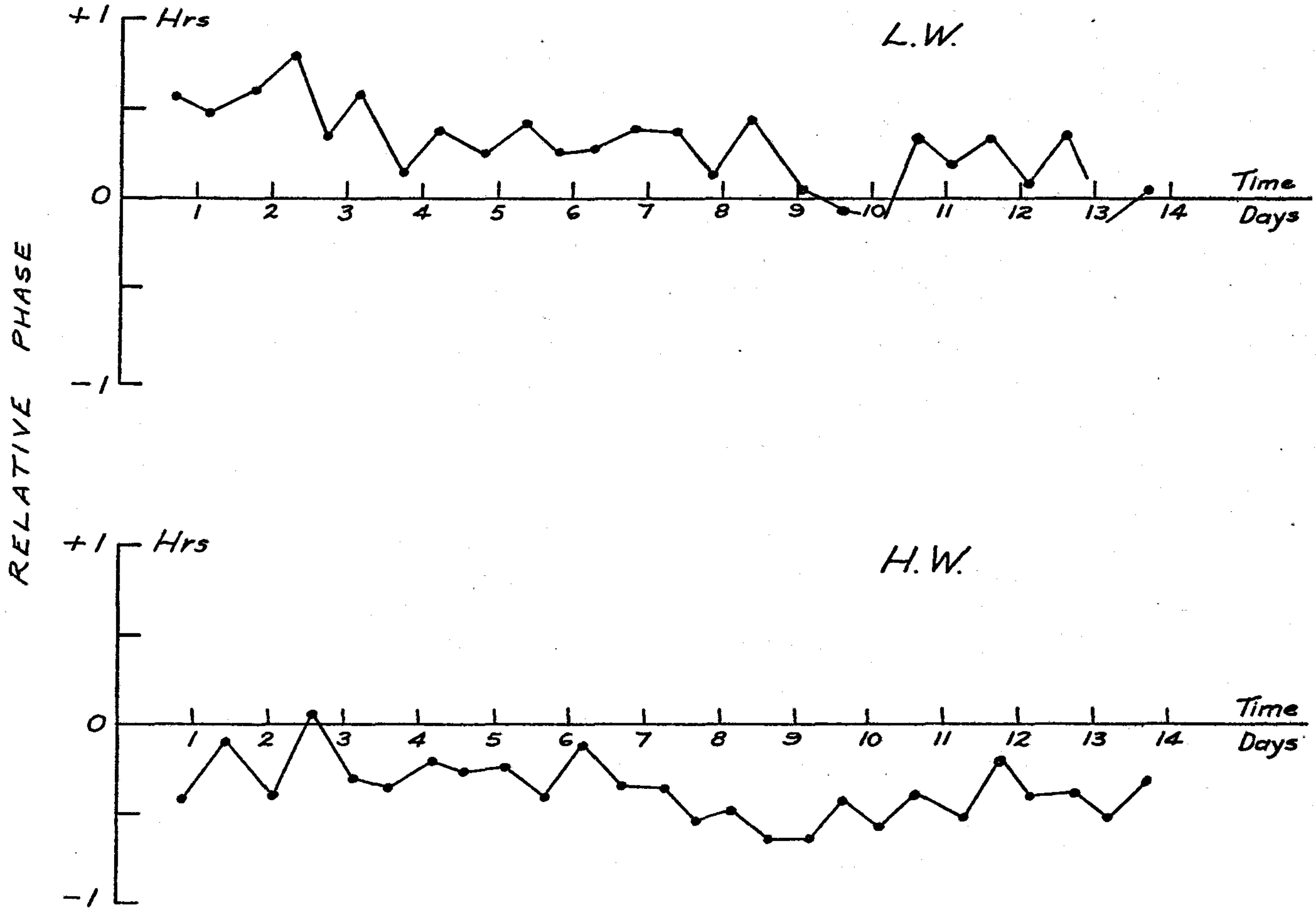
Phase of slackwater at Stn. G (Record 626K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·7



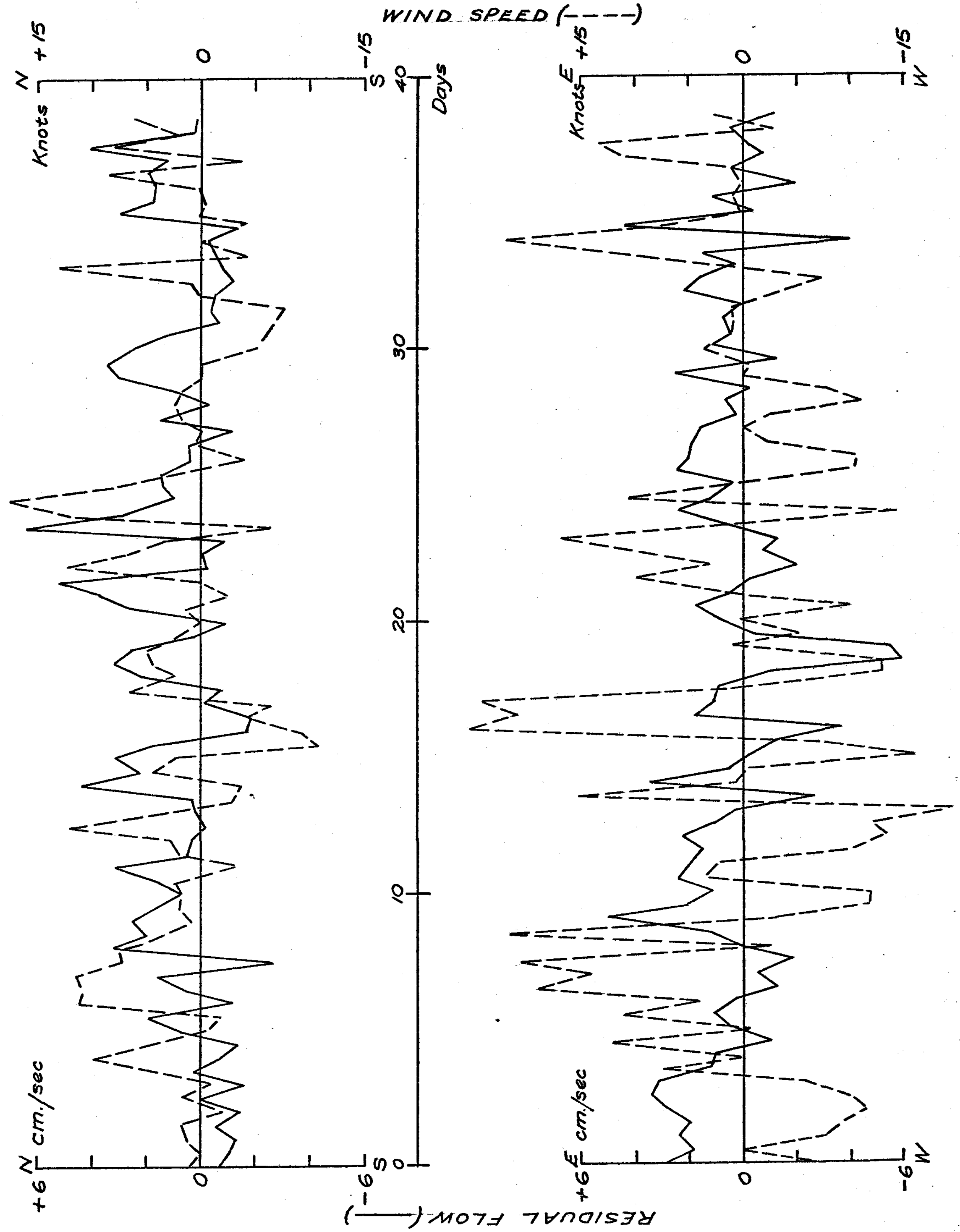
Phase of slackwater at Stn. G (Record 573K5) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only. Data for period 14 – 28 Oct. 1975. For contemporary record see Fig 9·7.

