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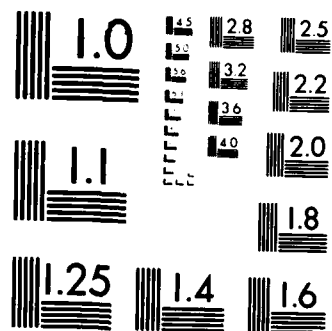
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NAVAL POSTGRADUATE SCHOOL

Monterey, California



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OBSERVATIONS OF THE
CALIFORNIA COUNTERCURRENT

by

Robert L. Harrod

June 1984

Thesis Advisors:

J. B. Wickham
S. P. Tucker

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. REPORT'S DATA NUMBER	
	AD A150781		
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED	
Observations of the California Countercurrent		Master's Thesis June 1984	
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)	
Robert L. Harrod			
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS	
Naval Postgraduate School Monterey, California 93943			
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE	
Naval Postgraduate School Monterey, California 93943		June 1984	
		13. NUMBER OF PAGES	
		147	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)	
		UNCLASSIFIED	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)		Accession For	
Approved for public release; distribution unlimited.		NTIS GRA&I ☒	
		DTIC TAB ☐	
		Unannounced ☐	
		Justification	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		By	
		Distribution/	
		Availability Codes	
18. SUPPLEMENTARY NOTES		Avail and/or Special	
		Dist	
		A-1	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)			
California Countercurrent, California Undercurrent, Davidson Current, California Current, Eastern boundary currents, metered currents.			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
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S/N 0102-LF-014-6601

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Observations of the
California Countercurrent

by

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Lieutenant Commander, United States Navy
B.S., Oregon State University, 1975

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

Results from moored current meters, 150 - 350 m, are discussed for a region over the continental slope off Cape San Martin, California from January 1979 to April 1980.

Current vector time series were constructed from the data and compared to a local upwelling index. Progressive vector diagrams of the data were also constructed, and spectrum analysis was performed for alongshore and cross-slope currents.

The California Countercurrent was found to be present in the study area during the entire period. Seasonally, the countercurrent was substantially stronger during the spring. Frequent current reversals and oscillations occurred between equatorward and poleward flow, less often at the nearshore station. Preferred low frequency energy peaks were found at periods of about 10 days. The intensity of the countercurrent increased with increasing coastal upwelling index, and the cross-slope flow also appeared to be related to the local coastal upwelling index.

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I. INTRODUCTION AND BACKGROUND

Eastern boundary currents are the subject of scientific investigation for a variety of reasons, particularly the impact of these currents on the fishing industry. Ryther (1969) concluded certain fishing grounds such as those off Peru, California, northwest and southwest Africa, Somalia, and the Arabian coast are so fertile, that they supply over half of the worlds fish harvest, yet constitute less than one percent of the oceans. These fishing grounds are invariably located close to shore, and their great fertility is due to frequent replenishment of near-surface nutrients from a few hundred meters deep in the open ocean offshore. The primary process for this is coastal upwelling, which in the Western Hemisphere is associated most markedly with the eastern boundary currents off North and South America. The economic need to understand these currents is made evident by the devastation of the coastal regions of Ecuador and Peru in 1982-1983 by the sudden influx of warm water termed El Niño. The socioeconomic effects included; flooding, landslides, destruction of transportation facilities, huge agricultural losses, disturbance of coastal fisheries, and loss of life (Halpern et al., 1983). This warm water influx takes place from

time-to-time, and recovery from a severe occurrence may take several years (Smith 1983).

Off the North American west coast, the eastern boundary flow regime is known as the California Current System. A comprehensive summary of the present knowledge of this system is given by Hickey (1978). The California Current System includes the southward flowing California Current, and a number of manifestations of a counter-flow: the California Undercurrent, the Davidson Current, and the Southern California Countercurrent. This system is part of the general circulation of the North Pacific Ocean which is dominated by an oceanwide, clockwise circulation known as the North Pacific Gyre. The eastern limb of the gyre is the California Current System, which extends along the North American continent from southern Canada to Mexico. The system includes both poleward and equatorward flows which vary on many time-scales. There are, for example, inter-annual variations such as El Niño, seasonal variations, and large variations with periods associated with weather systems. The California Current is a slow and broad equatorward surface flow, branching from the North Pacific Current, and marked by cold subarctic water type. The waters of the various countercurrents may be characterized by their admixture with water of equatorial origin which has relatively high levels of temperature, salinity and phosphate, and relatively low dissolved

oxygen. During the winter months a surface current with poleward flow occurs in nearshore regions off the west coast of the United States. This current, inshore of the California Current, is known as the Davidson Current and is ordinarily found north of Point Conception. The Davidson Current may be a surface manifestation of the California Undercurrent. The Southern California Countercurrent is the name applied to the poleward flow from San Diego to Point Conception; during winter months, this nearshore flow is sometimes continuous with the Davidson Current.

The study of eastern boundary currents is of both theoretical and practical interest. Dynamical models with features of observed eastern boundary currents have been developed since the turn of the century. Ekman (1905) described the effects of a steady wind blowing on an ocean, and stated the concepts now known as the Ekman spiral and the Ekman transport. Sverdrup, Johnson, and Fleming (1941) provided some understanding of the dynamics of the upwelling process. Munk (1950) computed the mass transports in a wind-driven ocean from the curl of the estimated wind stress.

Recent models include the two-dimensional and three-dimensional upwelling models, and sea breeze produced upwelling models reviewed by O'Brien (1977). These models considered the influences of horizontal boundaries, bottom topography, and the variability of wind stress on the

ocean. The first numerical model of coastal upwelling was constructed by O'Brien and Hurlburt (1972); this two-layer model successfully predicted the observed equatorward jet but failed to produce a poleward undercurrent. Sugimoto (1974) used a model with a straight coast and a bottom topography which did not vary in a coastwise direction. His model succeeded in developing a poleward flow in the lower layer. A later review of models is given by Allen (1980). These models permit inferences, such as the effects of shelf width and coastal winds, to be made about shelf-flow motions which have time scales like those of the atmospheric weather systems which drive them. Irregularities of the coastline and bottom topography force three-dimensional motions. However, there has been little theoretical work in this area until recently. An important conclusion from the models is that the currents arise from and are maintained by both local and remote atmospheric forcing. Significantly improved models of coastal upwelling include more realistic wind stress and finer resolution of bottom topography, especially the shelf break and steep bottom slopes.

Complementing models are field experiments which provide the basis for their motivation and verification. Two recent comparisons of models to field observations are Hickey (1980) and Janowitz (1980). Hickey used the two-dimensional, baroclinic, time-dependent model of

Hamilton (1978) and found it to be effective for time periods as long as fifteen days in predicting the displacement of isopycnals off the Oregon coast. Janowitz's comparison of a model of time-dependent quasi-geostrophic upwelling to moored meter data concluded tentatively that the model may have some validity, but further comparisons and verification should be undertaken.

Early observational studies of the California Current System emphasized relatively large-scale motions. Sverdrup and Fleming (1941) utilized T-S relationships to define the origins of water of two sorts (in northern hemispheric eastern boundary flows): northern water with increasing salinity as temperature decreases with depth and southern water with relatively constant salinity as temperature decreases. That the warmer water was a northward-flowing current was also demonstrated by Sverdrup and Fleming (1941) utilizing geostrophy; later, Reid, et al. (1958) showed that geo-strophic shear of the flow at the 200-dbar surface with respect to the 500 and the 1000-dbar surfaces indicates a northward flowing undercurrent. During the fifties and early sixties most Lagrangian current measurements were limited to drift bottle estimates of surface currents. One important exception was the tracking (for a few days) of deep drogues by Reid (1962), which also indicated a northward-flowing undercurrent off the central California coast. It is in the last decade that moored

current meters have provided a means to examine details of the flow over long time-periods. Moored current meters can be positioned to give direct measurements of the currents over extended periods (approximately two months for the Aanderaa meter, if a ten-minute sampling interval is used). Moored meters provide an excellent means for detailed local studies to elucidate better the properties, relationships, and interactions of the several portions of the California Current System. Studies of the California Current System during the 1960's using moored meters were primarily of the coastal waters off Oregon and Washington. While few current measurements have been made in the California Current and reliable wind stations are sparse, continuing studies off Washington and Oregon by Hickey (1979, 1980) and Huyer et al. (1979) show a significant relationship between local wind forcing and currents. Hickey stated that the seasonal variation of the nearshore region of strong flow appears to be related to the seasonal variation of the alongshore component of wind stress at the coast. Huyer et al. show that the transition from the predominantly northward surface currents of the winter oceanographic regime to the predominantly southward surface currents of the spring oceanographic regime over the Oregon continental shelf occurs within a period of several days during a strong southward wind event. Recent work for waters off the central region of the California

coast includes descriptive studies by Wickham (1975), Coddington (1979) and Dreves (1980). Wickham (1975) made salinity-temperature-depth (STD) sections, and parachute drogue observations off Monterey Bay. Wickham found the California Countercurrent to be present 15 km off the coast in August 1972 and in August 1973. Coddington (1979) compared direct current measurements from an array moored off Cape San Martin to indirect measurements from geostrophy. Coddington found the California Countercurrent to be present during the study period from November 1978 to February 1979. Dreves (1980) studied the relationship between local sea level gradient and alongshore flow for the same study period as Coddington. Dreves found that current and sea level gradient energy distributions were in close agreement, showing high energy concentration at the low frequency end of the spectrum.

The region of the central California coast off Cape San Martin (Figure 1) was chosen for study for several reasons: there is relatively little ship traffic or fishing and, consequently, less risk of current meter damage or loss; the bottom topography is relatively devoid of complications, consisting of an extremely narrow shelf, sharp shelf break, and depth contours approximately parallel to the coast; additionally, the close proximity of the study area to Monterey was a logistical convenience.

The current meter data used by Coddington and Dreves,

some six sets of current meter observations spanning six months from 25 July 1978 until 22 January 1979, have been augmented as part of the continuous monitoring of the countercurrent off Cape San Martin. An observational data base of direct current measurements of more than one year's duration now exists.

The objective of this study is to provide a preliminary analysis of current meter data for the period January 1979 to April 1980.

II. DIRECT CURRENT OBSERVATIONS

A. DATA COLLECTION

The data for this study were collected using Aanderaa Model RCM-4 recording current meters, which are self-recording and intended to be anchored in the ocean below the wind wave zone; they record current speed and direction and water temperature.

The meters were deployed off Cape San Martin, California, from August 1978 until July 1980 (see Figure 2). The station locations are shown in Figure 3. The present study covers the period from January 1979 to May 1980.

Coddington (1979) and Dreves (1980) have discussed data collected during the period from April 1978 to January 1979. Deployment of the arrays was accomplished with the Naval Postgraduate School's research vessel ACANIA. Each mooring of several meters was launched by being strung out behind the ship, the uppermost meter and flotation devices first and the anchor last. The array's descent was slowed by a small drogue about two meters in diameter attached to the anchor. An array of three meters was used at Station 2 ($35^{\circ} 52.16'N$, $121^{\circ} 33.76'W$) and four meters at Station 7 ($35^{\circ} 51.4'N$, $121^{\circ} 46.54'W$). They were arranged approximately as depicted in Figure 4. The anchor consisted of

one or two railroad wheels attached to an AMF-Seaflex Model 242 acoustic release. Benthos 17-inch glass spheres in plastic hard hats (55 pounds net buoyancy each) were used to provide wire tension, with two spheres directly above each current meter and six above the release. The entire array was moored below the region of strong surface wave action and was recovered by acoustically activating the release. Upon recovery the meters were returned to the laboratory for maintenance prior to subsequent redeployment.

B. DATA PROCESSING

The data were recorded on three-inch reels of 1/4-inch audio tape (Scotch Brand number 295) at ten-minute sampling intervals. Conversion of the data from the tapes recorded by the RCM-4 meters into a computer-acceptable format was accomplished with a Hewlett-Packard 9845 computer and an Andaria tape translator. The 1/4-inch tape was played back on a Wollensack audio deck and an oscilloscope was used to give a visual confirmation that data were present and of appropriate amplitude. The data were then translated from long and short to high and low voltage pulses and recorded on IBM-compatible 9-track tape on a Kennedy 9-track tape recorder. The Hewlett-Packard 9845 computer was also used to plot and print portions of the data.

Five different programs were used with the Naval Postgraduate School's IBM 360 computer in processing the data. They are listed in Appendix D. The initial program reads in the raw data from the 9-track magnetic tape, allows an initial look at the data if desired, and stores the data in mass storage for quicker, more efficient utilization. The second program applies temperature, speed, and direction calibrations to the data for each current meter. The third program reads in the calibrated output from program two, identifies missing records, and uses established cut-off parameters to suppress noise. Temperatures greater than 12°C , and less than 5°C are discarded, along with current speeds in excess of 100 cm-s^{-1} . Discarded and missing records are filled in by the following process: upon encountering a faulty value, searching continues until a value is found that meets the acceptance criteria. Linear interpolation is used to obtain fill-in values. Initial looks at the data revealed only minimal gaps in the records. Program three, by means of a binomial, converts the data record from ten-minute values to hourly values and then produces four plots. Currents are presented in the form of stickplots, and three other plots display U and V components of the current (respectively, eastward and northward for positive values), and temperature as functions of time. The fourth program reads in the output of program two, fills in missing and

faulty records, and then performs a spectrum analysis of the data. Its output consists of two plots of frequency versus power density for onshore and alongshore components of current. The fifth program uses the hourly records produced in program three to construct progressive vector plots. Two of the current meters used in the study were very noisy and gave unrealistically high indications of the speed. These noisy data are not shown here.

III. STUDY OBJECTIVES

The objective of this study is to provide a preliminary analysis of the current meter data. Questions to be considered are:

1. Do the data reveal seasonal variations of the flow?
2. Do the data reveal differences or similarities in the flow between Stations 2 and 7?
3. Are there indications of mesoscale events?
4. Are such mesoscale events coherent with respect to depth and/or position?
5. Is there a generalization about variation with depth that can be made?
6. How do the currents appear to be related to Bakun's coastal upwelling index (Bakun, 1980)?

IV. DESCRIPTION AND ORGANIZATION OF GRAPHICS

To highlight the salient features of the variations, and to examine them in the framework of Section III the data are presented in several ways. There are seven different graphical representations in Appendixes A, B, and C. These plots are:

1. Time series of Bakun's coastal upwelling index (Bakun, 1980).
2. Time series of current vectors.
3. Time series of eastward components of the current vectors.
4. Time series of northward components of the current vectors.
5. Time series of temperature.
6. Spectrum analyses of alongshore flow and on/offshore flow.
7. Progressive vector diagrams.

The plots are organized chronologically according to deployment date of the meters, beginning 5 January 1979 and ending in March 1980.

In Appendix A there are sets of time series. For example, Figure 8 and those like it contain time series of Bakun's coastal upwelling index (UI), and current series

(stickplots), in this case for the meters deployed on 5 January 1979 at Station 7, permitting visual comparison of one aspect of local forcing and the associated motions. The coastal upwelling indices are indicative of onshore-offshore Ekman transport, as estimated from wind stress at the position in the vicinity of Point Sur indicated in Figure 1. The procedure for calculating upwelling indices is presented in detail by Bakun (1973). The stickplots are graphical depictions of current speed and current direction. Time-scales are indicated along the top and bottom of Figure 5, and the units of measurement for the ordinates are shown on the left side of the figure. Pertinent information on the figures of this type include: station number, date of deployment, meter serial number, and depth of meter deployment.

Another type is represented by Figures 6 and 7. They depict U, V, and T for the two current meter records represented in Figure 8, where U (positive) is the eastward component of the current vector, V (positive) is the northward component of the current vector, and T is the temperature. Again, time scales and pertinent station information are given in the figure. The time series of these variables are complementary to the progressive vector diagrams found in Appendix C since they accentuate higher frequency events such as inertial and tidal oscillations.

The figures in Appendix B contain spectrum analyses of

alongshore flow and on offshore flow for each current meter. The abscissa (frequency) and the ordinate (power density function) are clearly labeled, and each figure also lists station number, meter serial number, meter deployment depth, and date of deployment. The spectrum analyses indicate regions of high energy in the frequency domain and suggest forces at work.

Appendix C contains the progressive vector diagrams (PVD). The vertical and horizontal scales are equal (kilometers), and true North is indicated. Crosses are positioned at 3-day intervals, and the letter "F" indicates the final plotted position. In addition to station number, meter number, meter depth, and period of computation, the mean speed and mean direction for the entire period are indicated. The PVD's depict well the low frequency variations, so-called "events", such as eddies.

Appendix D contains the listings of the computer programs used to process and plot the current meter data.

V. ANALYSIS

A. RELATION BETWEEN CURRENT AND LOCAL WIND FORCING

The coastal mountains of California tend to deflect the low level winds so that they blow equatorward parallel to the coast. Consequently, the average Ekman transport is offshore (Stewart 1967). In the simple Ekman model, the offshore flow lies generally above the level at which our current meters are moored. But there are strong vertical motions (up-and-downwelling) and other intense mesoscale exchange mechanisms in the area of study which negate the application of the simple Ekman model to observed cross-slope flow and suggest the possibility of a deeper "virtual" Ekman layer extending well into the pycnocline.

In this section qualitative relations between current and local wind forcing are examined through use of the time series of stickplots and upwelling index and also by referring to Figure 5. These relations will first be examined separately at each mooring station, and then for the time period July - August 1979, when current meters were deployed at both Station 2 and Station 7. Finally, seasonal and geographical variations will be considered.

1. Analysis at Station 2

The corresponding UI and current velocity for Station 2, the inshore station, are shown in Figure 11 for the period from 23 April to mid-June. There are event-scale (ca. one week) changes in current direction and speed that appear to be coherent with depth. The upwelling index is positive all during the months of May and June with nearly periodic episodes of great intensity. It is reasonable that there be upwelling in this period of strong positive upwelling index ($\overline{UI}=+138$). The mean cross slope flow ($\overline{V'}$) for this period (Table II) is small and positive, which indicates that the meters are below the Ekman layer. The poleward alongshore flow shown by the stickplots indicates the presence of a countercurrent at 169 and 241 m. Strong equatorward winds (positive UI) seem to correlate well with strong poleward flow of the countercurrent during this time period, especially at the level nearest the surface. Also, very large drops in the index are associated with a slightly lagging decrease in the poleward current speed, and increased variability in current direction during intervals centered on 21 May, 1 June, and 9 June (Figure 11).

Continuing at Station 2 in the period 21 July - 12 September 1979 (Figure 18), there is also an overall tendency for poleward flow associated with positive upwelling index especially at the level nearest the surface. The mean cross-slope flow (Table II) for this

period of strong upwelling index ($\overline{UI}=+125$) is noticed: if an extended Ekman layer is postulated, this cross-slope flow can be interpreted as lying within a layer which includes both meters. The magnitude of UI declines during the latter part of this period. On a shorter time-scale (about 9 days) the rise and fall of the upwelling index is accompanied throughout the record, beginning about 10 August, by poleward currents during periods of high upwelling index, and equatorward or diminished poleward currents during periods of reduced upwelling index. Thus, decreases in the upwelling index clearly relate to decreases in, or disappearance of, the counter current on these time scales (ca. 9 days), especially at the greater depth, 237 m.

In the following period, 24 November 1979 through 18 January 1980, as shown in Figure 24, the upwelling index is further reduced ($\overline{UI}=-20$), becoming dominantly negative after mid December. The meter at 194 m (Figure 24) is suspect due to lack of direction changes. This could be the result of a stuck vane, or a malfunction in the sensor. The alongshore current at depth 266 m alternates between poleward and equatorward flows with durations between three and ten days. There is a marked change in currents after 23 December; they become weak and variable following a strong surge in the downwelling index at that time.

1. Analysis at Station 7

First consider the winter period January - February 1979, illustrated in Figure 8. The mean flow at both levels (152 m and 223 m) is predominantly poleward; but there are important event-scale variations. There are also alternating periods of positive and negative upwelling index during this period. The significant current variations and the upwelling index changes do not seem correlated. For example, from 5 to 10 January 1979 the currents at both depths were toward the southwest and during the next 15 to 17 days rotated clockwise. While the upwelling index varied erratically about zero, a similar rotation of the currents and unrelated variation of the upwelling index continued until about mid-February, when predominantly poleward flow again resumed, and the currents flowed in this direction for the remainder of the record, approximately twelve days. A fair conclusion for this period, when wind forcing is inconsistent and weak, is that there is no simple relation between the local upwelling index and the observed behavior of the currents on time scales of tens of days, and that some other mechanism than local forcing is involved.

During July and August 1979 (Figure 14), the index is positive and the flow at Station 7, is also predominately poleward at 158, 231, and 356 m, especially in July. Large events involving reversals in the currents can be seen on

about 7 August and 24 August at all three observed levels. These events appear to occur at all depths almost simultaneously, which suggests that they are not directly related to the local wind.