Fig. 9·8



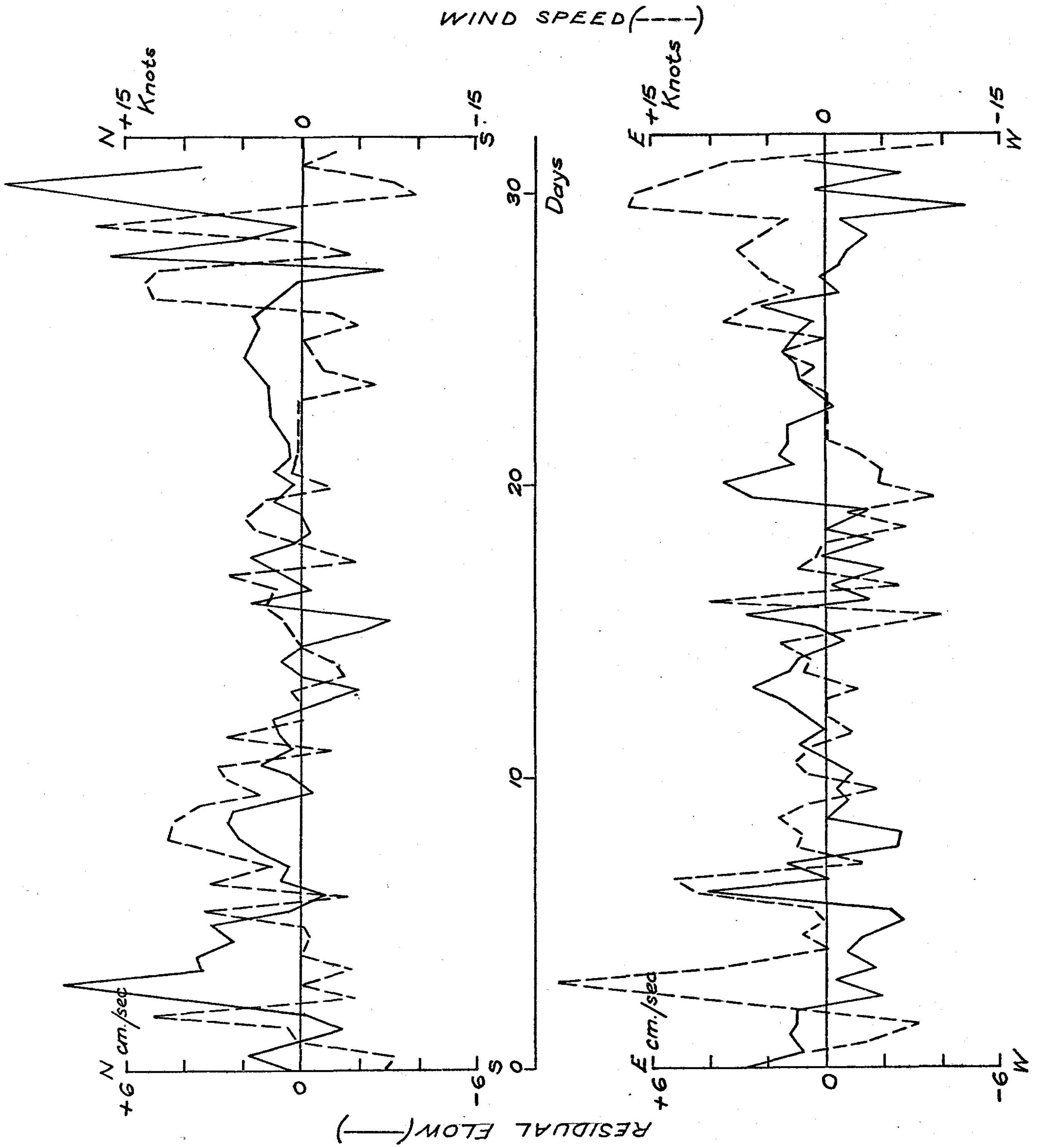
Phase of slackwater at Stn. H (Record 534K6) relative to predicted LW (top) and HW (bottom) Swansea. First 14 days of good data only.

Fig. 9·9



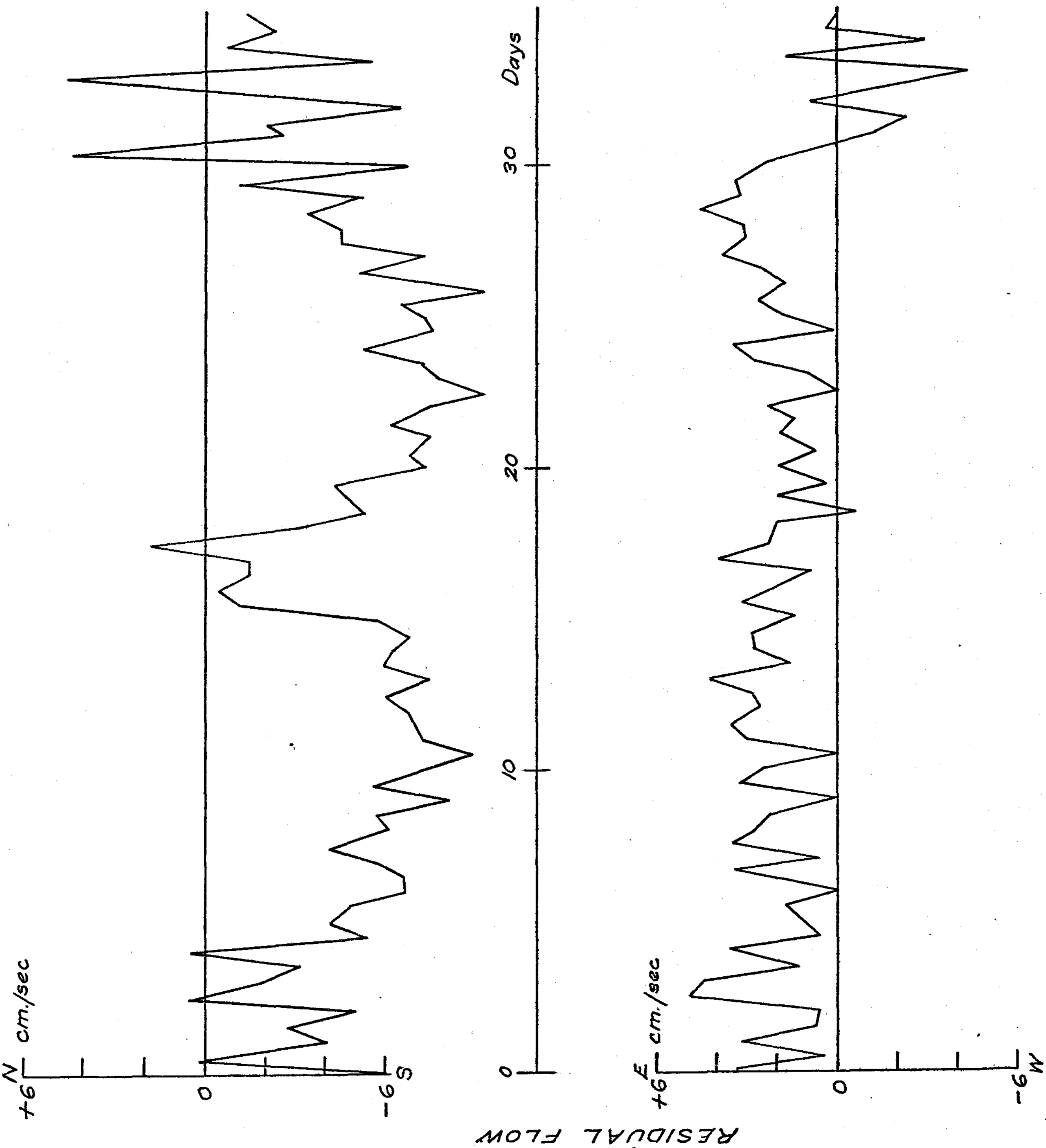
Tidal mean(12·5hr)residuals and wind speed for Stn. A, record 237J6
Note: Direction of wind plotted with same sense as tidal flow.