During October and November 1979 (Figure 21) there is again a period of generally weak upwelling index when that index has no obvious relation to the currents. These currents were equatorward from 12 until to 30 October, followed by a reversal to become poleward from 1 through 21 November while the upwelling index again varied erratically near zero.

During the period 3 March through 12 April 1980 (Figure 27) poleward and equatorward flow alternate until about mid-March, while the upwelling index remains low. Following a rise in the upwelling index at that time (mid-March) and its persistence at high levels for nearly three weeks, predominantly poleward flow begins and persists for the remainder of the recorded period, some three weeks.

The meter at 113 m (Figure 27) is suspect due to lack of direction changes and small magnitude, and its data will be ignored.

3. Comparison of Stations 2 and 7

Current meter arrays were deployed at both Stations 2 and 7 during the period from 21 July to the end of August, providing an opportunity for examining horizontal

variations. As mentioned above, the currents at Station 2 (depicted in Figure 18) appear to respond with little or no lag to local forcing for this entire period. The response of the currents to local winds is not so clear at Station 7 (Figure 14). The currents at Station 7 may respond differently to local winds than currents at Station 2 because of the increased distance from the controlling boundary (coast). It is also possible that the response of the currents at Station 7 to local forcing may be masked by other influences. Certainly, there is no longer a nearly in-phase response of the current (note, for example, that on 27 August flow at Station 2 is predominantly poleward while flow at Station 7 is predominantly equatorward). If flow at Station 7 is being driven by local winds, the response must lag the wind.

Seasonally, the countercurrent was strongest during the spring months of 1979 at Station 2 (Figure 11). Geographically, the major discernable difference is the closer correlation between the current and the local forcing at Station 2 (inshore) than at Station 7 (offshore).

In summary, there are four important conclusions to the analysis of the currents and their relation to the upwelling index:

1. The entire record from January 1979 to April 1980 indicates currents are predominantly poleward at both stations, especially while Bakun's coastal upwelling index is high and positive.

2. Throughout the period, many events with time scales of tens of days occur at all recorded depths.

3. Current response to local forcing is more apparent at Station 2.

4. The countercurrent runs most strongly during the periods of high upwelling index at the nearshore station (Station 2).

B. SPECTRUM ANALYSIS

The current meter data are subjected to spectrum analysis in order to identify regions of high energy in the frequency domain, and consequently suggest forces at work in the study area.

The information from spectrum analysis, in this case via a program using Fast Fourier Transform (FFT), depends upon the record length and the sampling interval. The parameters used in the spectrum analysis program are:

Record length	= $TR = 1024 \text{ h}$
Sampling interval	= $\Delta t = 1 \text{ h}$
No. of points per record	= $N = 1024$
Resolution	= $\Delta f = .0098 \text{ h}^{-1}$
Nyquist frequency	= $f_N = .5 \text{ h}^{-1}$
No. of frequencies resolved	= $M = f_N / \Delta f = 512$
No. of degrees of freedom	= $N/M = 2$

The records available are typically about 50 days (1200 h) long; the maximum resolution attainable by FFT is, therefore, obtained from data sets of length 1024 hours.

For a fixed record length, however, high resolution is paid for at the expense of stability. The resolution with no averaging of spectral estimates over frequency is $\Delta f = 1024^{-1} \text{ h}^{-1}$; and for single spectra (with no ensemble averaging) the estimates of variance have only two degrees of freedom (and are thus uncertain indicators of the variance distribution).

For time series defined at equal time-intervals Δt , the highest frequency component discernable is given by $N_f = (2\Delta t)^{-1}$, the "Nyquist frequency". The variance of frequencies higher than this are attributed, spuriously, to lower frequencies. Such misread ("aliased") variance is thought to be of minor concern in the data sets of this study except for those few (discarded) with high frequency instrumental noise. Among forces known to be at work in the ocean which are likely to contribute to energetic currents are tidal and (possibly) inertial forces. Some of the most important components are the semi-diurnal tide-producing forces (Sverdrup, et al., 1942):

Name	Symbol	Period(h)	Frequency(h^{-1})
Principal lunar	M_2	12.42	.0805
Principal solar	S_2	12.00	.0833
Luni-solar	K_2	11.97	.0835

The inertial frequency and period, calculated with the average latitude (35.8°) of Station 2 and Station 7, are $f(i) = .0487 \text{ h}^{-1}$, and $T(i) = 20.5 \text{ h}$.

The spectral estimates consistently indicate energetic components at tidal and inertial frequencies as well as at periods of approximately 10 days. The dominant tidal components present are the semi-diurnal, with the most significant peaks appearing to be the luni-solar. In Table I are shown the approximate values of the low frequency, inertial, and semi-diurnal tidal peaks for both alongshore, and onshore/offshore motion. These values in Table I are taken from the spectrum analysis plots to show what, if any, relation there is between high energy and depth, season, and proximity of the shore. In general the spectra indicate greater energy for tidal, inertial, and low frequencies at the upper meters. It appears that motions at these frequencies are also more energetic in winter than in summer. Finally, tidal and low frequency energy are greater near shore, while energy in the inertial frequency is greater offshore.

C. INFERENCES FROM PROGRESSIVE VECTOR DIAGRAMS

The PVD's are helpful in observing low frequency variations and the mean currents which are summarized in Table II. As a meander, eddy, or wave in the countercurrent moves through a stations position the boundary between the poleward flow and equatorward flow moves about, with the current meters alternating between either side of that boundary. Such an occurrence is reflected in the PVD's as a current reversal.

TABLE I

COMPARISON OF HIGH ENERGY PEAKS (1000 CM. SQ. HOUR)

STATION	START DATE	DEPTH	LOW FREQ. (10 DAY)		INERTIAL		S.D. TIDAL	
			ALONG SHORE	ON/OFF SHORE	ALONG SHORE	ON/OFF SHORE	ALONG SHORE	ON/OFF SHORE
2	23 APR 79	169	5.3	0.5	1.0	0.5	8.0	6.5
		241	4.0	SMALL	1.0	0.5	11.0	5.0
2	21 JUL 79	165	17.0	0.5	1.0	0.3	3.0	1.7
		237	8.0	0.5	SMALL	0.2	3.0	1.2
2	24 NOV 79	194*	0.3	0.5	SMALL	SMALL	SMALL	0.1
		266	45.0	1.0	SMALL	1.0	11.0	17.0
7	5 JAN 79	152	6.8	7.0	1.8	2.3	1.8	2.0
		223	1.5	5.4	0.6	0.5	1.4	0.8
7	7 JUL 79	158	2.6	17.0	0.2	SMALL	1.6	2.0
		231	2.0	5.1	0.4	SMALL	1.3	1.8
		356	0.8	1.0	0.9	0.7	0.5	0.6
7	7 OCT 79	127	1.0	1.6	4.5	3.4	3.7	3.8
		200	1.3	1.1	2.0	2.3	3.0	2.6
7	3 MAR 80	113*	0.2	0.1	0.1	0.1	0.3	0.1
		186	1.8	1.1	1.4	1.5	2.6	2.0
		311	0.9	0.2	1.8	1.8	5.0	1.2

S.D. = Semi-Diurnal

* = Meter is suspect

TABLE II
COMPARISON OF MEAN CURRENT AND TEMPERATURE

STATION	TIME PERIOD	DEPTH	$\bar{\theta}$ (azim. °T)	$\bar{V}$ (cm/sec)	$\bar{T}$ (° cent.)	$\bar{V}'$ (cm/sec)	$\bar{U}'$ (cm/sec)
2	23 APR 79	169	341.2	16.0	8.5	+16.0	+ 0.34
	thru 16 JUN 79	241	340.4	11.1	8.0	+11.1	+ 0.08
2	21 JUL 79	165	325.1	6.1	9.0	+ 5.89	- 1.57
	thru 13 SEP 79	237	314.3	1.5	8.5	+ 1.35	- 0.65
2	24 NOV 79	194*	279.8	6.2	9.0	+ 3.08	- 5.38
	thru 18 JAN 80	266	003.1	2.7	8.0	+ 2.48	+ 1.06
7	9 JAN 79	152	354.8	4.6	9.4	+ 4.58	+ 0.39
	thru 28 FEB 79	223	16.6	4.3	8.6	+ 3.84	+ 1.93
7	9 JUL 79	158	312.2	4.5	8.7	+ 3.56	- 2.76
	thru 30 AUG 79	231	330.6	5.8	8.3	+ 5.47	- 1.93
		356	338.6	2.8	7.4	+ 2.74	- 0.55
7	9 OCT 79	127	68.1	5.1	9.3	+ 1.05	+ 4.99
	thru 29 NOV 79	200	70.6	4.1	8.4	+ 0.67	+ 4.05
7	4 MAR 80	113*	310.5	4.4	9.0	+ 3.40	- 2.80
	thru 15 APR 80	186	328.7	3.4	8.0	+ 3.17	- 1.24
		311	8.2	2.7	7.0	+ 2.56	+ 0.84

$\bar{U}'$ = Mean cross-slope current

$\bar{V}'$ = Mean alongshore current

* = Meter is suspect

Two interesting features readily seen in the progressive vector diagrams Figures 47 through 52, are current reversals of long duration, and the mean current for the duration of the mooring. The mean current direction (θ), given as azimuth, speed (V), cm-s^{-1} , and temperature (T), degrees Celsius, for each current meter for the entire study period are shown in Table III; and they are also shown on the individual plots. Also shown in Table II are the mean onshore and alongshore current components respectively. The alongshore direction in this case is defined as 340° T for Station 2, and 350° T for Station 7, which represent the azimuths of the mean contours at those sites.

For both Stations 2 and 7 over the entire period, the seasonal and depth variations will be considered. The mean alongshore current is always poleward at all observed levels (from 127 m to 356 m) and at both stations. Mean alongshore current speeds were greater nearshore at Station 2, than offshore at Station 7. Mean alongshore current speed at the upper levels appears to vary only slightly seasonally at both stations, approximately 4 to 6 cm-s^{-1} , with the exception of the upper meter at Station 2, 23 April to mid-June, i.e., the counter current appears weak at observed depths, except in late spring.

The PVD's indicate predominantly unidirectional flow at the near-surface levels of Station 2, while at the deeper,

lower meters there were often current reversals and oscillations possibly associated with meanders, waves, and eddies. Current reversals occurred in greater numbers and were present at all depths at Station 7 which may possibly be due to Station 7 being near a boundary between north and south currents. The semidiurnal components of the currents are at times apparent in the PVD's as for example in Figures 49 and 57.

Shorter term variations are also indicated by the PVD's, in particular reversals. No apparent current reversals are present at the upper meter of Station 2, 24 April to mid-June (Figure 49), and only two minor reversals can be seen near the end of the record for the lower meter (Figure 50). At the same station from 23 July to mid-September, two current reversals of short duration are evident at the upper layer (Figure 54); and more than half a dozen current reversals of from three to twelve days in duration can be seen for the current at greater depth (Figure 55). Current reversals are not present at the upper level of Station 2 (Figure 58), 27 November 1979 to mid-January 1980, but several current reversals of approximately three to nine days duration can be seen at depth (Figure 59).

A single current reversal is present at both meters of Station 7 (Figures 47 and 48), 9 January to the end of February 1979. At the same station, 9 July to the end of

August 1979, three current reversals are apparent at the upper two meters (Figures 51 and 52), and two reversals can be seen in the lower meter (Figure 53). These reversals all appear to be of a relatively long duration, 15 to 20 d. Two current reversals are present at both meters of Station 7 (Figures 56 and 57), 9 October to 29 November 1979. For the period 4 March to 15 April 1980 at the same station, no reversals are seen in the upper meter (Figure 60), but several oscillations and reversals are seen in the two lower meters (Figures 61 and 62).

D. CROSS-SLOPE CURRENT

The mean cross-slope currents from Table II are plotted against time in Figure 5. The dominant feature of these currents is an annual variation with onshore flow in winter months and offshore in spring and summer. This annual variation correlates with the strong upwelling occurring in the spring and summer, and the weak upwelling index in the winter.

Qualitatively, the relation between the upwelling index and the cross-slope current means is consistent with a thick layer influenced by a modified surface Ekman regime.

E. TIME SERIES

The time series plots of U (positive-east) and V (positive-north) components were primarily used as an aid in interpreting the stickplot data. They are also useful for their resolution of high frequency variations. The

semidiurnal components of the currents are evident as well as the larger scale current oscillations indicated in the stickplots.

The temperature versus time plots also indicate the semidiurnal components and large-scale oscillations found in the stickplots. Approximate mean temperatures for the current meters at Station 2 and 7 throughout the record are shown in Table II. The temperature decreased with depth at all stations. The mean temperatures at Station 2 at all depths (Figure 6) become increasingly warmer during the period from April 1979 to January 1980, while the mean temperatures at Station 7 at all depths (Figure 7) become increasingly cooler. This is consistent with existing wind stresses, which would tend to uplift the isotherms at the nearshore station (Station 2) in the spring (strong upwelling index) and depress them in winter (weak upwelling index). The cooling continues at Station 7 at all depths from December 1979 until April 1980, and no simple explanation is apparent.

IV. CONCLUSIONS

A northward flowing current was found for the entire period of this study. It was strongest at the upper levels, roughly between 100 and 200 m. Seasonally, this countercurrent was strong during spring and substantially weaker during winter. The speed and direction of the countercurrent at any given time may differ markedly from the average flow. There were events on scales of tens of days which appeared to be qualitatively coherent between stations and also between depths at a given station. Frequent current reversals and oscillations occurred, consistent with the weak, poorly defined, broad flows associated with eastern boundary currents.

Bakun's coastal upwelling index is an indicator of possible wind-driven coastal upwelling. The coastal upwelling index is, in the mean, consistent with the observations of a deep cross-slope flow (Ekman layer), a large upwelling index corresponding to thickening of the Ekman layer. The countercurrent is present during the entire study, and the low frequency alongshore current is never equatorward.

Relatively high-energy peaks at semidiurnal tidal frequencies and inertial frequencies occurred in the

majority of the current records. Additionally, low frequency energy peaks were found at periods of about 10 d.

At Station 2, (nearshore), the alongshore component of these three frequencies tends to be greater than the on/offshore component, and generally speaking, the low frequency energy peak ($T = 10$ d) is dominant. At Station 7 (offshore), the on/offshore component of these three frequencies is noticeably greater, but there is no obvious pattern to the energy distribution.

The countercurrent was present at the study site, but it was not possible to unequivocally identify and correlate local forcing with the countercurrent. The vertical migration of the frontal boundary between equatorward and poleward flow was observed at both stations, but less often at the nearshore Station 2 than at Station 7. Hydrographic data from the study area for this time period were not examined at all, and deserve future consideration. Correlation of currents and wind or upwelling index, comparison of observed currents with predictions of various models, and the relation of metered currents to those inferred from hydrographic data are recommended for future studies.

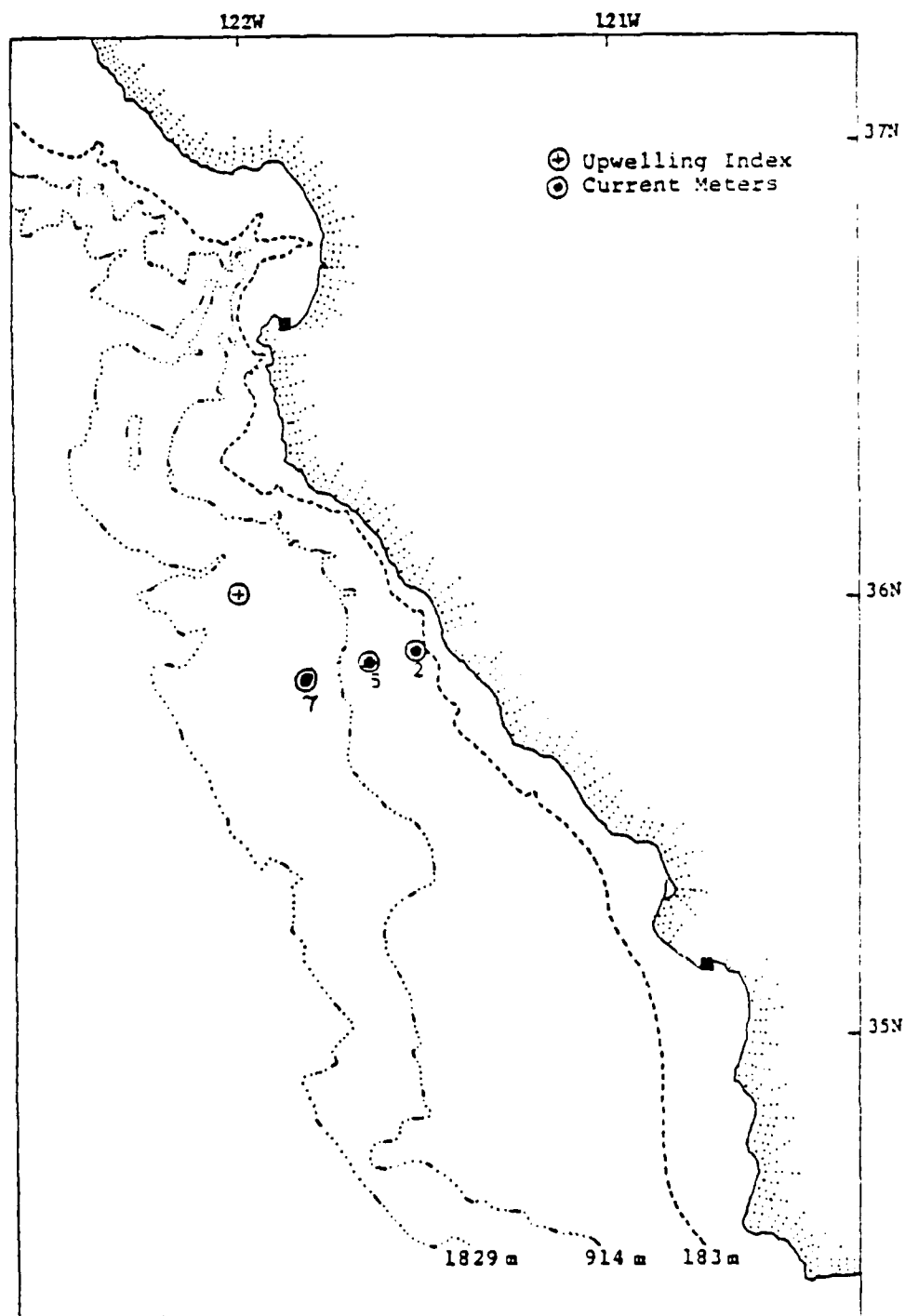


Figure 1. The study area.

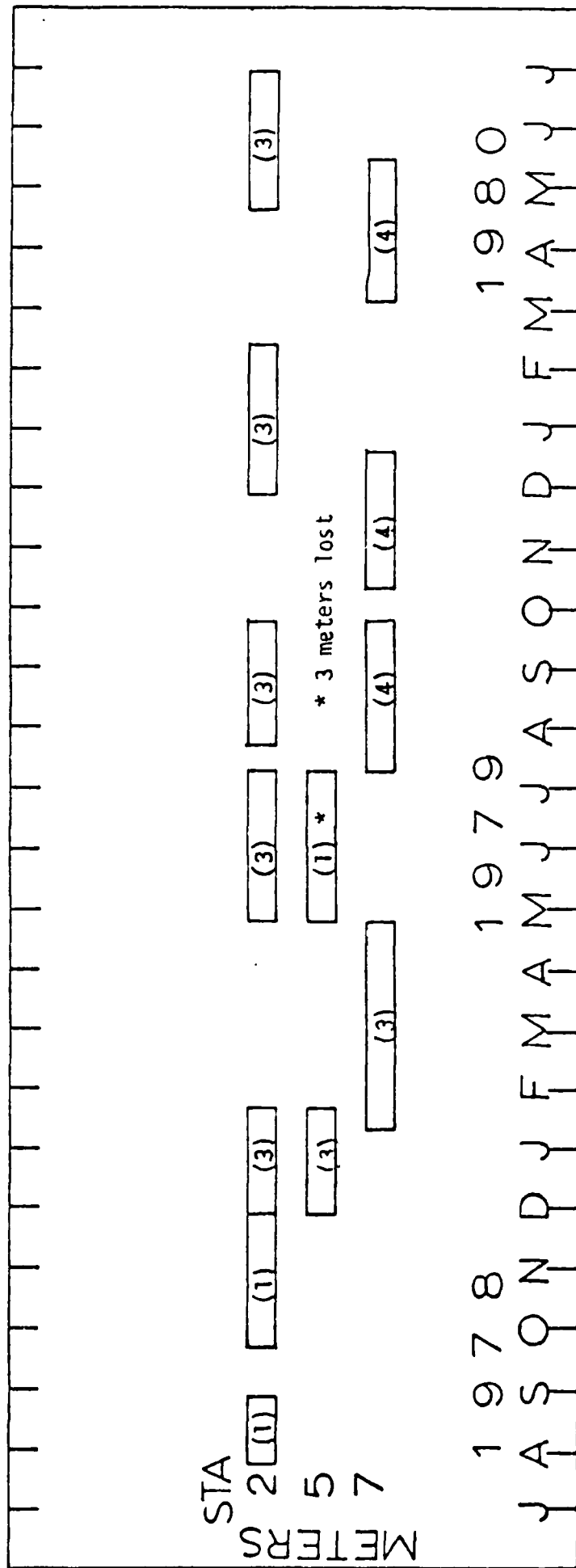


Figure 2. Chronology of current meter deployment.

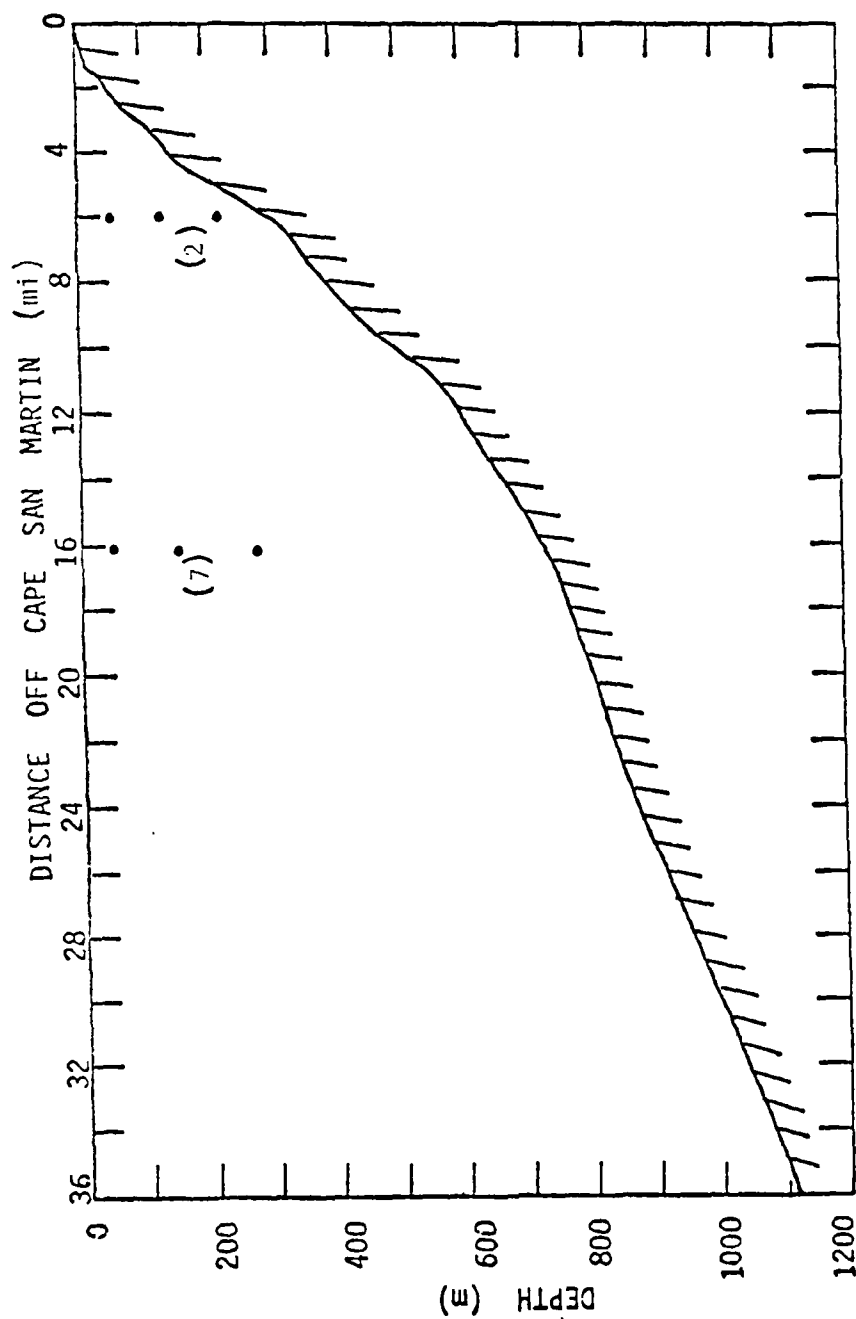


Figure 3. Vertical section showing representative locations of current meters off Cape San Martin, California.

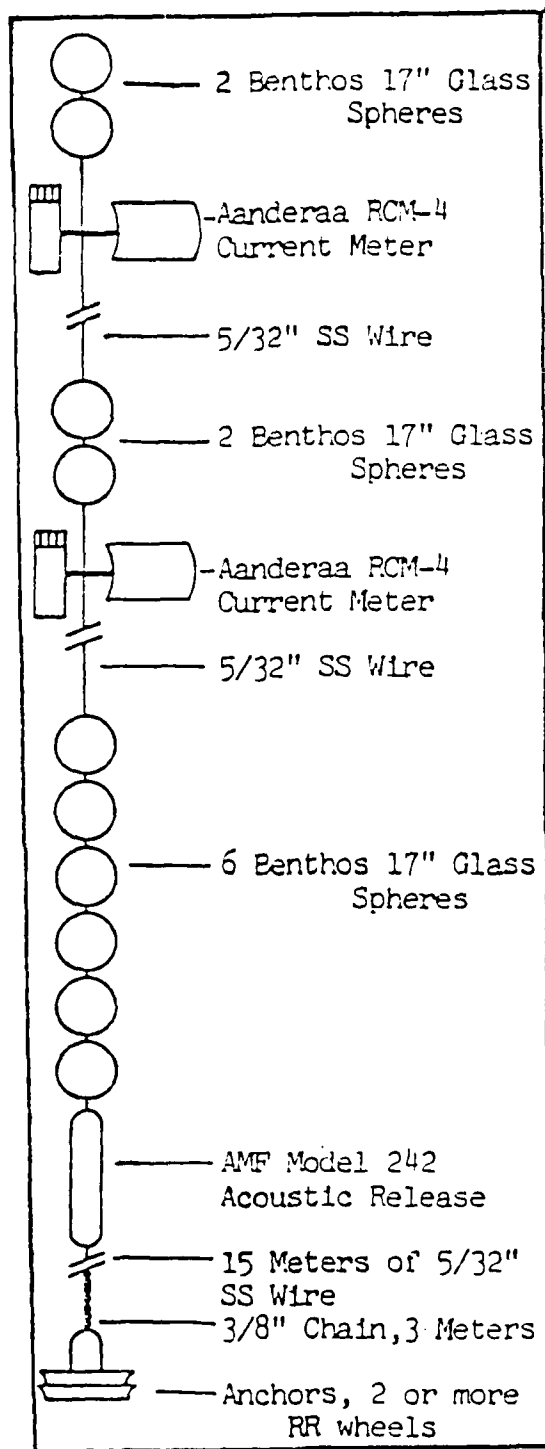


Figure 4. Current meter array.

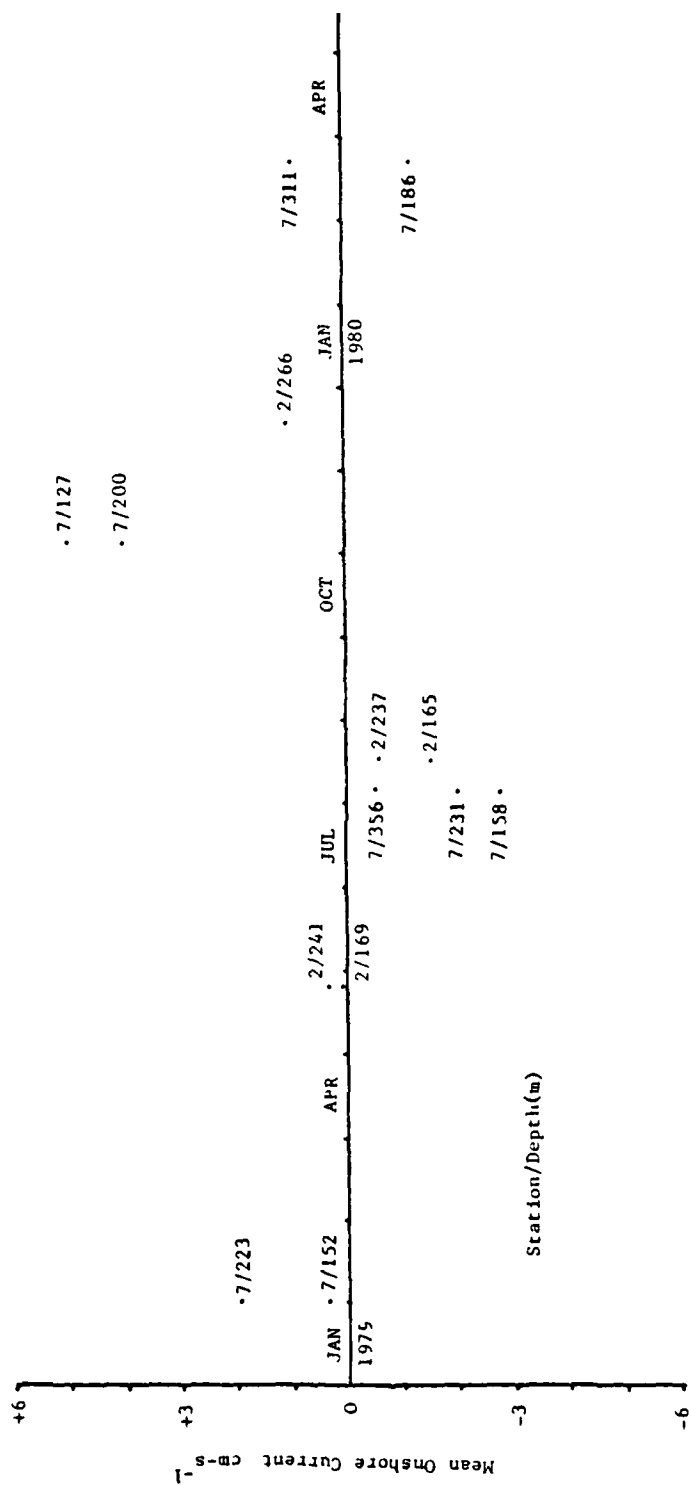


Figure 5. Mean onshore currents.

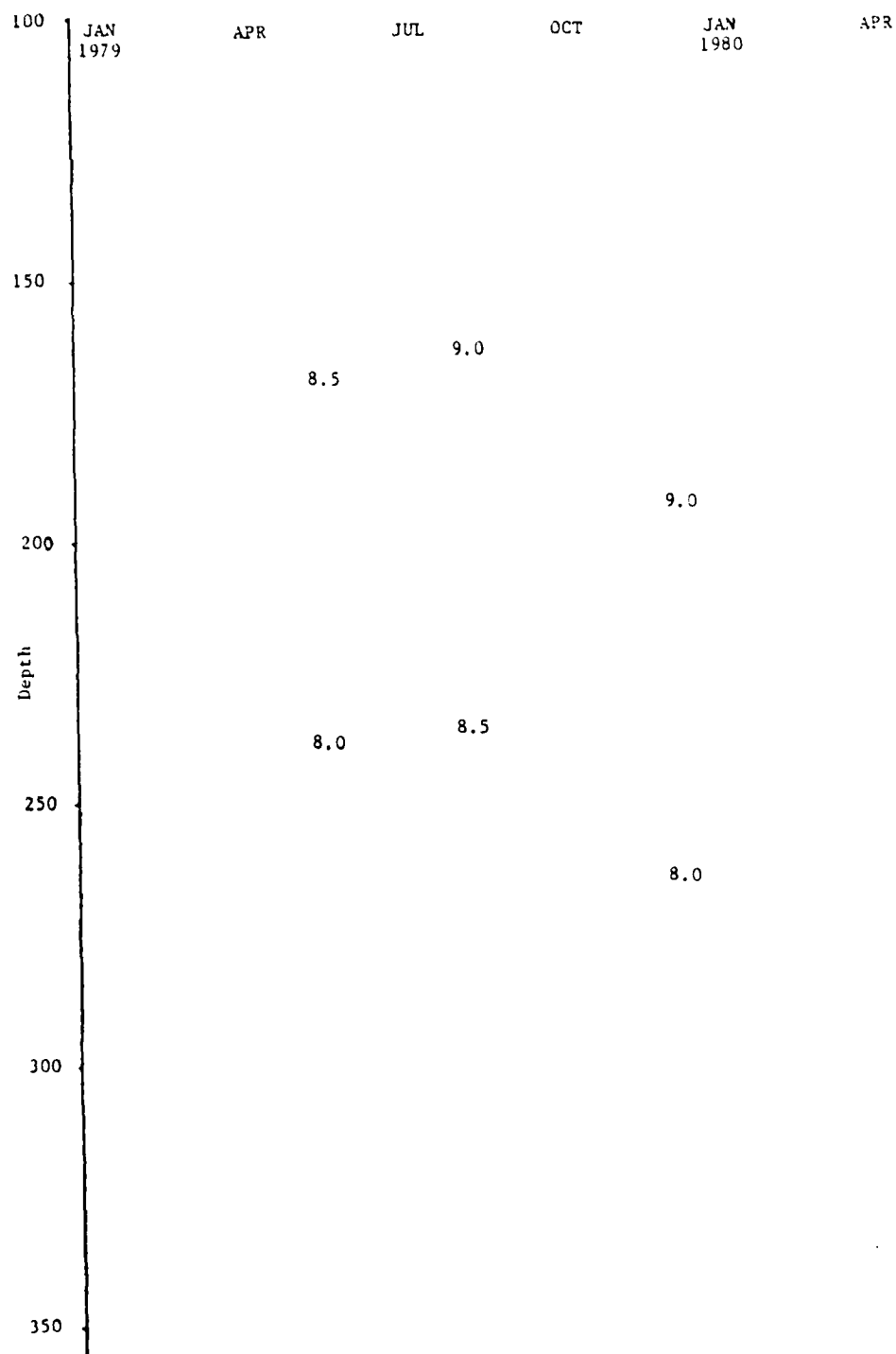


Figure 6. Mean temperatures at Station 2.

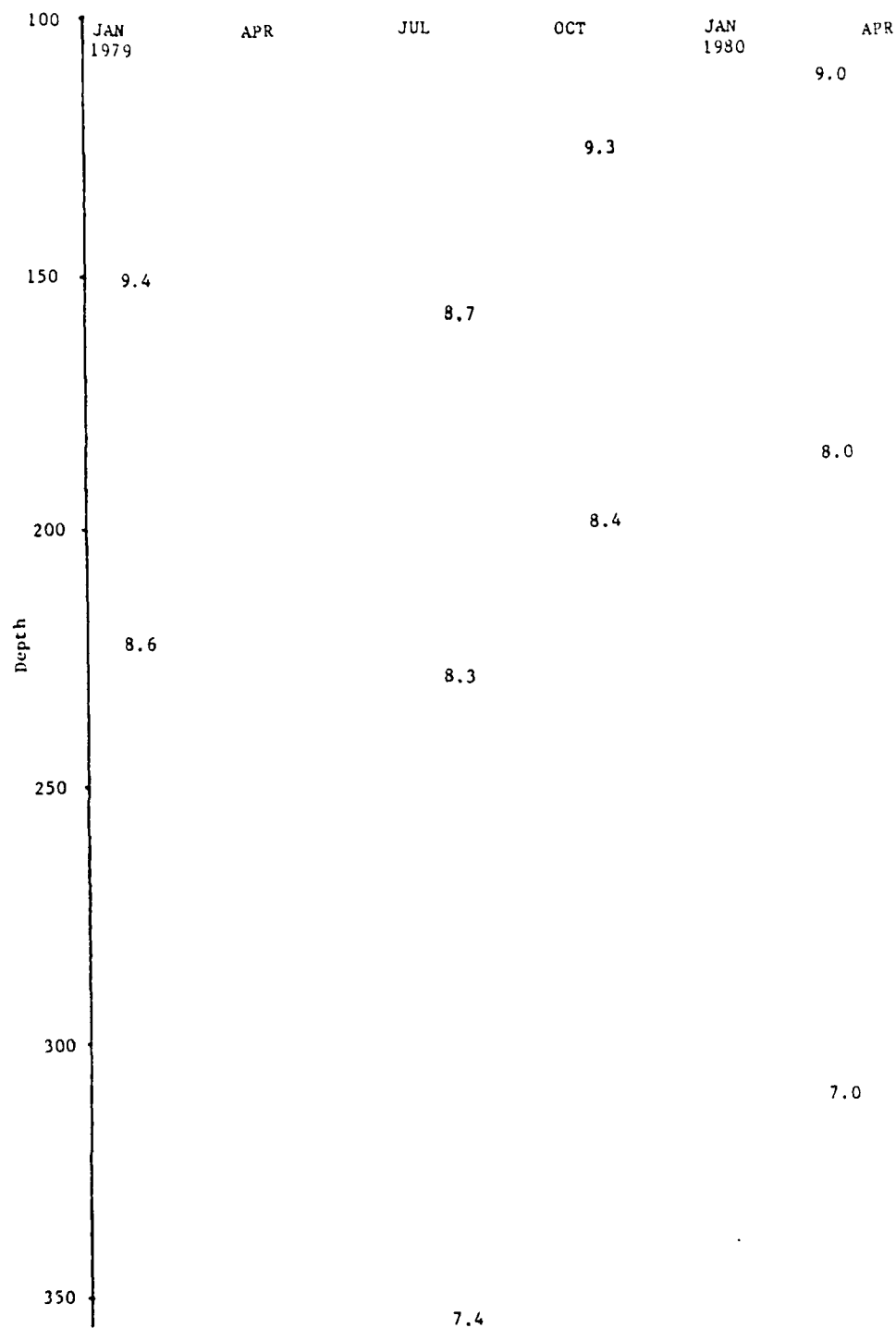


Figure 7. Mean temperatures at Station 7.

APPENDIX A: TIME SERIES PLOTS

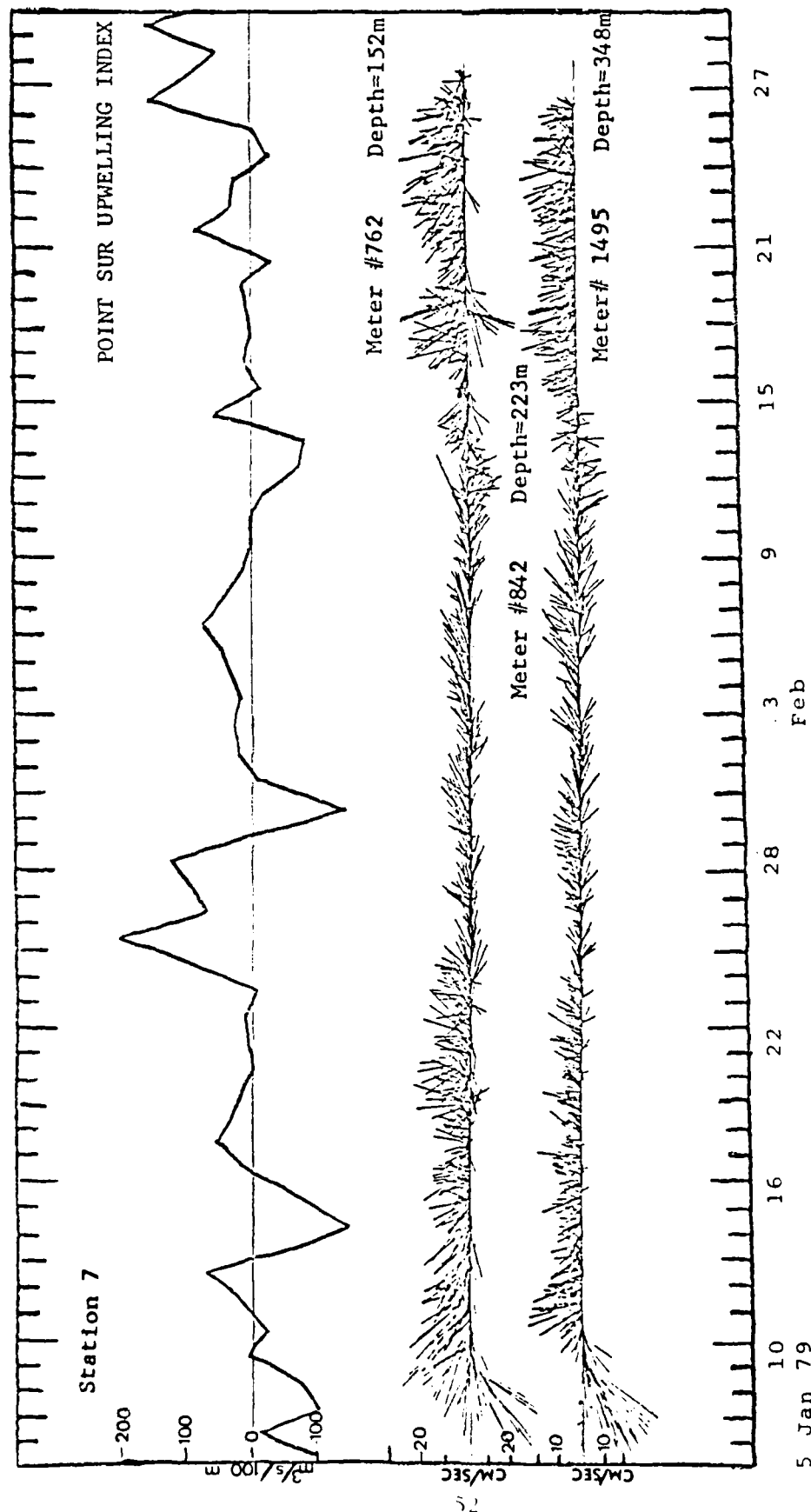


Figure 8. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 7 deployed on 5 January 1979.