Fig.10·1



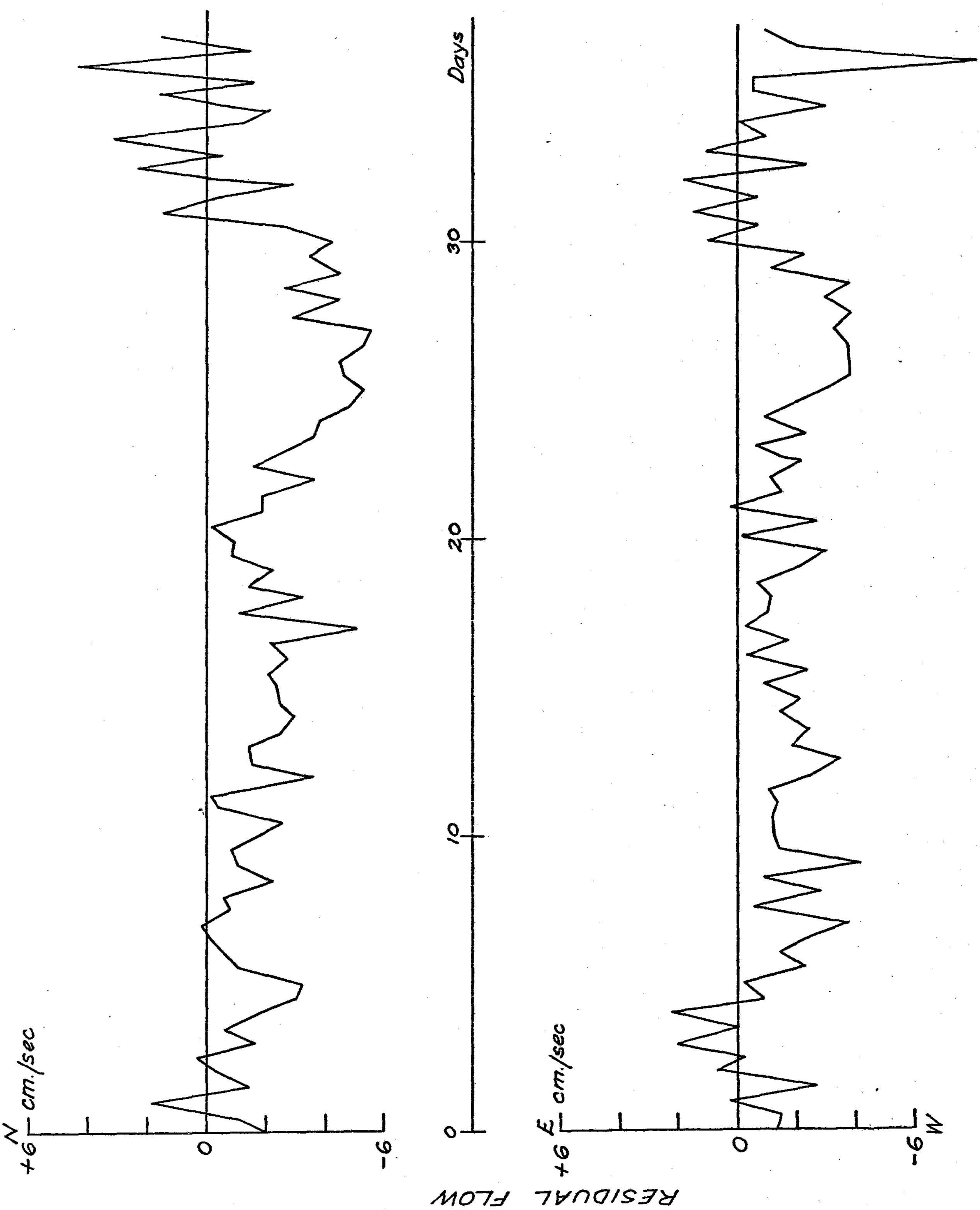
Tidal mean(12·5hr)residuals and wind speed for Stn. B, record 680K6
Note: Direction of wind plotted with same sense as tidal flow.

Fig.10·2



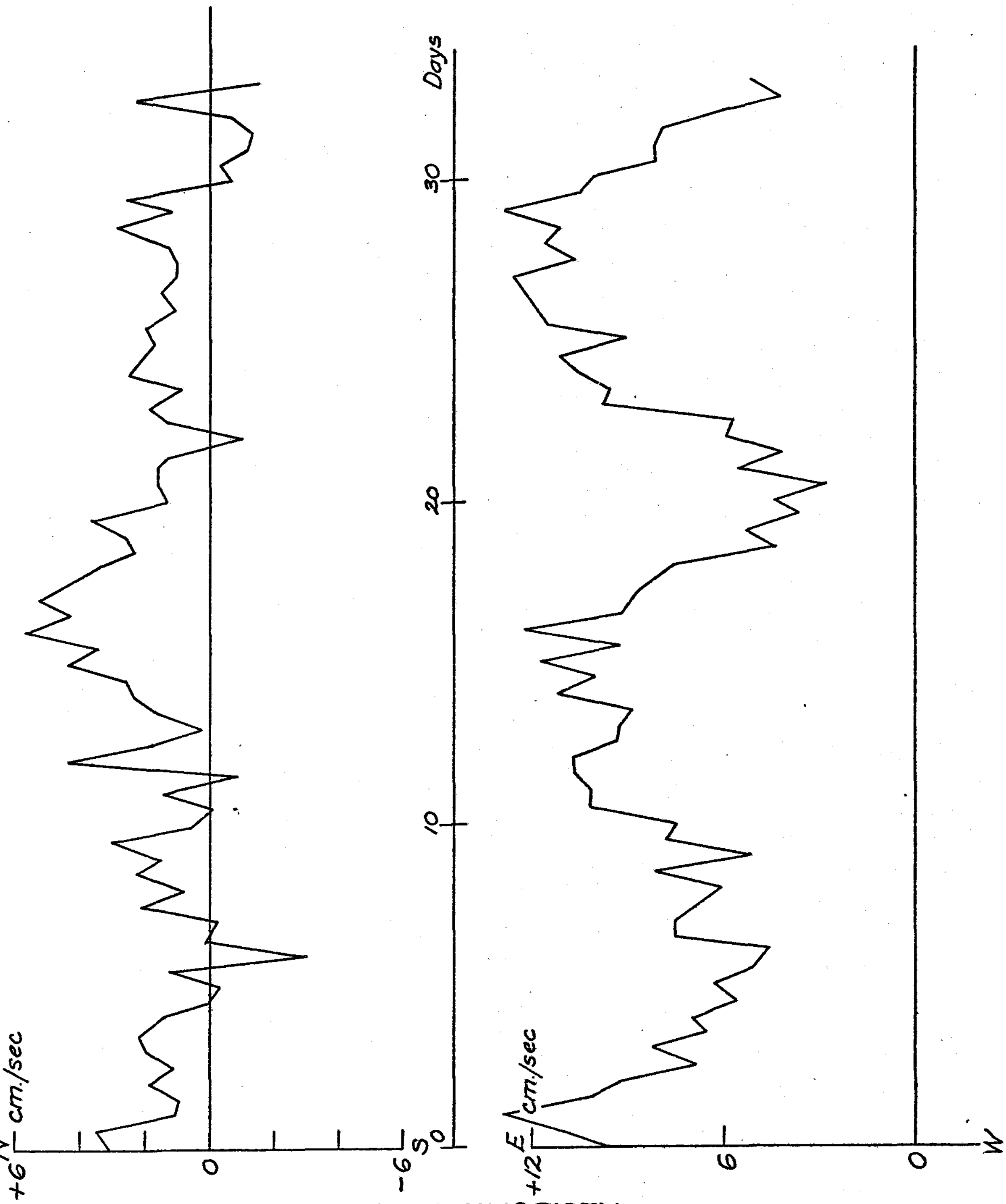
Tidal mean (12·5 hr) residuals for Stn. C, record 594K6.