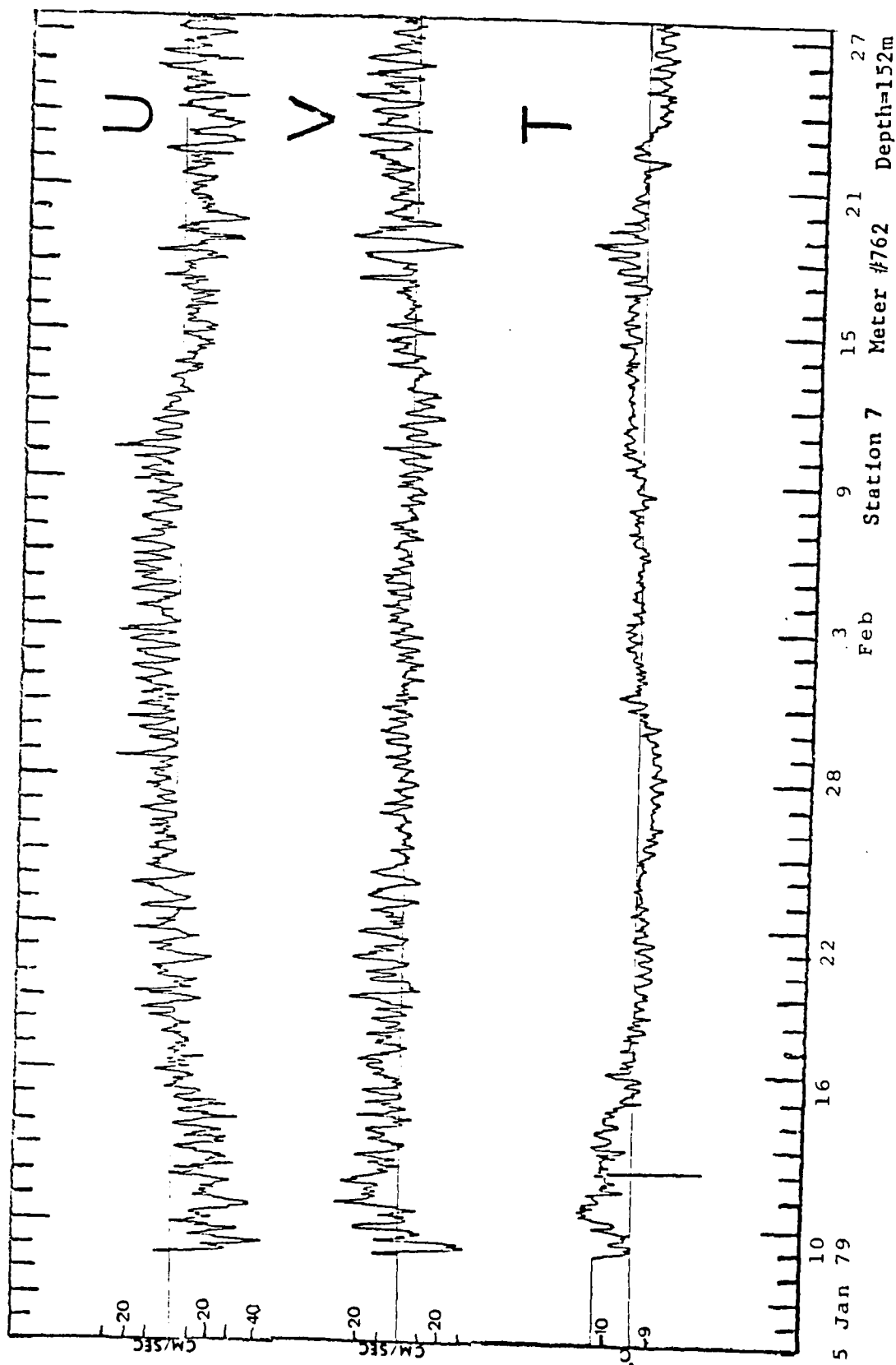


Figure 9. U component, V component, and temperature plots versus time for the current meter at 152 m depth at Station 7 deployed on 5 January 1979.

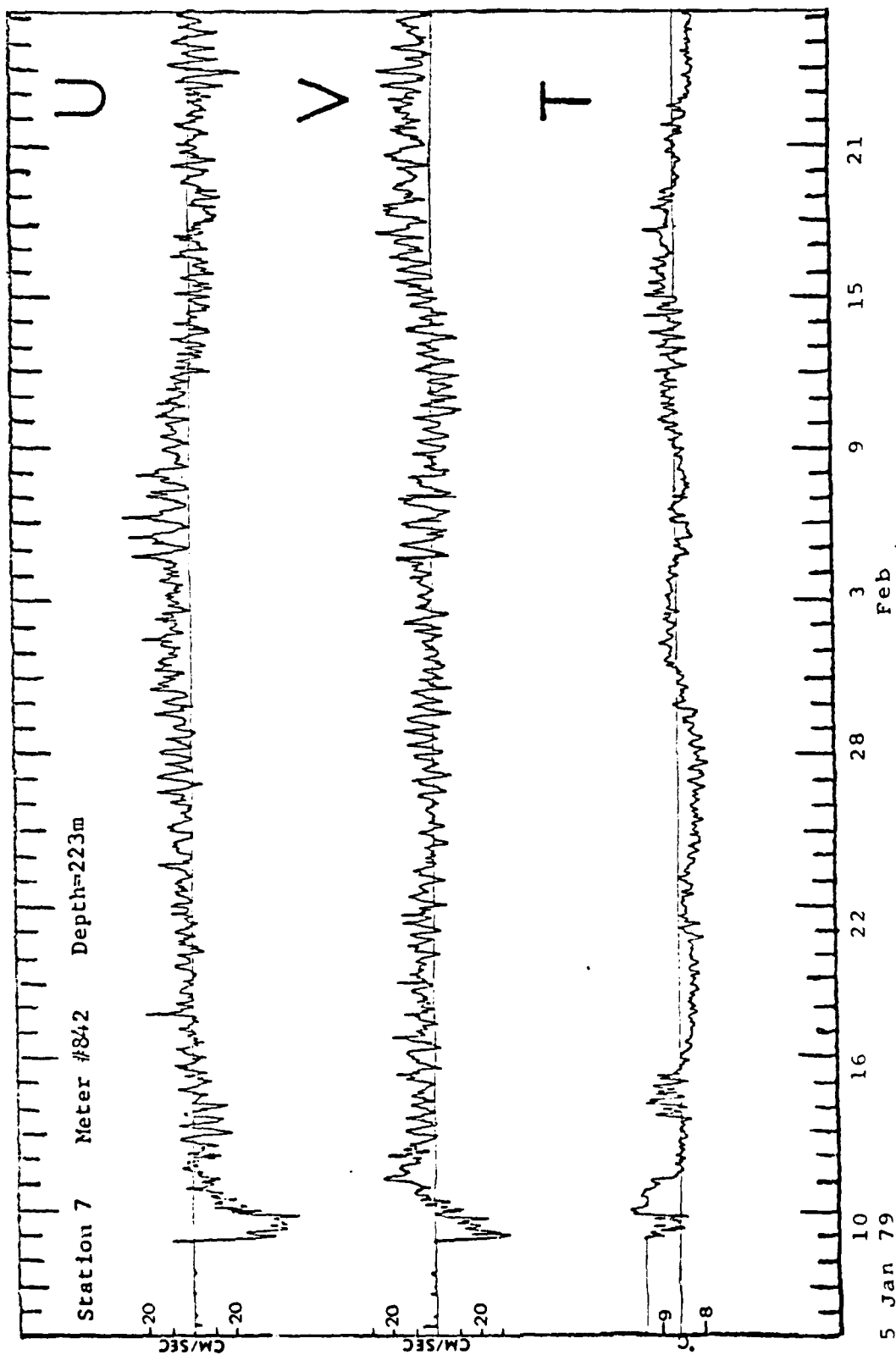


Figure 10. U component, V component, and temperature plots versus time for the current meter at 223 m depth at Station 7 deployed on 23 April 1979.

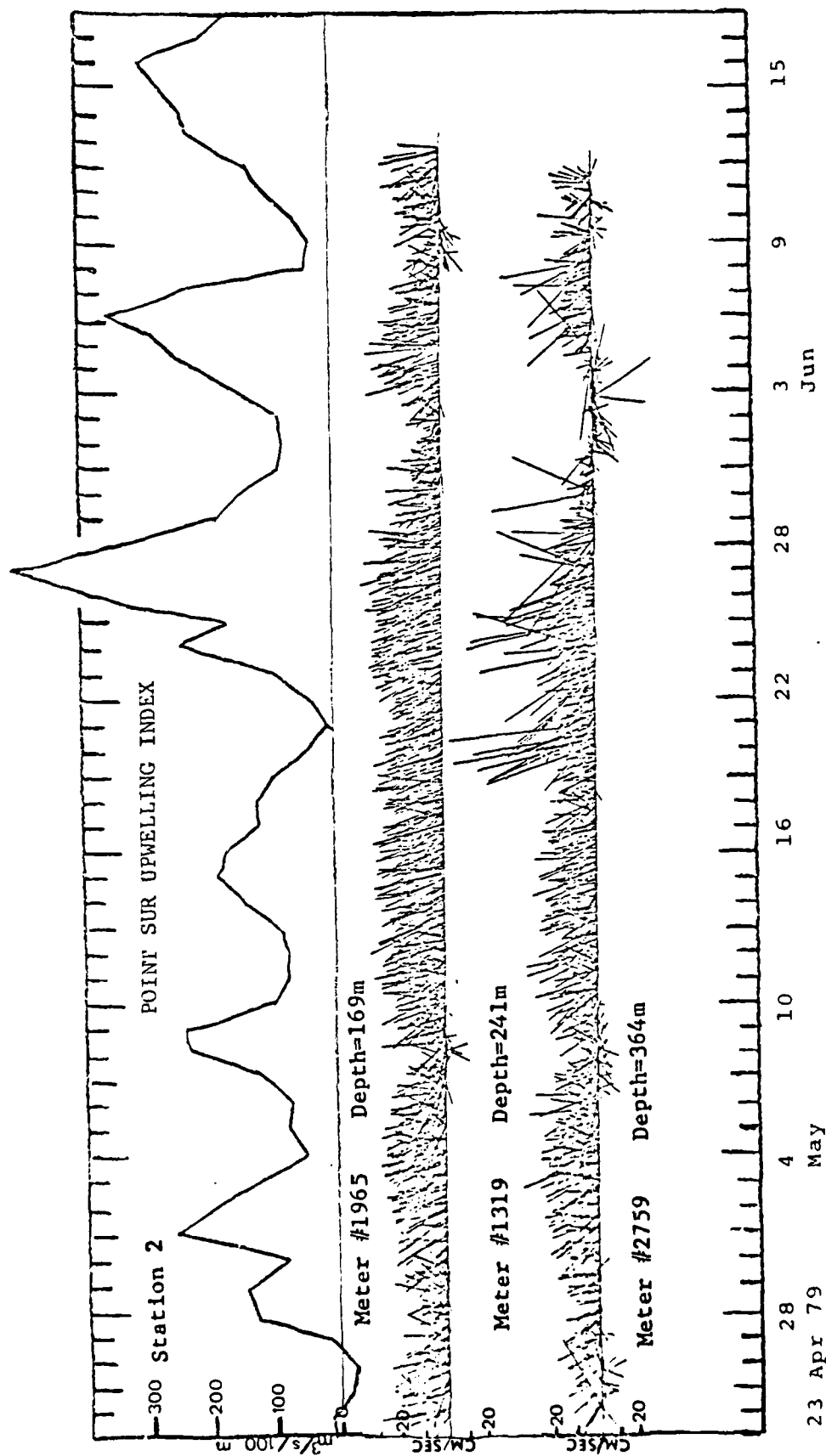


Figure 11. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 2 deployed on 23 April 1979.

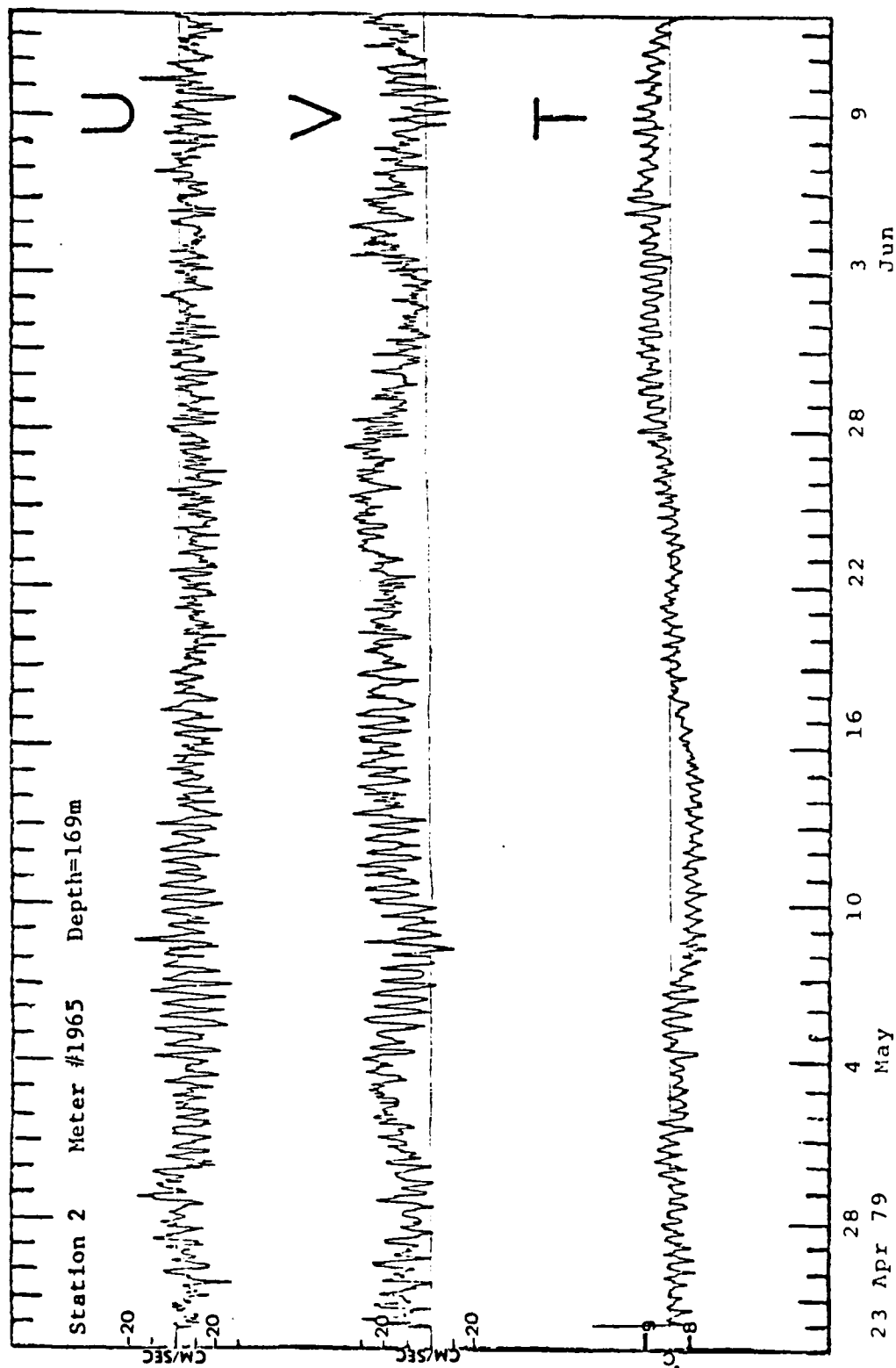


Figure 12. U component, V component, and temperature plots versus time for the current meter at 169 m depth at Station 2 deployed on 23 April 1979.

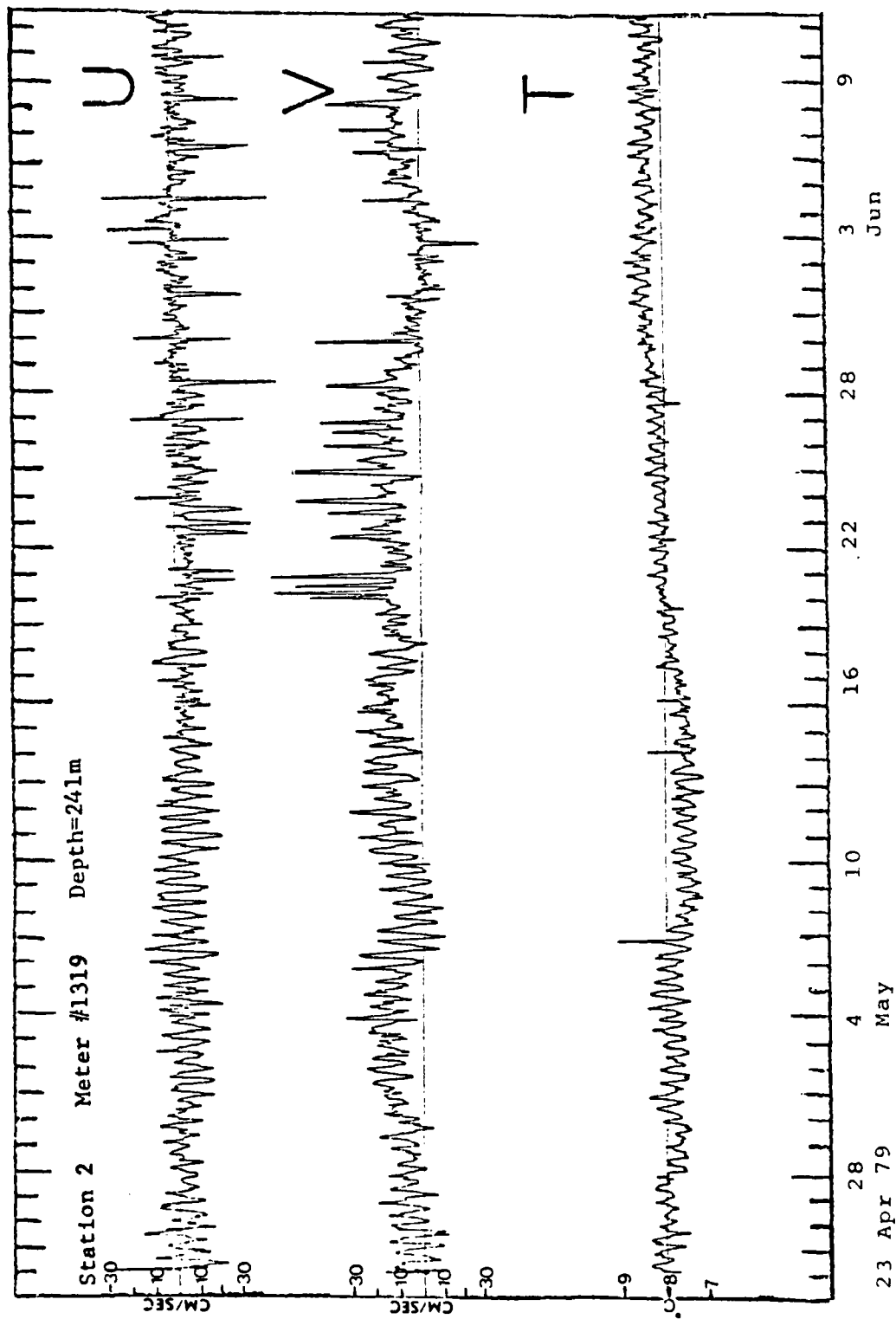


Figure 13. U component, V component, and temperature plots versus time for the current meter at 241 m depth at Station 2 deployed on 23 April 1979.

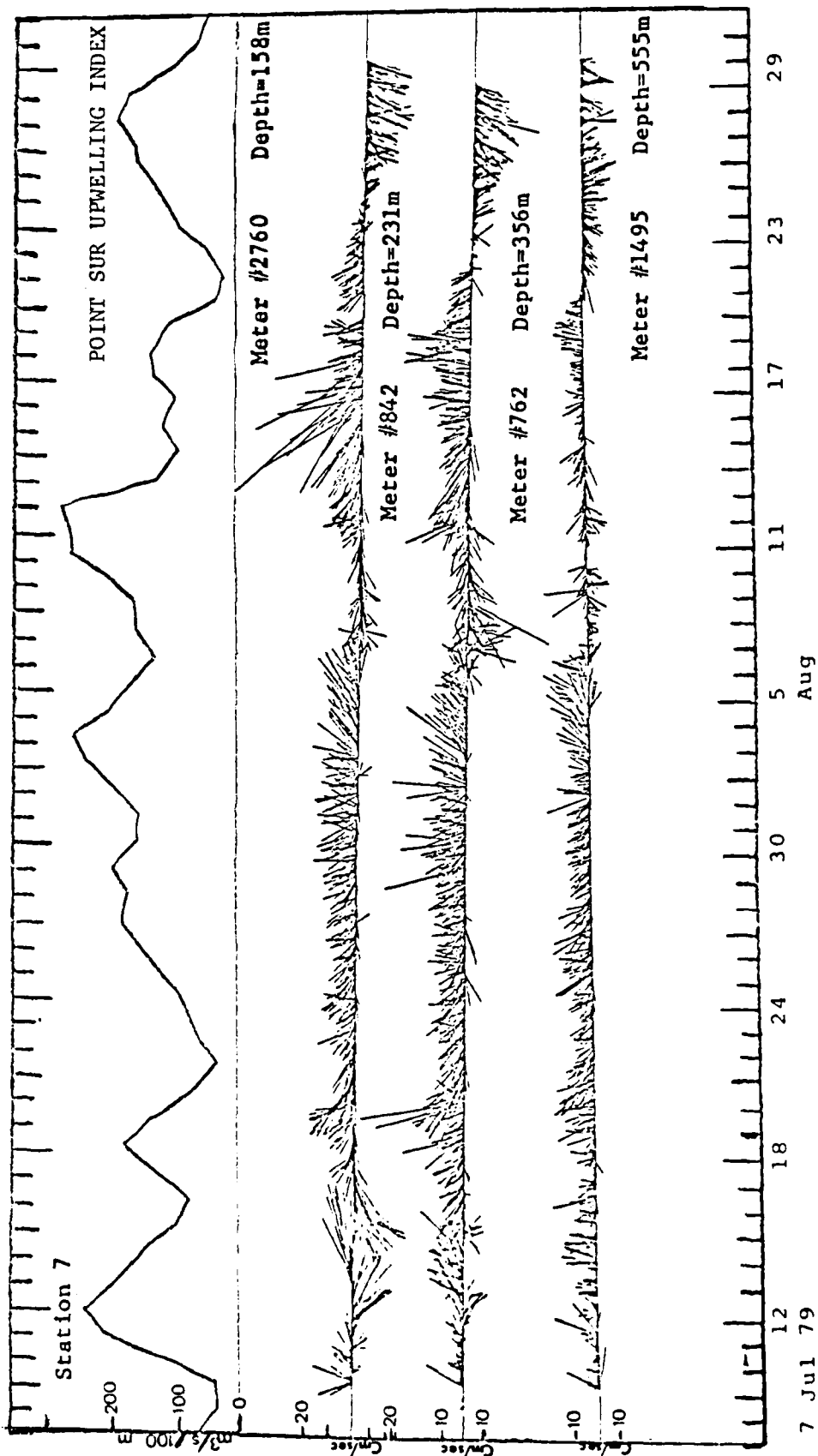


Figure 14. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 7 deployed on 7 July 1979.

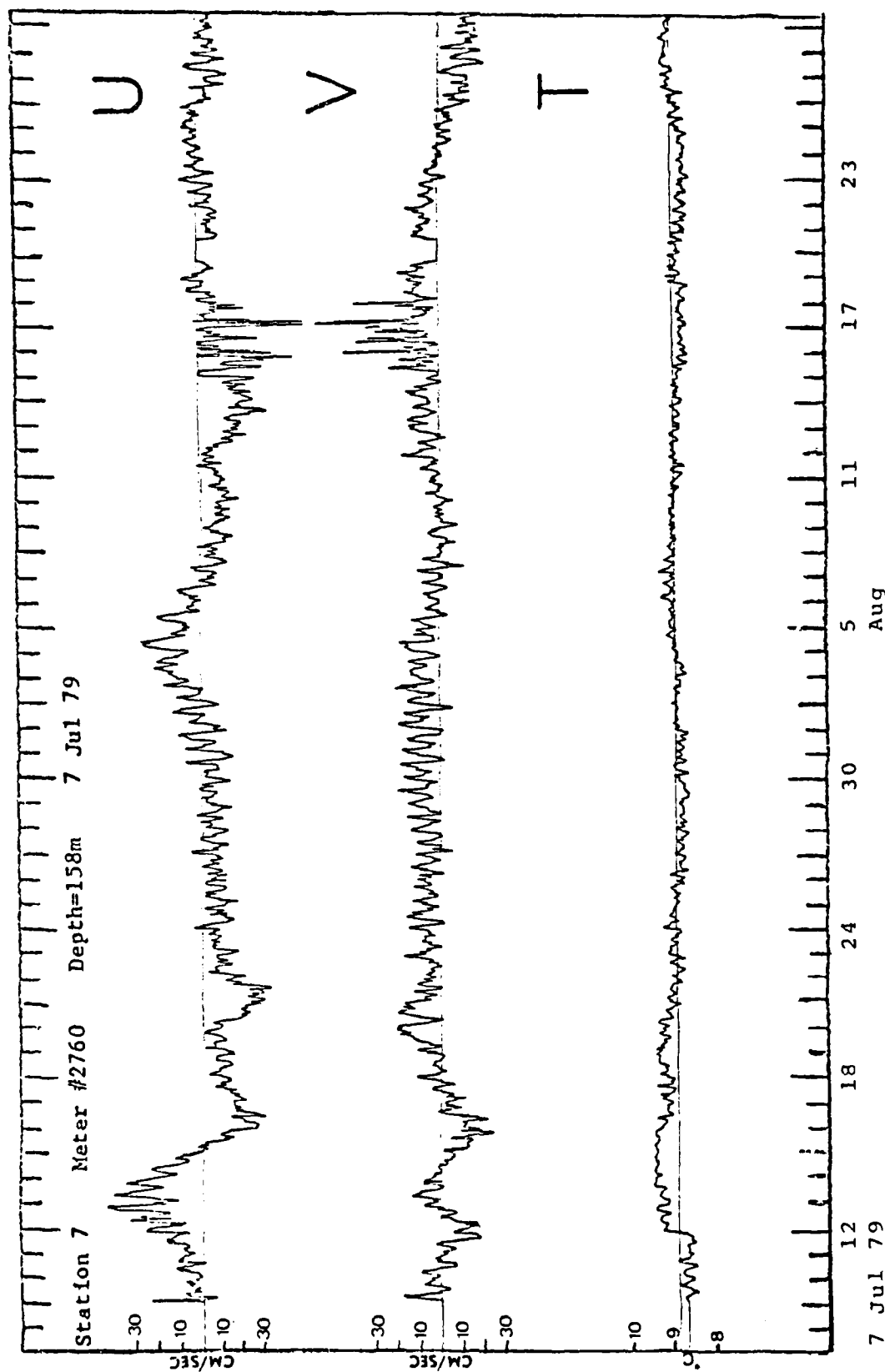


Figure 15. U component, V component, and temperature plots versus time for the current meter at 158 m depth at Station 7 deployed on 7 July 1979.

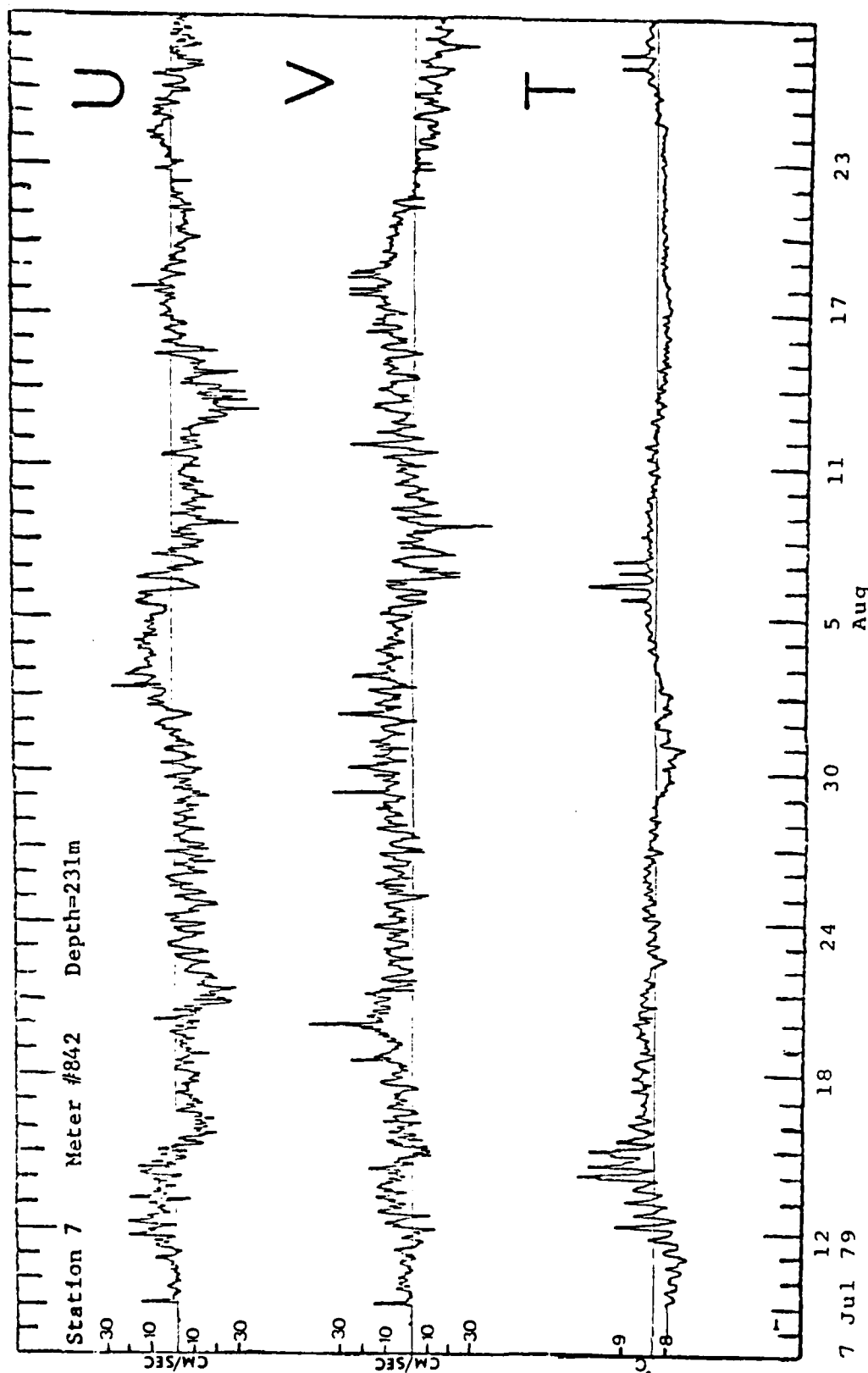


Figure 16. U component, V component, and temperature plots versus time for the current meter at 231 m depth at Station 7 deployed on 7 July 1979.

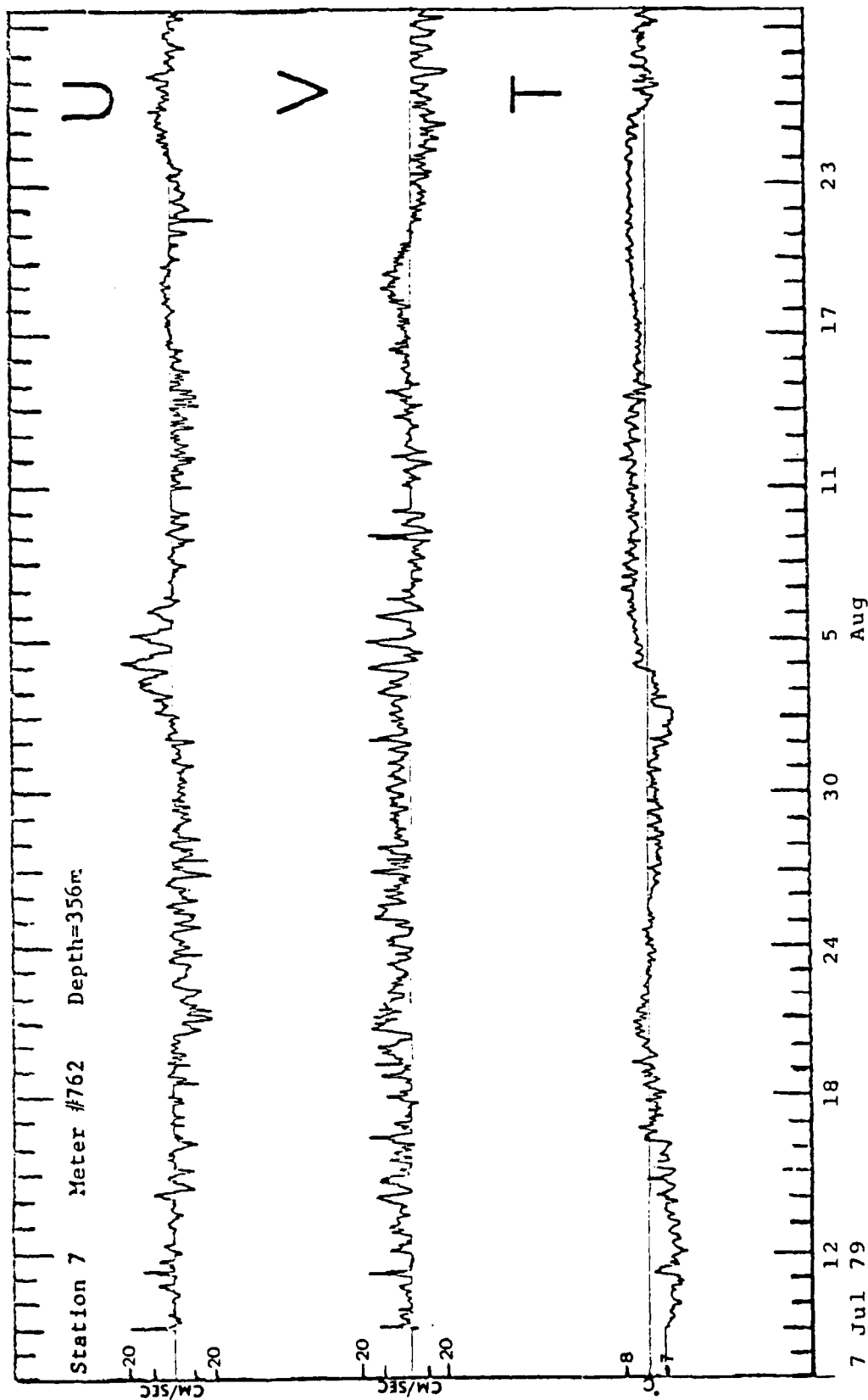


Figure 17. U component, V component, and temperature plots versus time for the current meter at 356 m depth at Station 7 deployed on 7 July 1979.

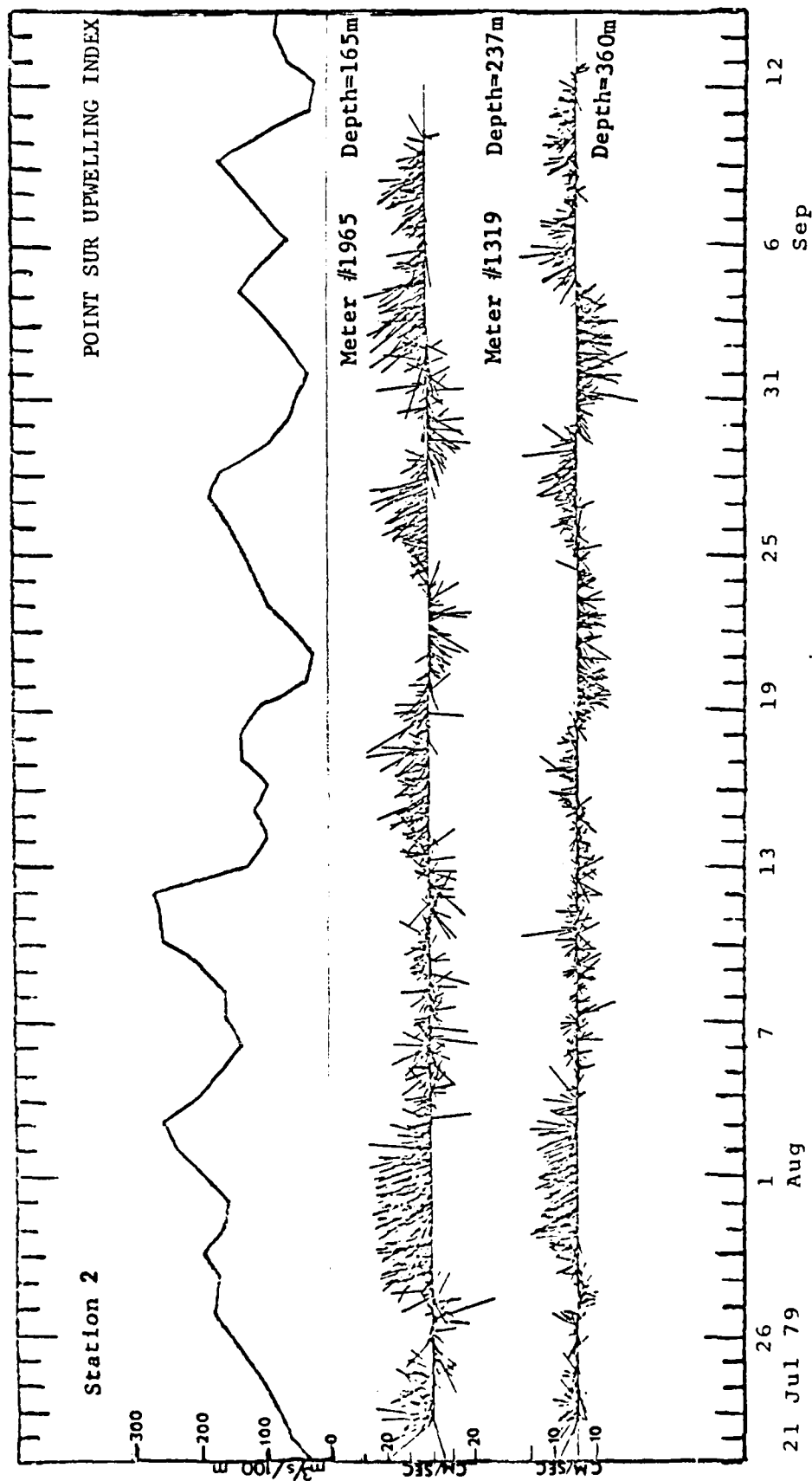


Figure 18. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 2 deployed on 21 July 1979.