Fig. 10·3



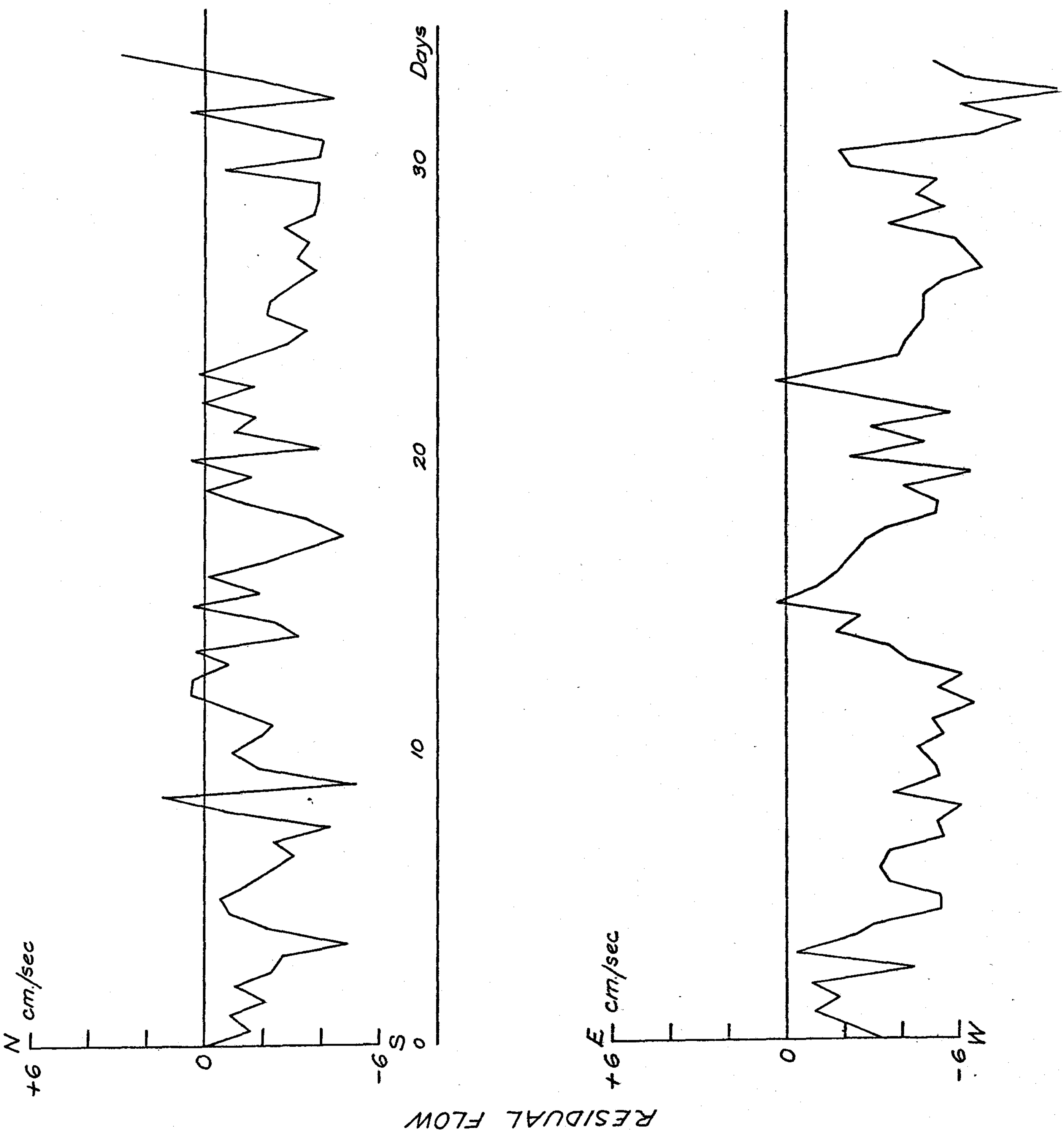
Tidal mean (12·5 hr) residuals for Stn. D, record 244K6.

Fig. 10·4



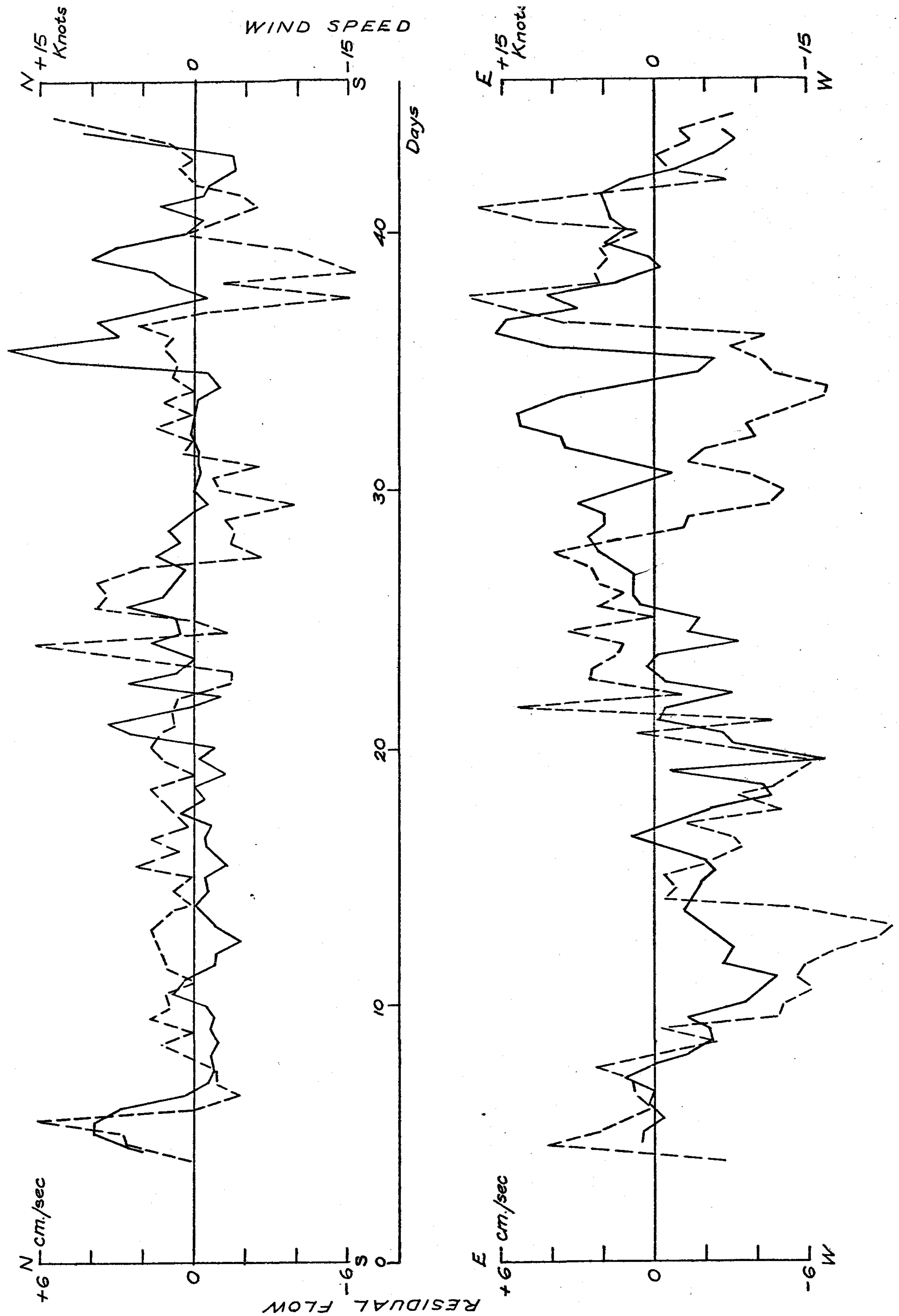
Tidal mean (12·5 hr) residuals for Stn. E, record 269K6