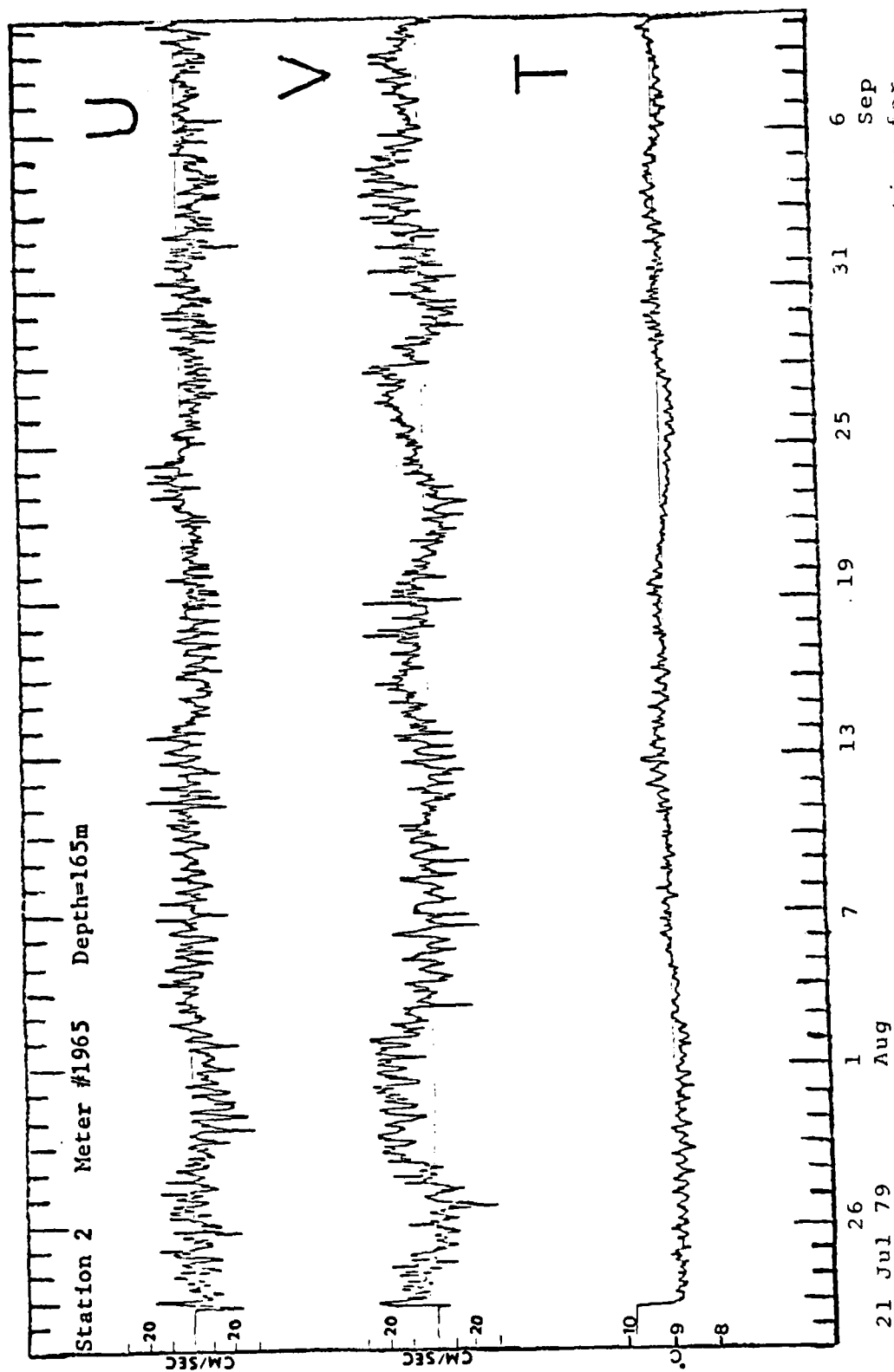


Figure 19. U component, V component, and temperature plots versus time for the current meter at 165 m depth at Station 2 deployed on 21 July 1979.

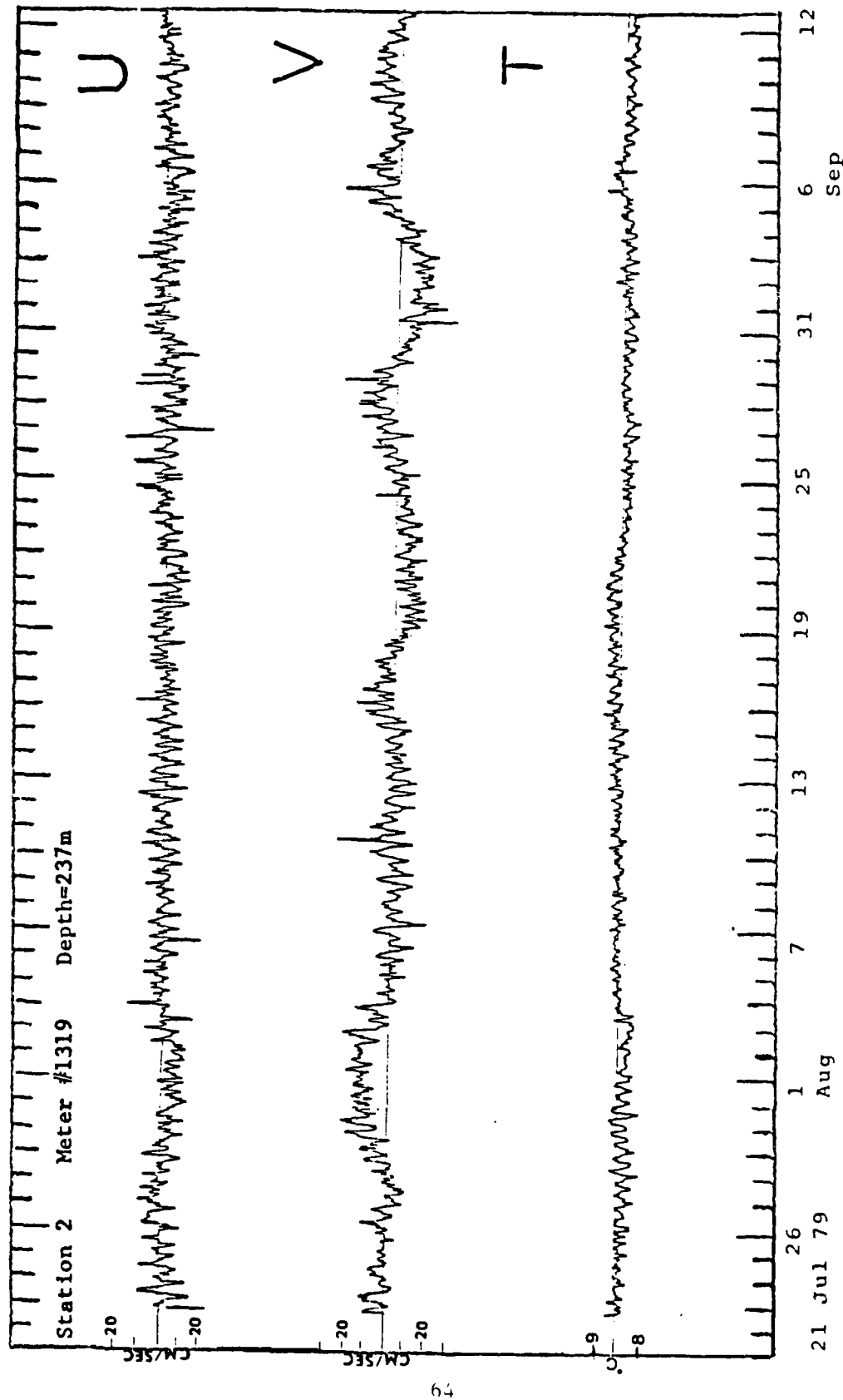


Figure 20. U component, V component, and temperature plots versus time for the current meter at 237 m depth at Station 2 deployed on 21 July 1979.

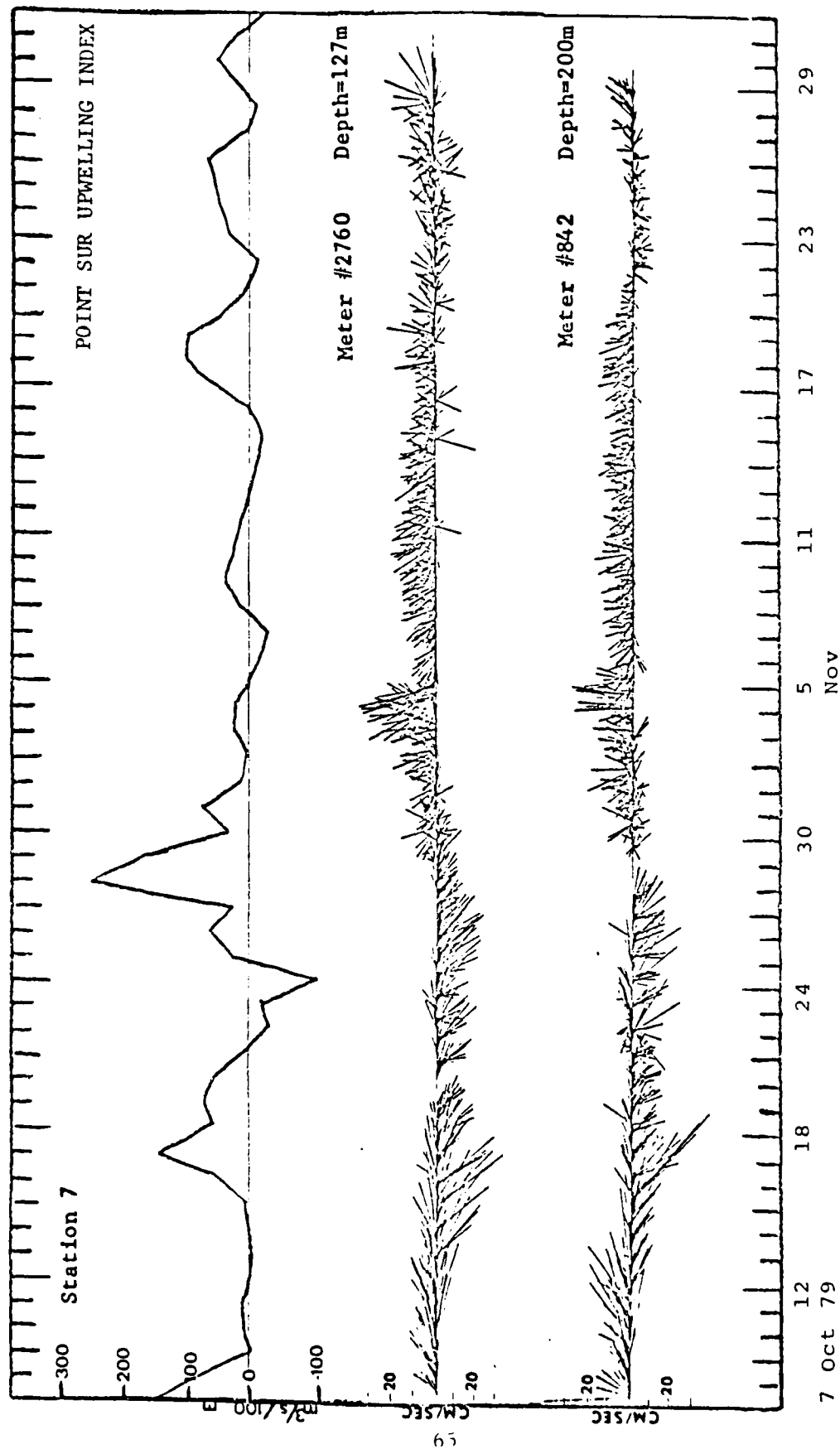


Figure 21. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 7 deployed on 7 October 1979.

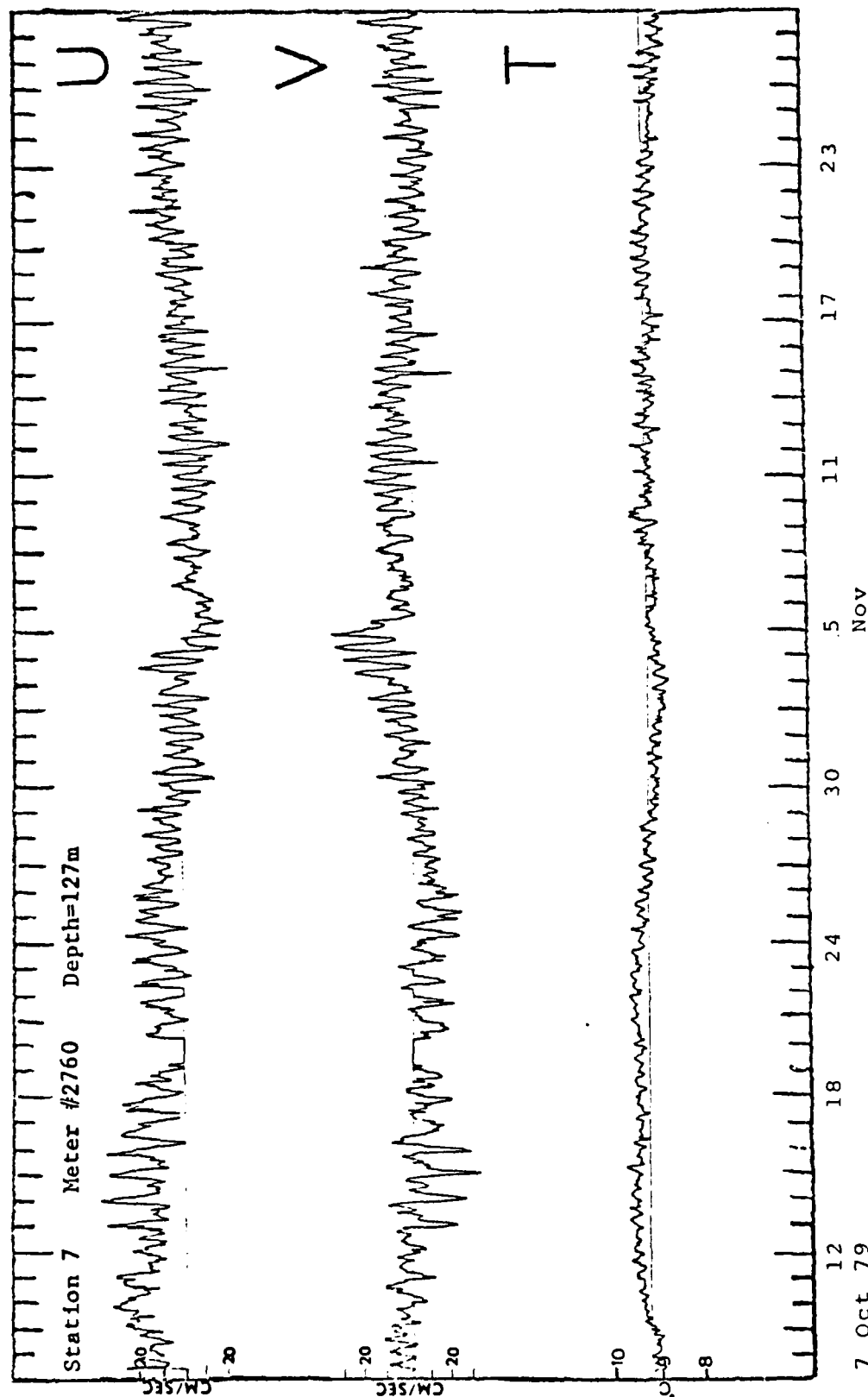


Figure 22. U component, V component, and temperature plots versus time for the current meter at 127 m depth at Station 7 deployed on 7 October 1979.

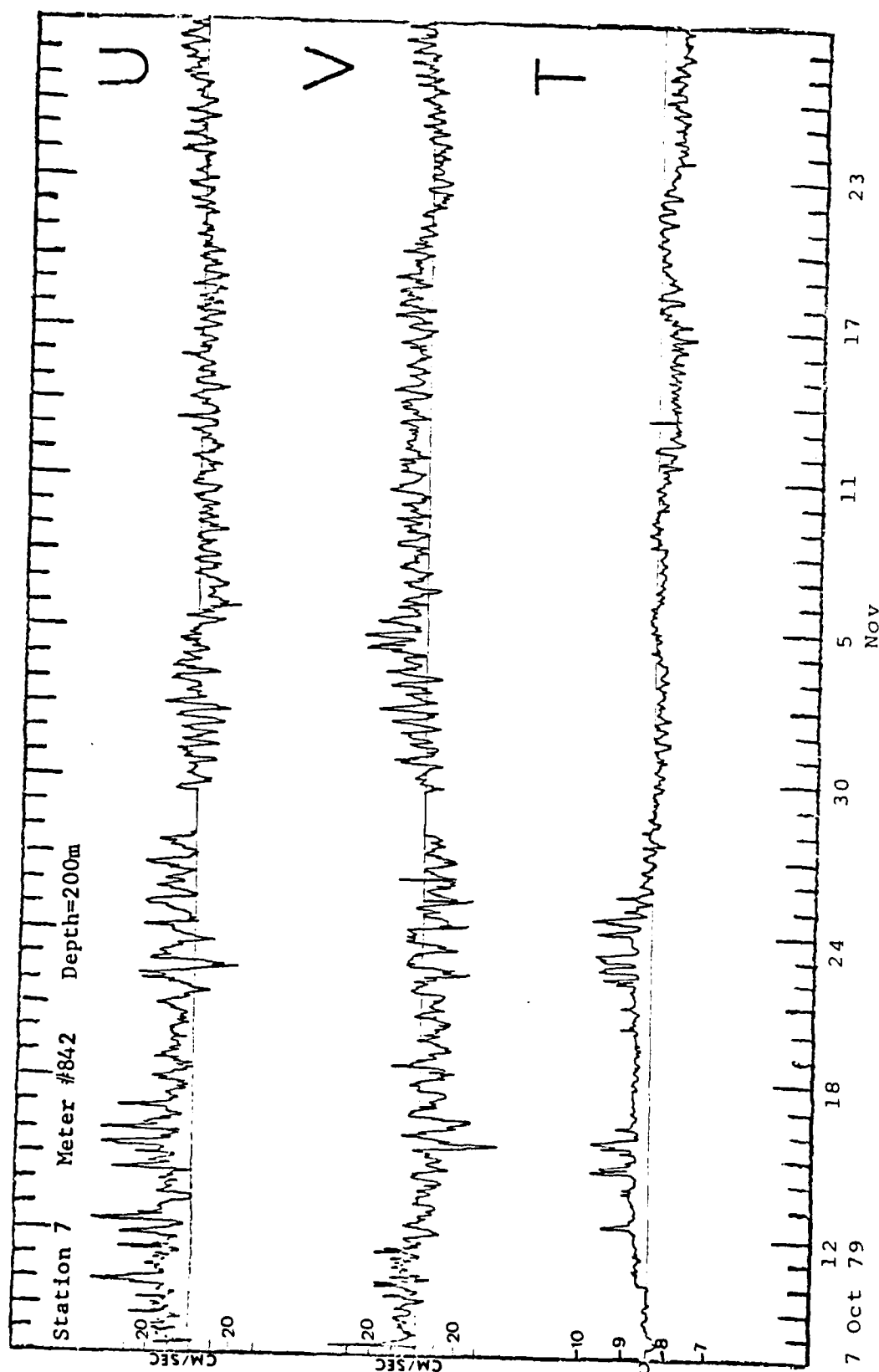


Figure 23. U component, V component, and temperature plots versus time for the current meter at 200 m depth at Station 7 deployed on 7 October 1979.

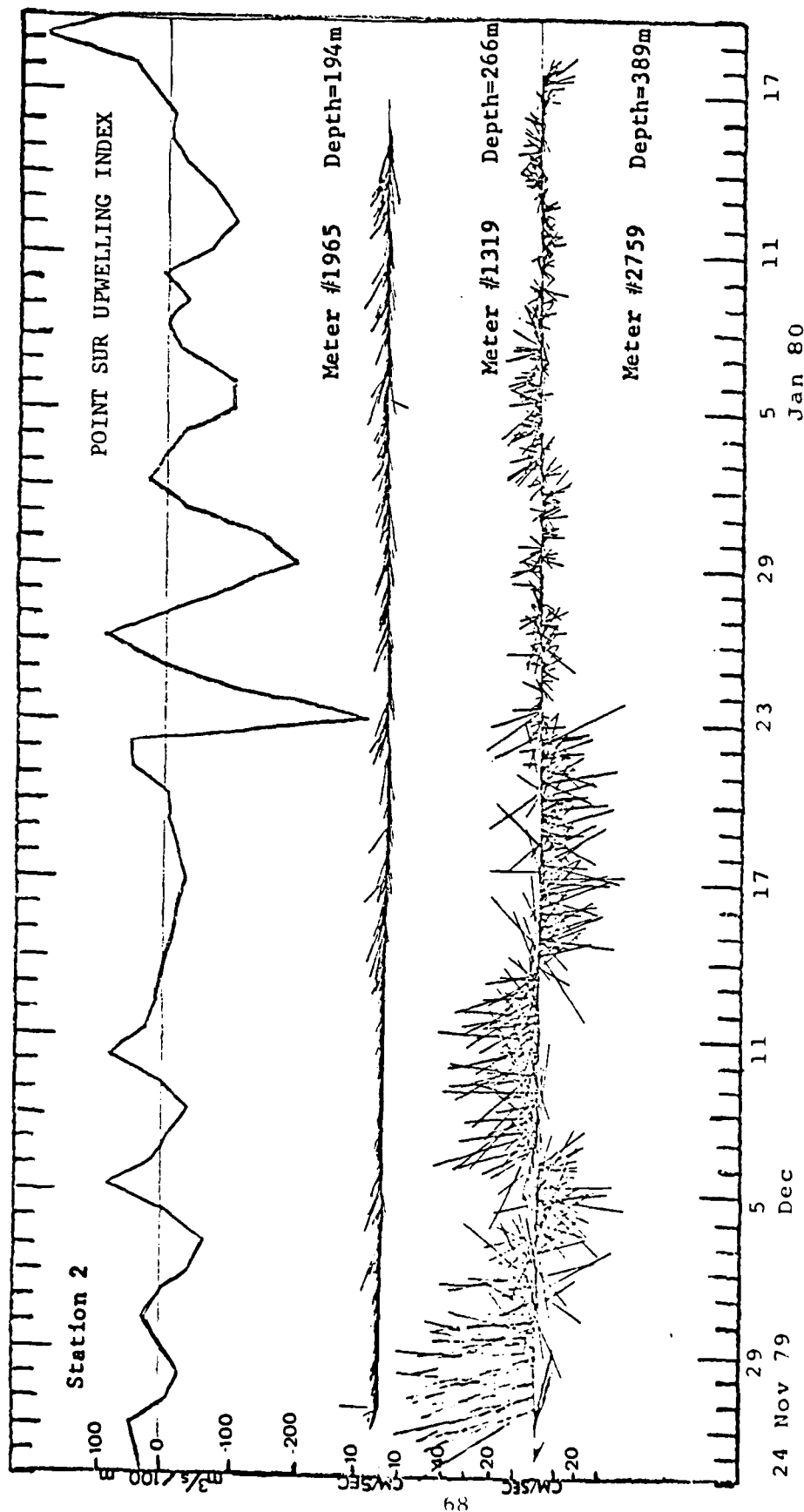


Figure 24. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 2 deployed on 24 November 1979.