Fig.10·5



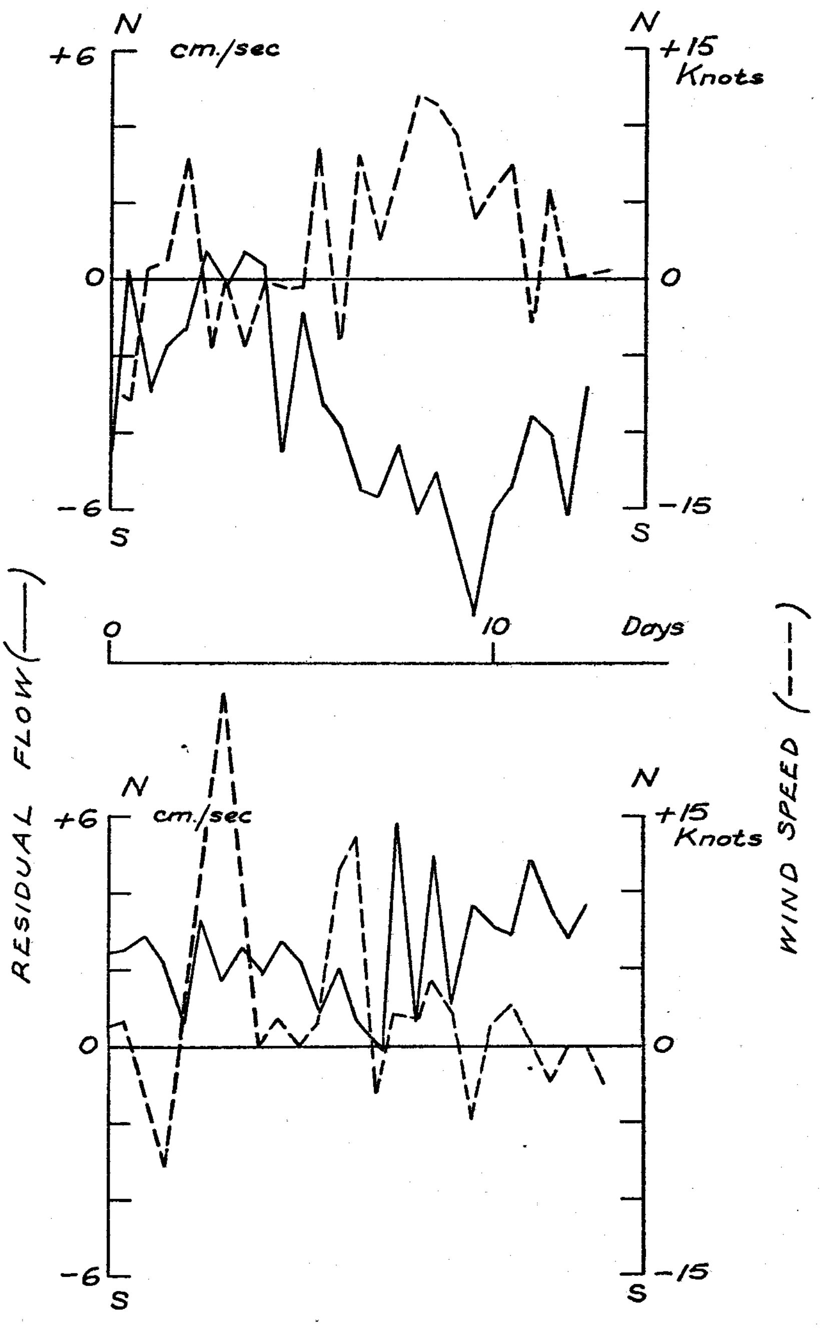
Tidal mean (12·5 hr) residuals for Stn. F, record 260 K6

Fig.10·6



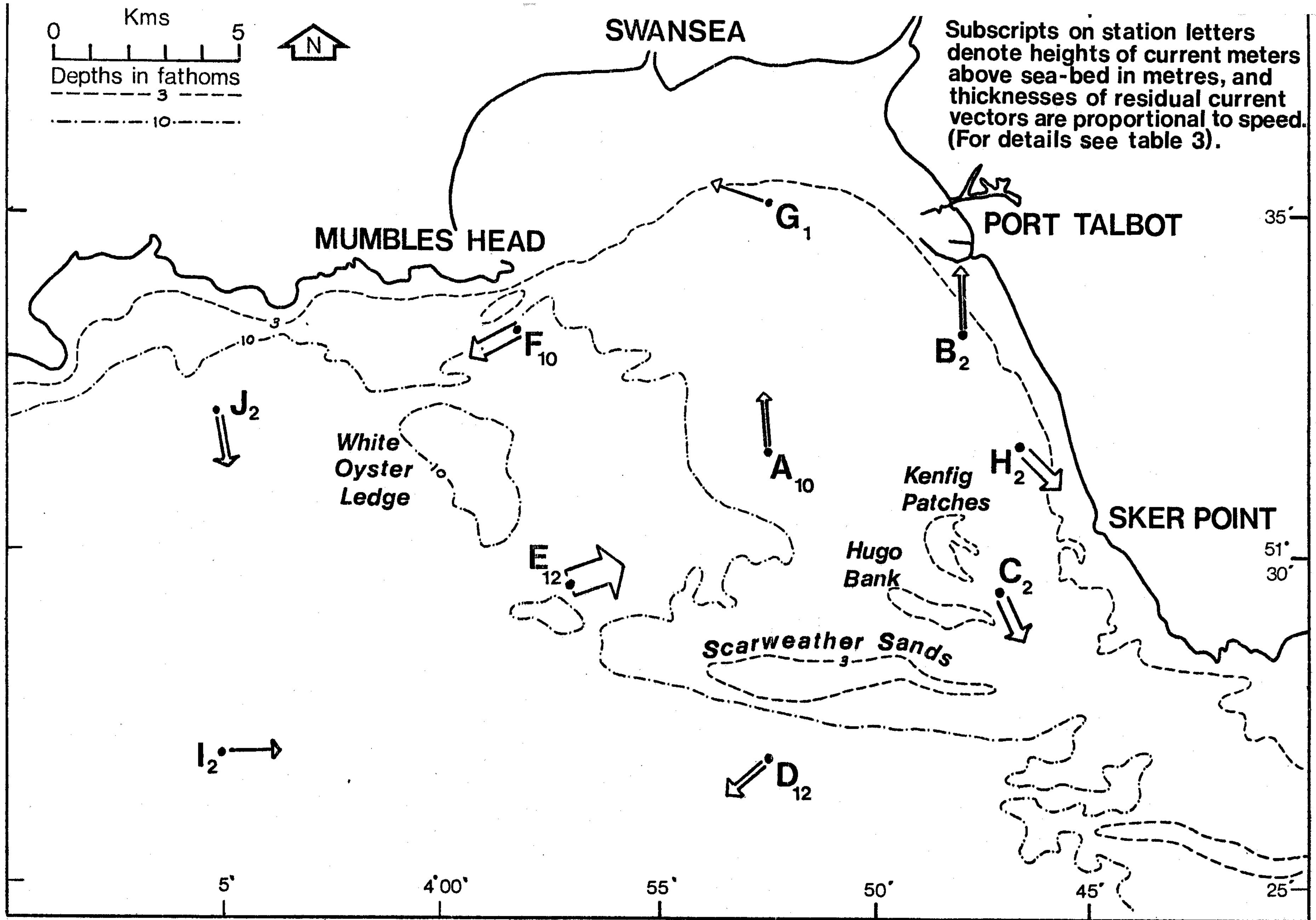
Tidal mean(12·5hr) residuals and wind speed for Stn. G, record 573K5.
Note: Direction of wind plotted with same sense as tidal flow.

Fig.10·7



Tidal mean(12·5hr)residuals and wind speed for Stn. H, record 534 K6
Note: Direction of wind plotted with same sense as tidal flow.

Fig.10·8



Directions and relative magnitudes of measured tidal residuals in Swansea Bay from I.O.S. moorings A–J. (Note: moorings I & J are not discussed in this report).

Fig. 11

APPENDIX 1

F2/B1/29

NATURAL ENVIRONMENT RESEARCH COUNCIL

MEMORANDUM OF AGREEMENT FOR A PROGRAMME OF RESEARCH

DEPLOYMENT OF CURRENT METERS IN SWANSEA BAY

PROGRAMME OF RESEARCH

1. The Natural Environment Research Council (hereinafter referred to as NERC) will undertake for the Welsh Office (hereinafter referred to as WO) the deployment of current meters in Swansea Bay in accordance with the requirements of the research programme set out in Annex A (and appendices A and B thereto). The work under this agreement shall be carried out by the Institute of Oceanographic Sciences (hereinafter referred to as IOS).

CO-ORDINATION OF THE PROGRAMME

2.1 WO and NERC will each appoint a Nominated Officer (see paragraph 14) who will together provide the formal link between the two parties to this Agreement.

.2 The Nominated Officers operating in close liaison with Science Division at NERC headquarters shall establish priorities for the work, monitor progress against the agreed research objectives and keep the financial aspects under review. They will discuss any other matters arising including inter alia, proposals from NERC or WO for changes in the programme and changes in costs. Any proposed changes in the programme and/or costs must be notified to NERC Headquarters and WO immediately.

3. The management of the research programme shall be the responsibility of NERC who in particular shall be responsible for:

i. The determination of how work is to be carried out, including where and by whom the work is to be done, and whether the arrangements are to be by direct employment, sub-contract or other arrangements;

ii. the management of all employees, including the sole right to issue instructions to such employees and the sole right to issue such instructions to grantees or sub-contractors as may be legitimate under the terms of a grant or sub-contract.

NERC will discuss these arrangements with WO and give due consideration to proposals or representations from WO concerning them.

4. WO will need to be satisfied that funds are used effectively and economically for the approved programme. The WO Nominated Officer

shall be afforded reasonable access to the work under arrangements to be made between WO, the Director of IOS and NERC Headquarters.

5. The work shall commence as soon as possible after the arrangements set out in this Memorandum of Agreement enter into force and once the current meters have been deployed continue until 31 October 1977. Either party shall have the right to terminate the agreement prior to the deployment of the current meters by giving 1 week's notice in writing. In the event of termination prior to deployment of the meters WO shall make payment to NERC in respect of all expenditure properly incurred on the research programme up to the date of termination. Thereafter WO shall reimburse NERC in respect of expenditure incurred after the date of termination only insofar as such expenditure results from commitments entered into by NERC in good faith during and on behalf of the research programme and that cannot be avoided on or before the date of termination.

<u>ESTIMATED COSTS</u>

6. (Omitted from this report)

7. Total expenditure on the programme shall not exceed the total estimated cost set out in paragraph 6 and annual expenditure shall not exceed the annual apportionments there stated unless such expenditure has the prior written authority of WO. NERC shall keep the costs under review and consult WO if at any time it should appear that an excess might occur. WO shall reimburse NERC for increases in costs outside NERC's direct control such as pay awards, increases in costs of materials and consumable items, etc, and also for such increased costs as may result from changes in the programme approved by WO.

<u>REPLACEMENT COSTS</u>

8. The WO shall reimburse NERC half the replacement costs of any equipment lost in the course of meter deployment.

<u>PAYMENT</u>

9. Payments will be made quarterly in advance. NERC will render to the WO detailed quarterly statements of actual expenditure supported by an explanation of any major variations. Subject to the provisions of Condition 7 any differences between the advance payment and the actual expenditure will be adjusted as soon as possible. All statements must quote the reference number F3/B1/29.

REPORTS AND PUBLICATION

10.1 A final report will be made to the WO in accordance with the conditions of Annex A. The Department of the Environment shall have full access to the results of the work which will be used by IOS to further the progress of the research undertaken for the Department. The results will remain the property of WO and WO retain the right to use and publish the results.

.2 Except as stated in 10.1 above and subject to the agreement of the Department of the Environment, NERC shall undertake to publish and communicate any information about the results of such research in the furtherance of scientific knowledge. The Director of IOS shall send concurrently to WO and to NERC Headquarters one copy each of the draft approved by himself of all reports intended for publication. In exceptional circumstances, for example, in relation to national or commercial security, WO may require the results of commissioned research to be withheld from publication for a specified period.

.3 WO reserves the right to determine whether or not the results shall be exploited commercially by patent or otherwise, and if so on what conditions, subject to negotiations with NERC.

INSURANCE AND INDEMNITIES

11. NERC shall indemnify WO against claims for loss or damage to any property or injury or death to any person during the course of the work and attributable to the negligence of NERC or its employees. WO shall similarly indemnify NERC in respect of any such claim attributable to the negligence of WO or its employees.

DISCLAIMER OF LIABILITY

12. NERC shall not be liable for any consequential losses, damage or injuries arising from the use of the results of the programme that is the subject of this Agreement.

OFFICIAL SECRETS ACT

13. NERC agrees to draw the attention of its employees, sub-contractors or agents to the provisions of the Official Secrets Act 1911/1939 and Government Security Regulations affecting any official information to which they may have access during the course of the project.

NOMINATED OFFICERS

14. The Nominated Officers shall be:

NERC: Dr A I Rees
Institute of Oceanographic Sciences
Brook Road
Wormley, Godalming
Surrey GU8 5UB
(Telephone Wormley 4141)

WO: Mr W D A Waters
Welsh Office
Pearl Buildings (13th floor)
Greyfriars Road
Cardiff
(Telephone Cardiff 28066)

LAW

This Agreement shall be a contract made in England and subject to English Law.

Signed ....
On behalf of the Natural Environment Research Council

Date..............................

Signed ....
On behalf of the Welsh Office

Date ....

(Appendices A and B from Memorandum of Agreement)

Title	Deployment of current meters in Swansea Bay, Oct-Dec 1976 IOS 50/WO
Brief Description of the work	Eight recording current meters will be deployed at mid depth in Swansea Bay for approximately 30 days during the period 25 October - 6 December or as near to that period as can be arranged

A limited interpretation of the measurements will be undertaken and a final report made to the Department, in the form of a Data Report, by 31 October 1977.

Details of the proposed current meter deployment and of the interpretation procedures are given in appendices A and B.

APPENDIX A

Station	Position Lat (N)	Long (W)	Min/Max depths (m)	Current meter elevations Mid-depth (m)
A	51°31.5'	3°52.5'	16/26.5	10
B	51°33.4'	3°48.0'	6.5/17	4
C	51°29.5'	3°47.0'	10.5/21	5
D	51°27.0'	3°52.5'	22.0/32.5	16
E	51°29.6'	3°58.5'	22.0/32.5	16
F	51°32.8'	3°57.5'	26.0/36.5	20
G	51°35.0'	3°52.5'	7.0/17.5	4
H	51°31.5'	3°46.5'	7.3/18.0	4

The maximum depth is based on the highest predicted tide of 10.5m (to the nearest 0.5m) which occurs during the survey period.

Station A is the existing long term mooring site being operated by IOS Taunton.

Stations B-H are short term mooring sites which were used for a period during 1975.