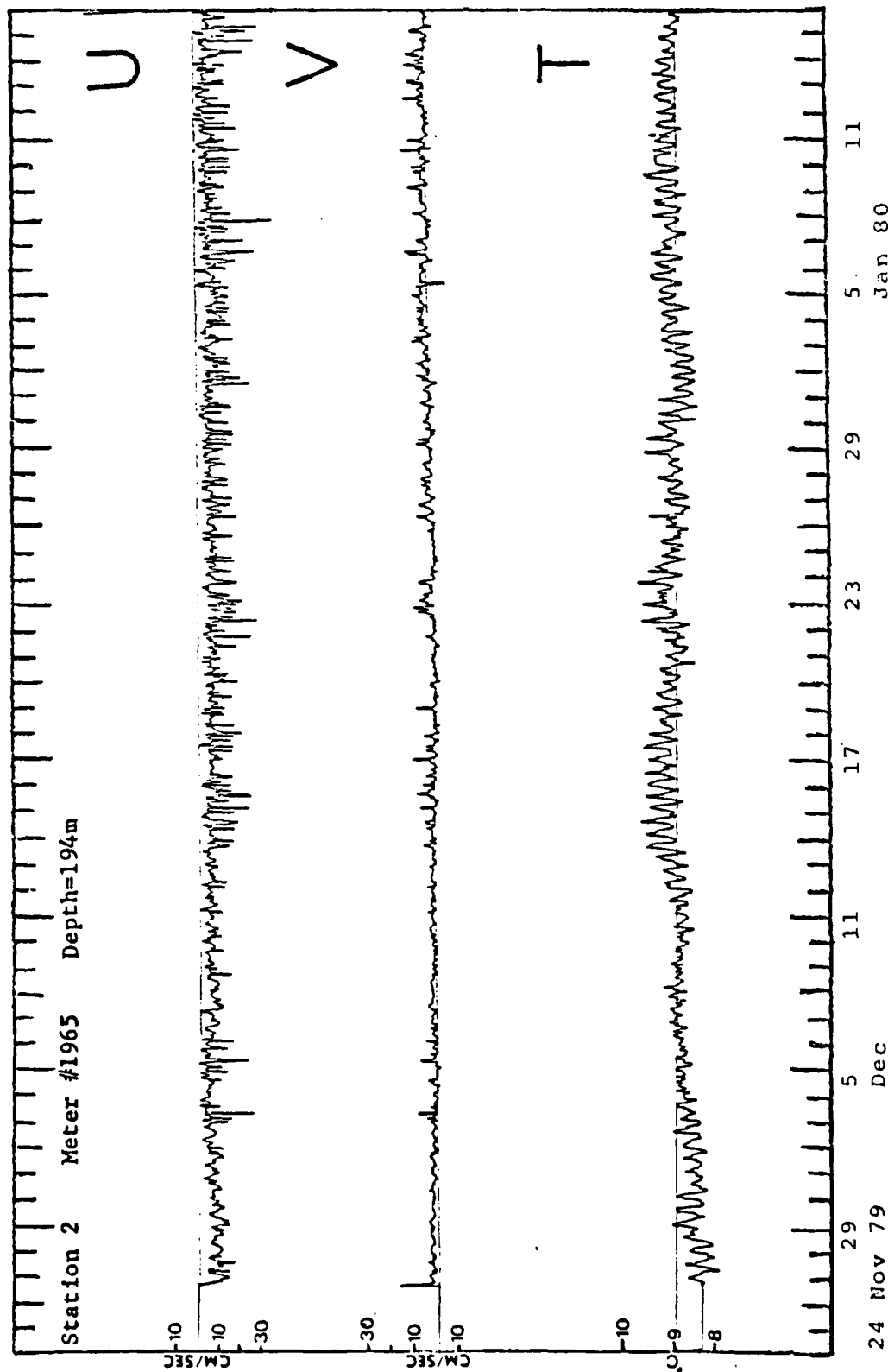


Figure 25. U component, V component, and temperature plots versus time for the current meter at 194 m depth at Station 2 deployed on 24 November 1979.

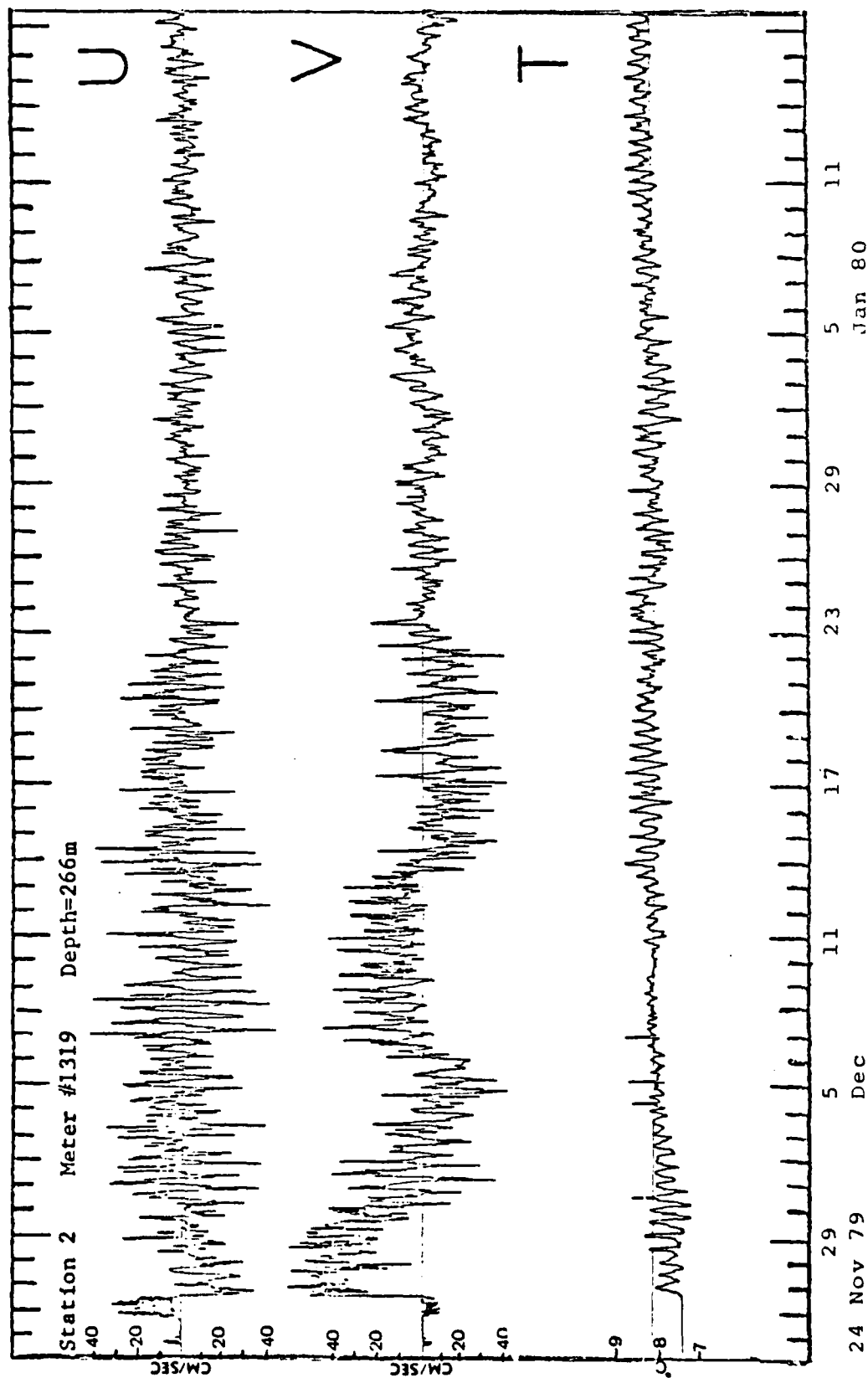


Figure 26. U component, V component, and temperature plots versus time for the current meter at 266 m depth at Station 2 deployed on 24 November 1979.

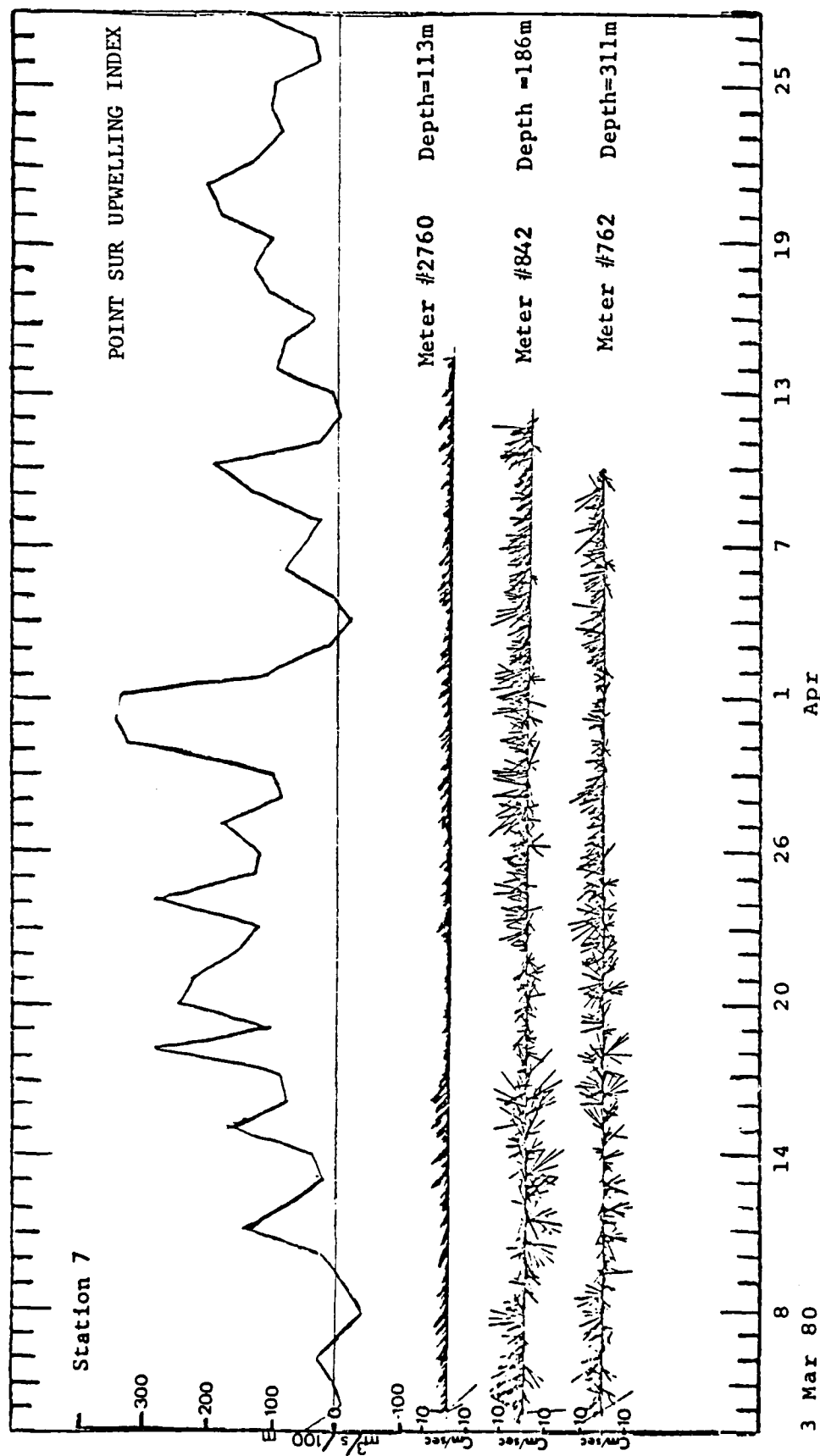


Figure 27. Point Sur Upwelling Index and stickplots of hourly current vectors for the current meters at Station 7 deployed on 3 March 1980.

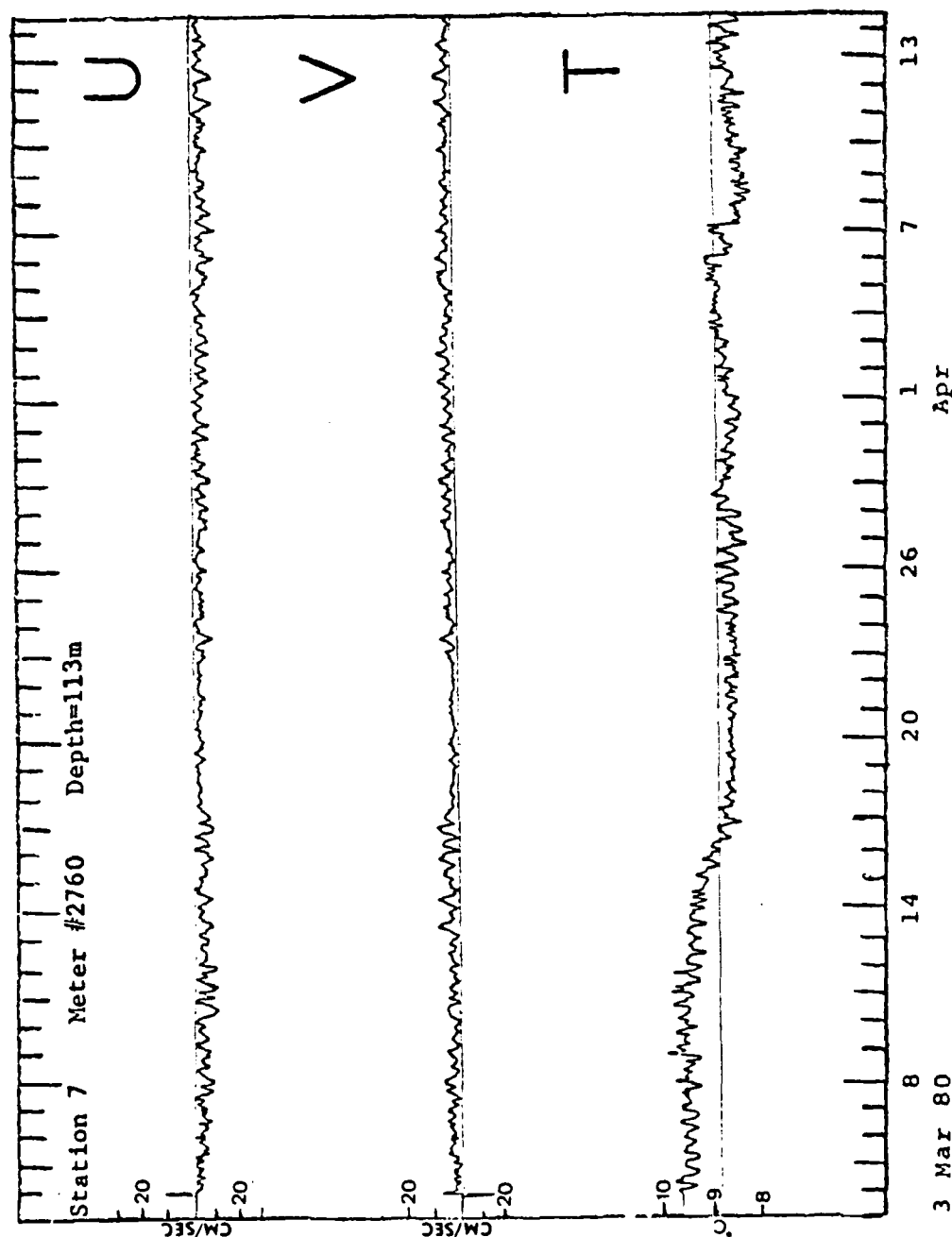


Figure 28. U component, V component, and temperature plots versus time for the current meter at 113 m depth at Station 7 deployed on 3 March 1980.

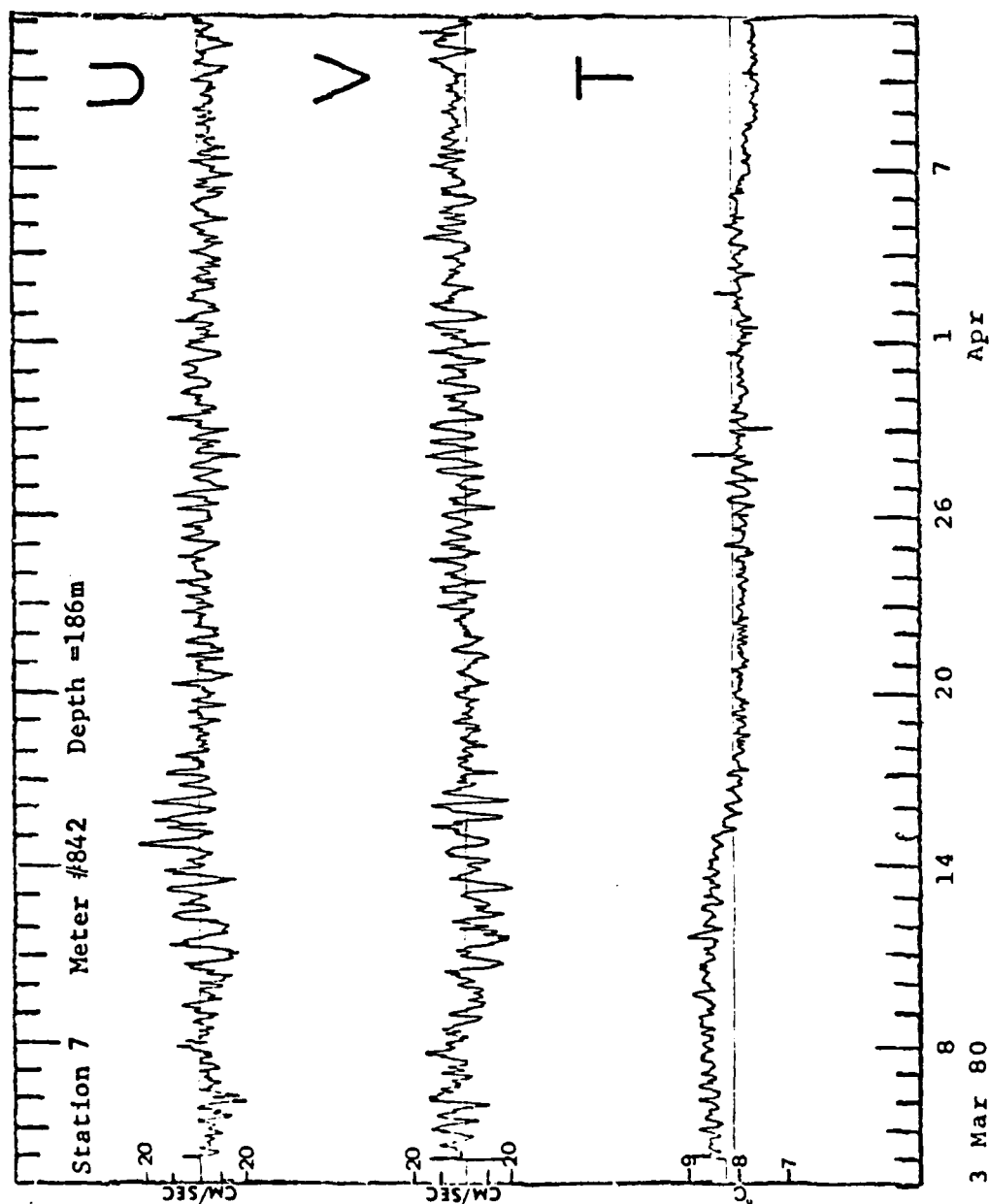


Figure 29. U component, V component, and temperature plots versus time for the current meters at 186 m depth at Station 7 deployed on 3 March 1980.