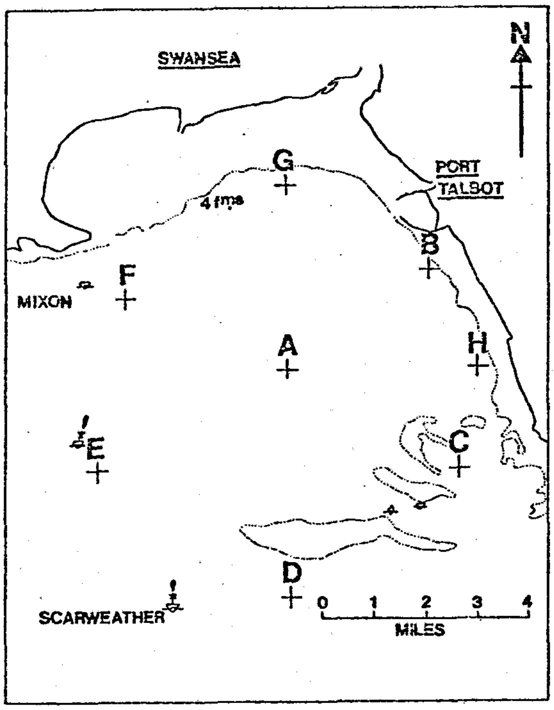
The mooring positions are shown in Fig.A1.

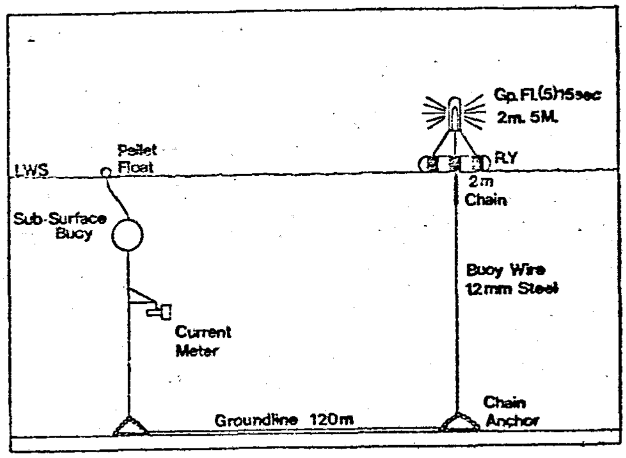
All moorings except where indicated by an asterisk would be the conventional 'U' shape type. An example of this type of mooring is shown in Fig A1.

The moorings would be marked with toroidal buoys carrying a flashing light and radar reflector and conforming to the IMCO recommendations.

Notices to Mariners and Radio Navigation warnings would be issued through the usual channels.

It is proposed to deploy the current meters during the period 25 October to 6 December 1976, using the RV Ocean Crest on charter from University College, Swansea.





STATION	POSITIONS			
	LAT/LONG		DECCA (CHAIN 1B/MP)	
	N	W	Green	Purple
A	51°31.5′	3°52.5′	D41.05	B64.80
B	51°33.4′	3°48.0′	D38.85	B74.80
C	51°29.5′	3°47.0′	D36.30	B69.60
D	51°27.0′	3°52.5′	D38.95	B55.20
E	51°29.5′	3°58.5′	D44.55	B51.70
F	51°32.8′	3°57.5′	D45.25	B59.70
G	51°35.0′	3°52.5′	D42.65	B70.60
H	51°31.5′	3°46.5′	D36.95	B74.10

Fig A1. Proposed current meter mooring position in Swansea Bay (top left) and a typical 'U' shape mooring (top right).

APPENDIX B

The analysis of current meter records

The analysis of each record would consist of the following:

(a) Preparation of pre- and post-cruise direction calibration tapes

(b) Conversion of Plessey MO21 magnetic tape records to 8 hole paper tape records

(c) Reading and editing of direction calibration tapes

(d) Reading and editing of data tapes (current speed and direction)

(e) Computation of current speed and direction time series (speed resolved into N-S and E-W components - or other directions, if required).

(f) Computation of current speed scatter plots

(g) Computation of unsmoothed and smoothed progressive vector plots. Smoothing and calculation of residual flows would be carried out by arithmetic averaging (running mean) over a period of 24 hours 50 minutes (2 tidal cycles).

(h) Computation of percentage frequency speed and direction histograms.

Examples of a typical format for the presentation of the current meter data are included with this proposal (see Figs B1 - B3).

No further interpretation of these results would be carried out by IOS Taunton unless specifically requested.

The proposed date for the submission of a Data Report is October 1977.

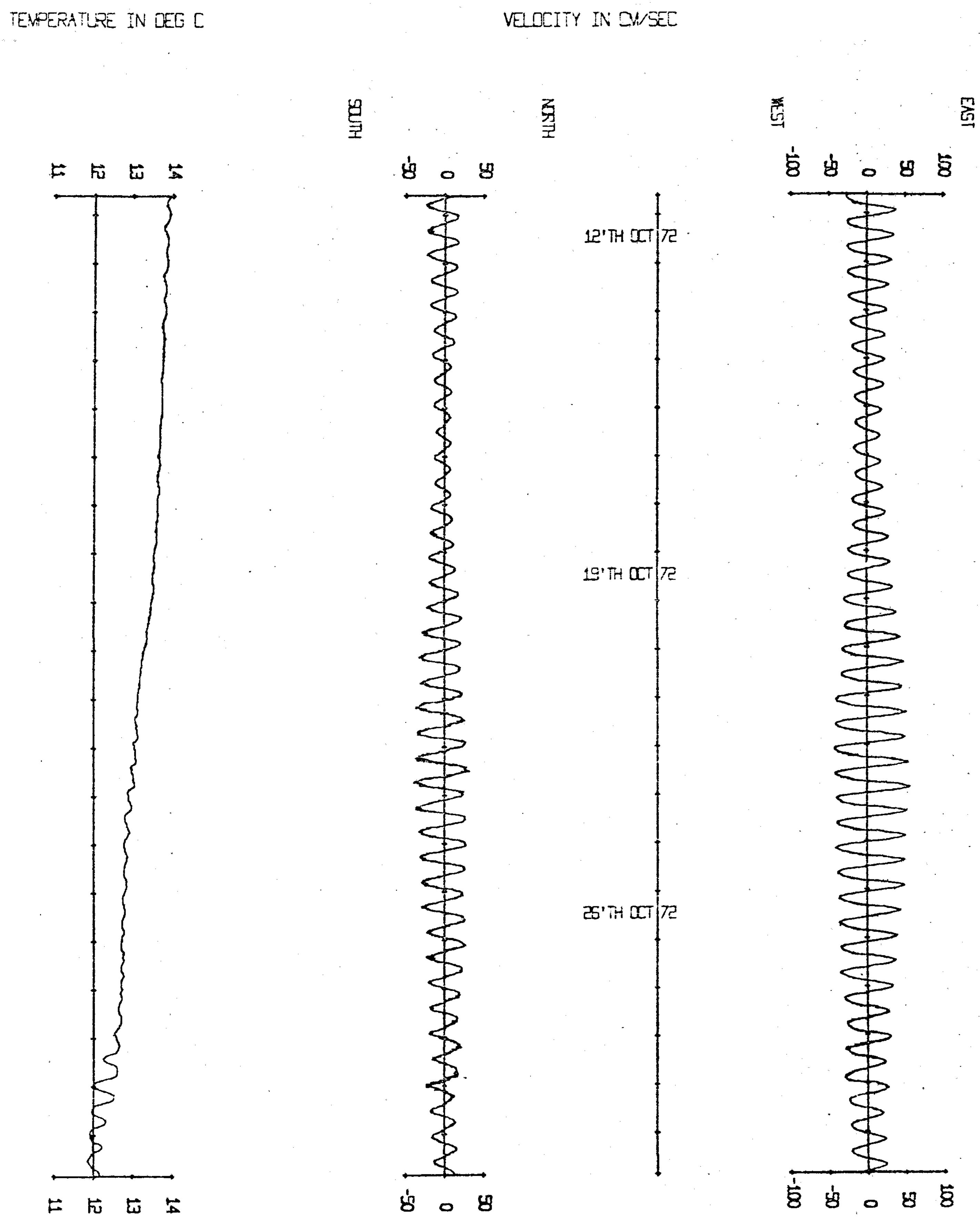


FIG B1. Typical example of resolved components of tidal flow.
Note: for the work outlined in these proposals the temperature time series above would be replaced by a current direction time-series.

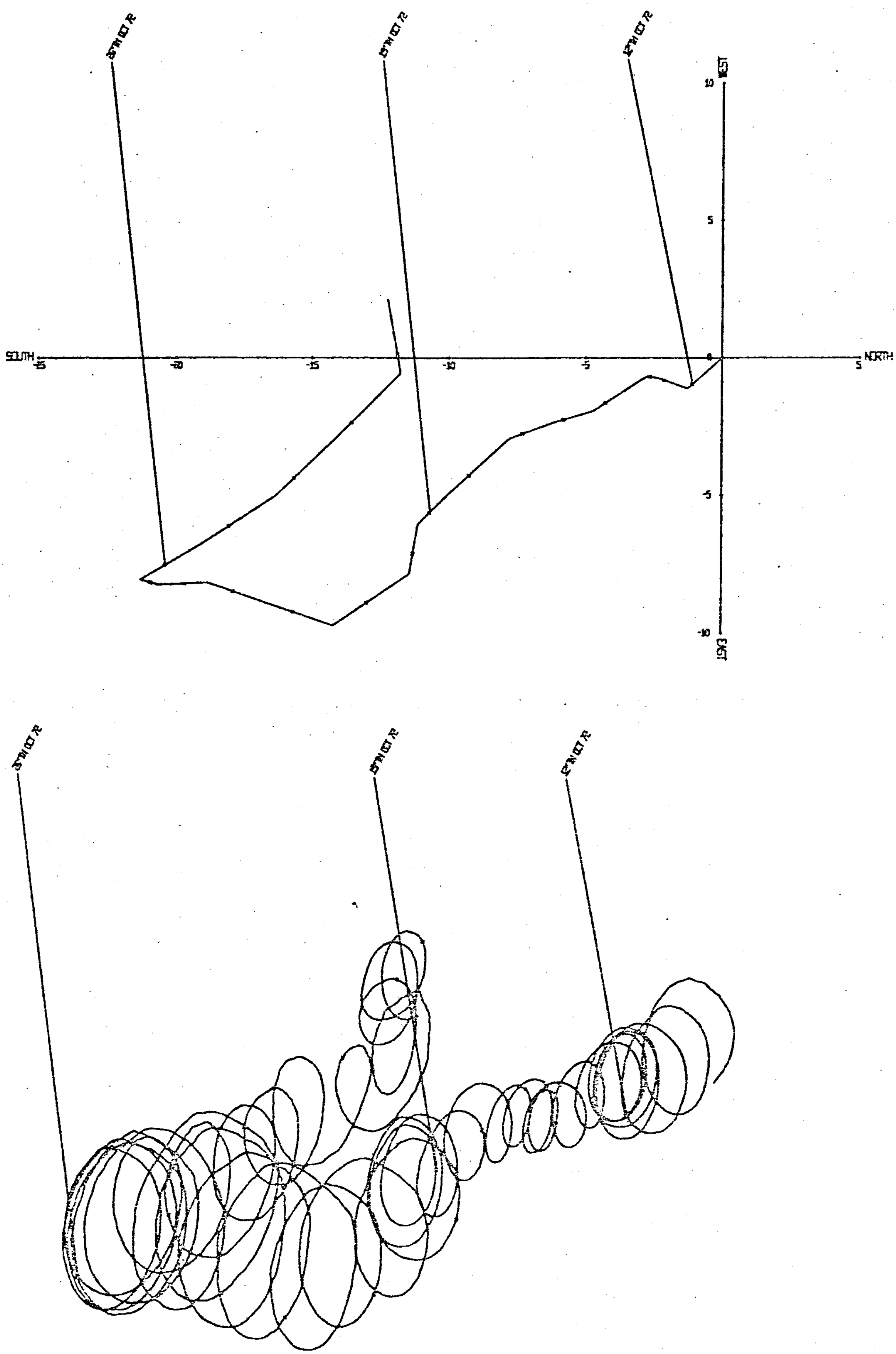


FIG B2. Typical examples of smoothed(top) and unsmoothed(bottom) progressive vector plots. Scales on axes are in kilometres.

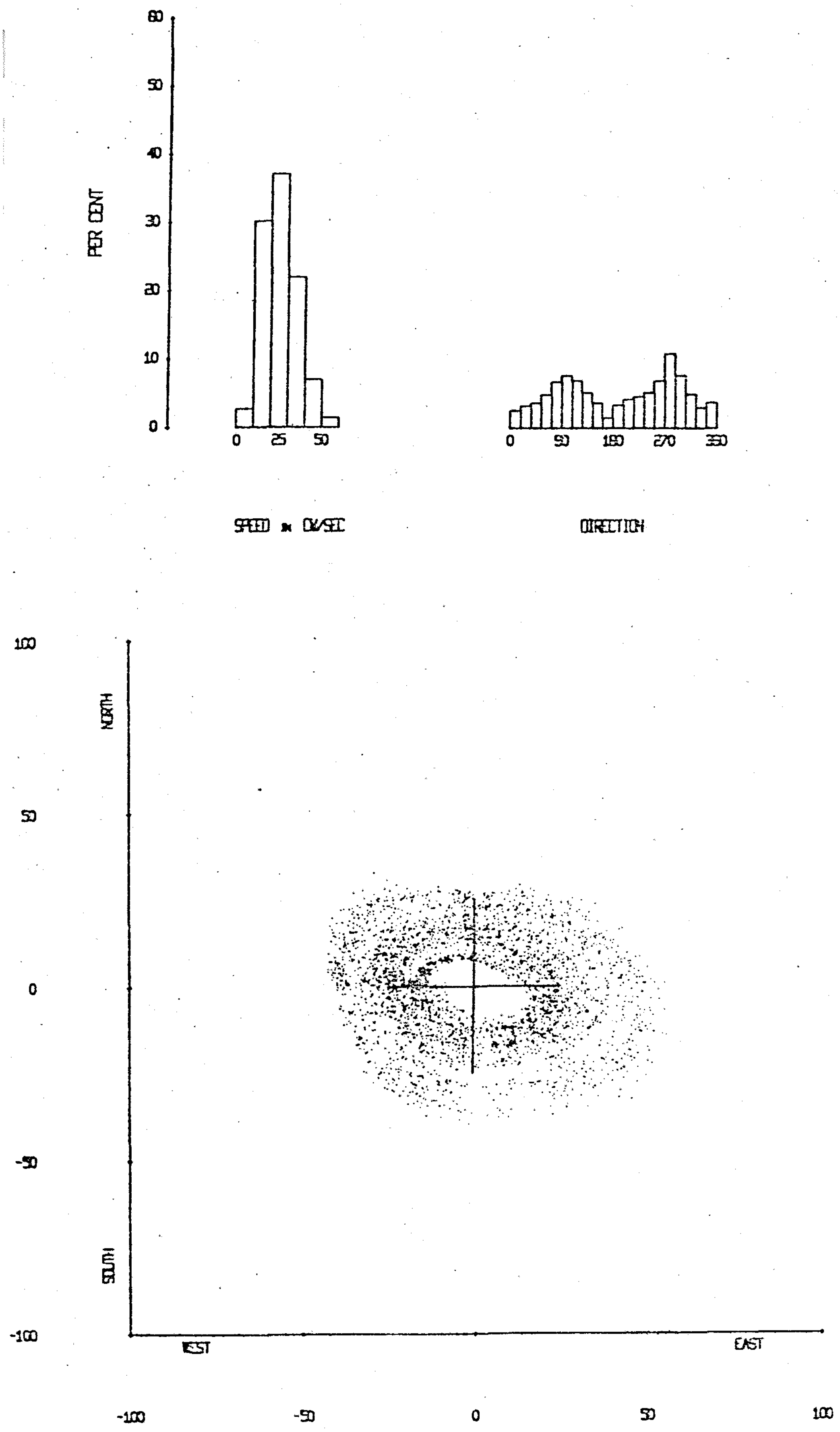


FIG B3. Typical examples of percentage frequency speed and direction histograms (top) and current speed and direction scatter plot (bottom). Scales on axes of scatter plot are in cm s^{-1}.