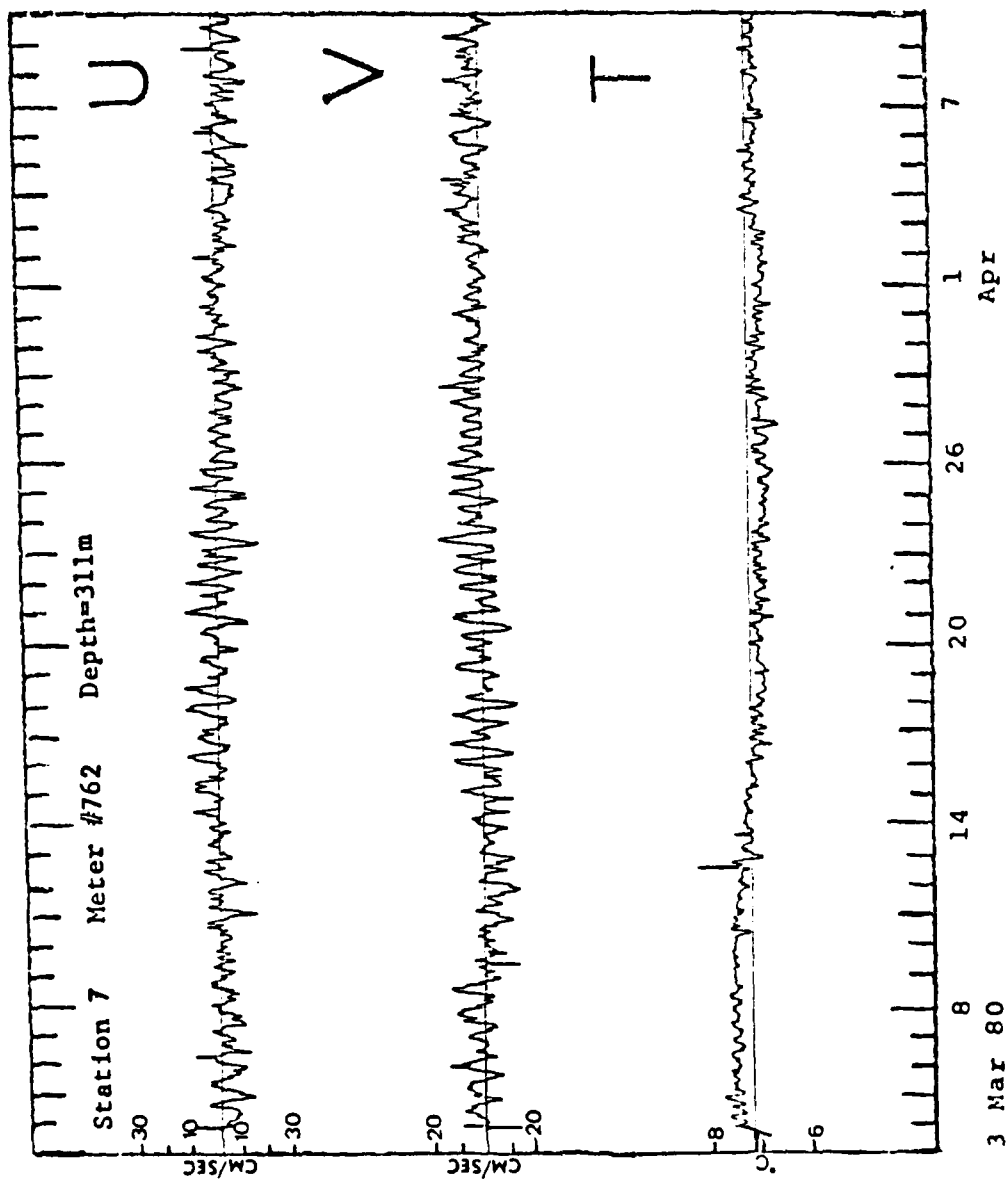


Figure 30. U component, V component, and temperature plots versus time for the current meter at 311 m depth at Station 7 deployed on 5 January 1979.

APPENDIX B: SPECTRUM ANALYSES OF ALONGSHORE FLOW AND
ON/OFFSHORE FLOW

Station 7 Meter #762 Depth=152m 5 Jan 79

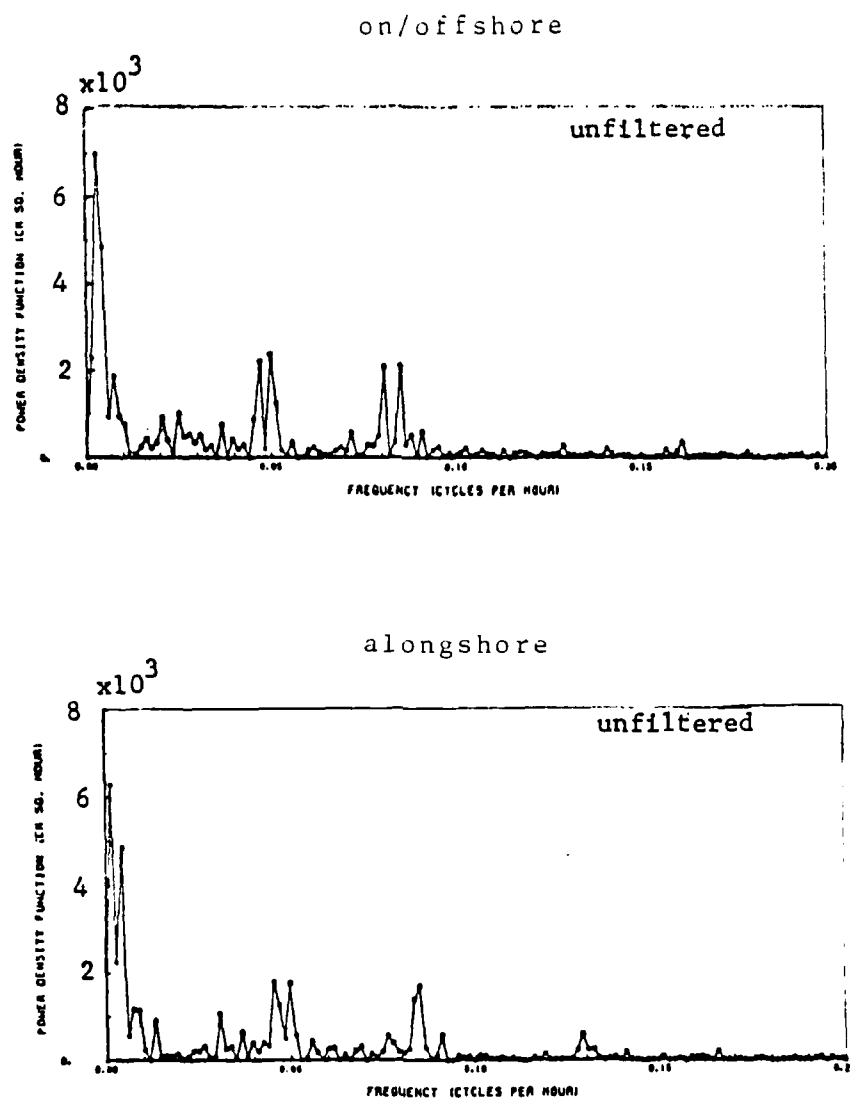


Figure 31. Energy density spectrum of current meter at 152 m depth at Station 7 deployed on 5 January 1979.

Station 7 Meter #842 Depth=223m 5 Jan 79

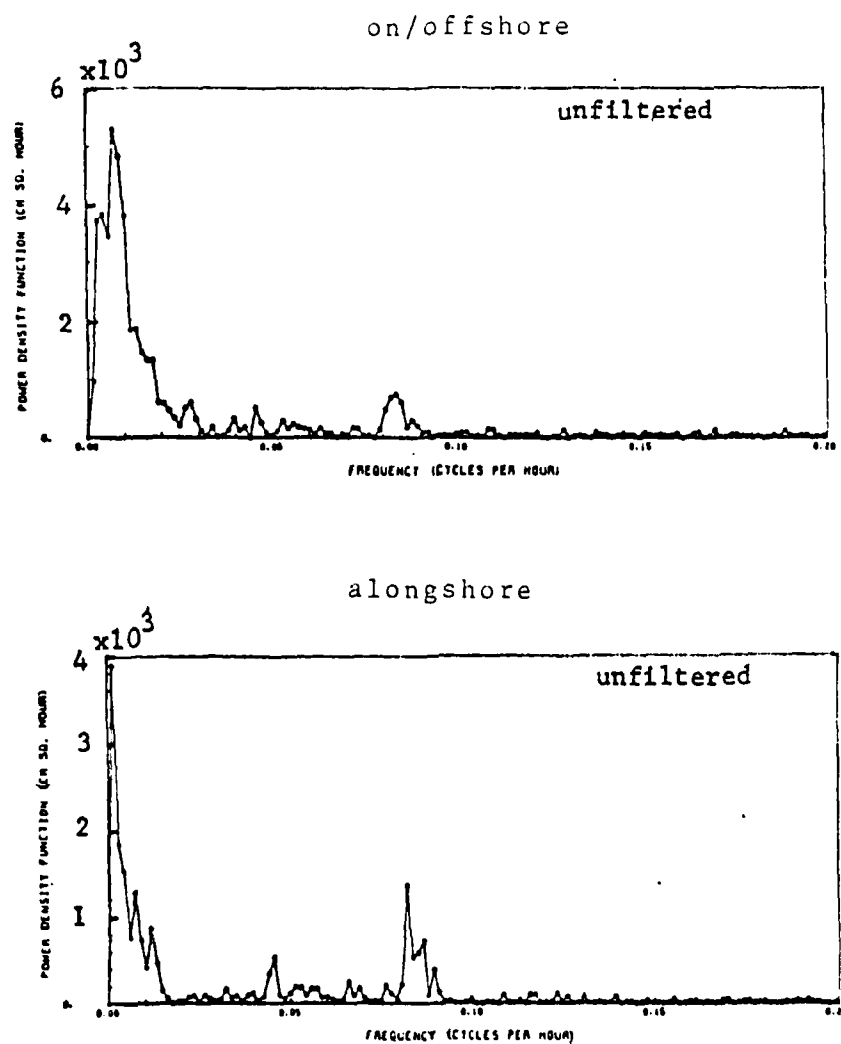


Figure 32. Energy density spectrum of current meter at 223 m depth at Station 7 deployed on 5 January 1979.

Station 2 Meter #1965 Depth=169m 23 Apr 79

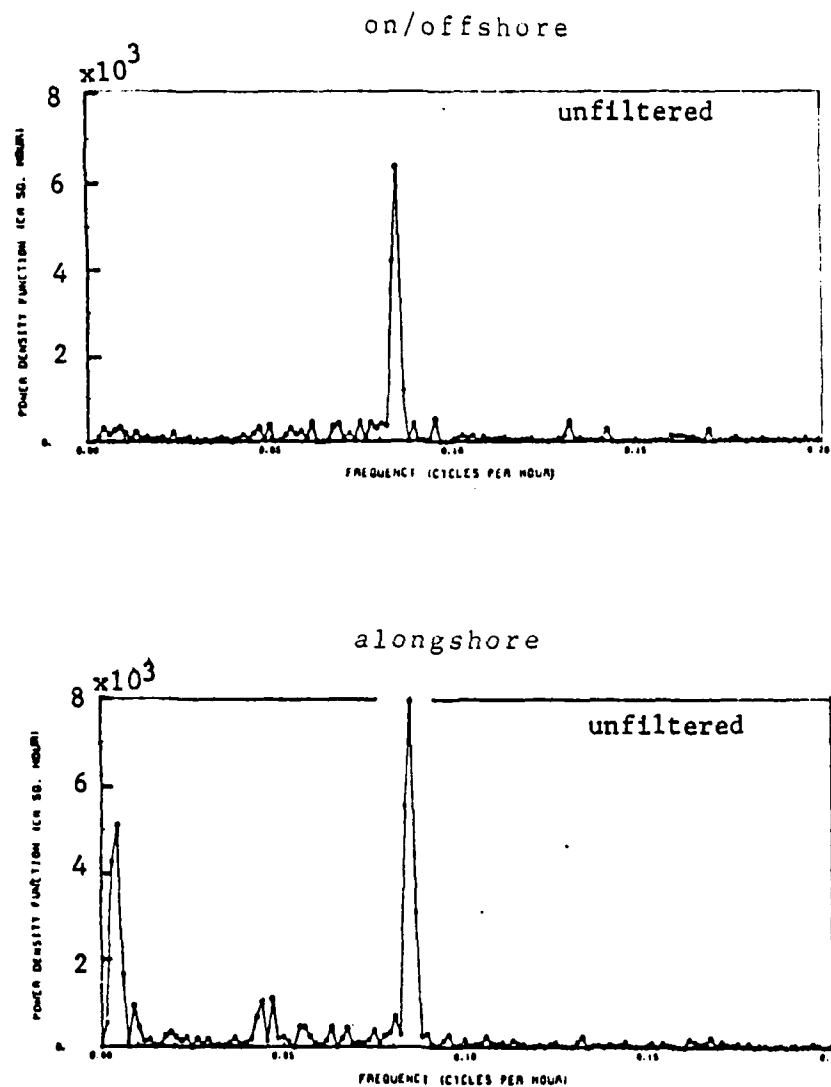


Figure 33. Energy density spectrum of current meter at 169 m depth at Station 2 deployed on 23 April 1979.

Station 2 Meter #1319 Depth=241m 23 Apr 79

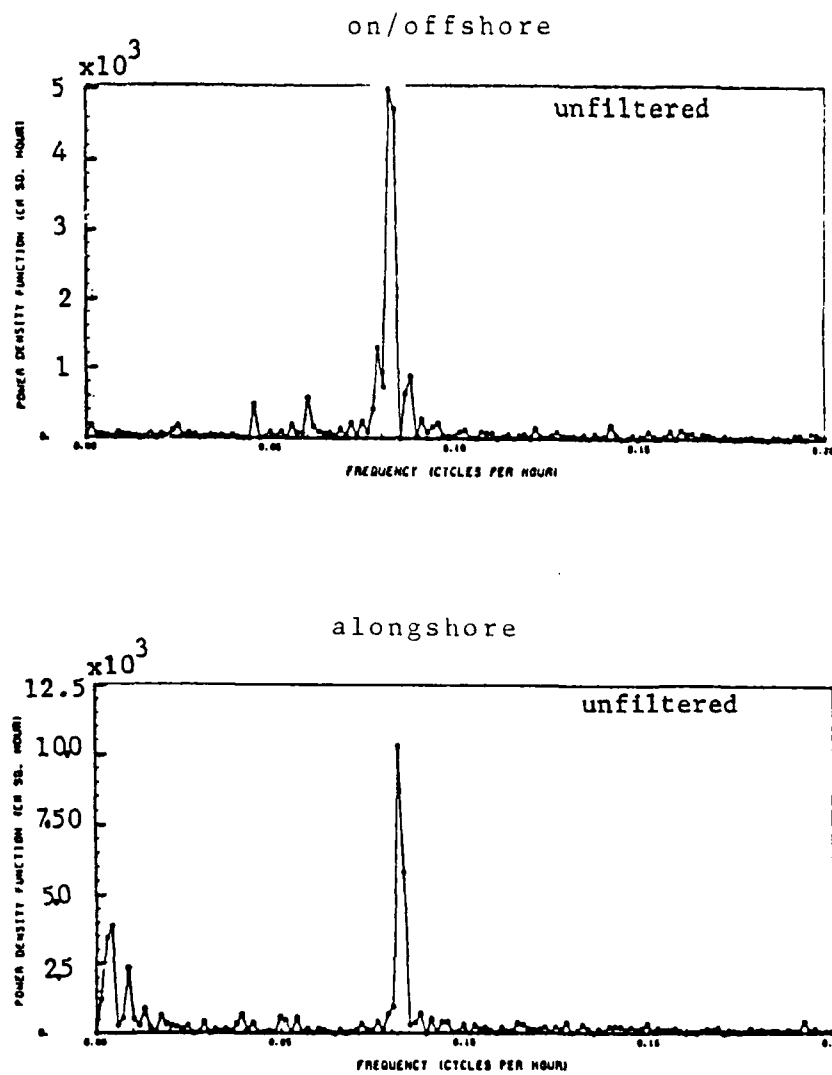


Figure 34. Energy density spectrum of current meter at 241 m depth at Station 2 deployed on 23 April 1979.

Station 7 Meter #2760 Depth=158m 7 Jul 79

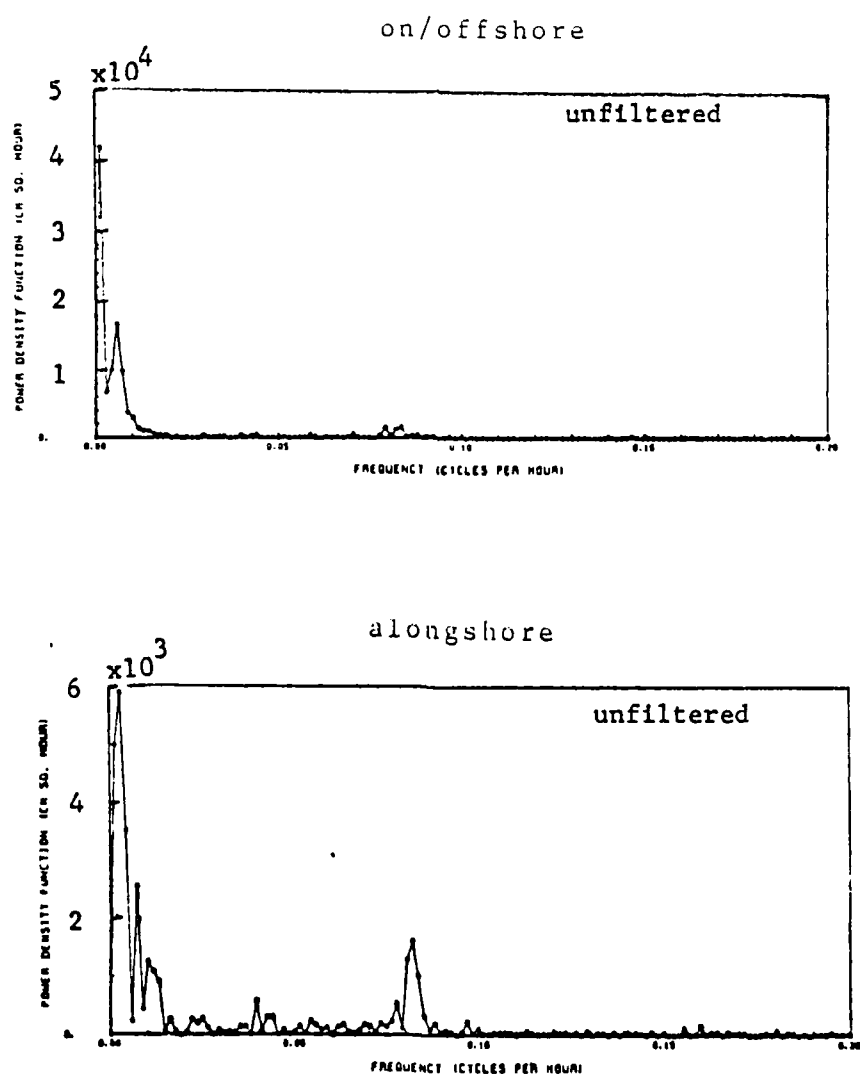


Figure 35. Energy density spectrum of current meter at 158 m depth at Station 7 deployed on 7 July 1979.

Station 7 Meter #842 Depth=231m 7 Jul 79

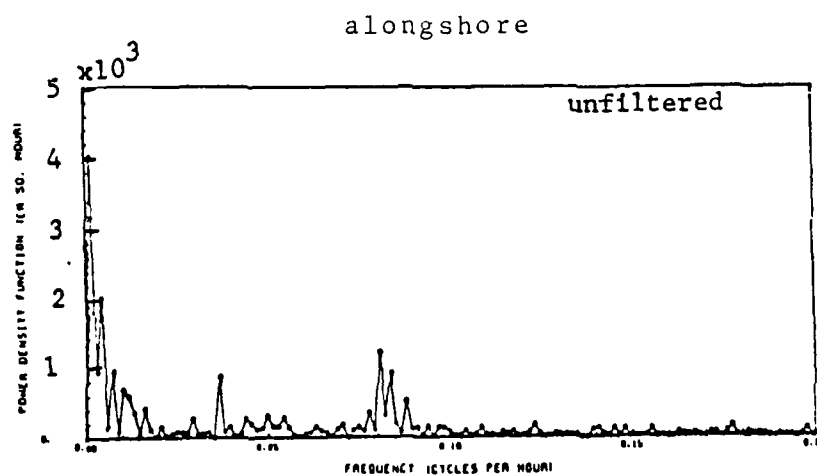
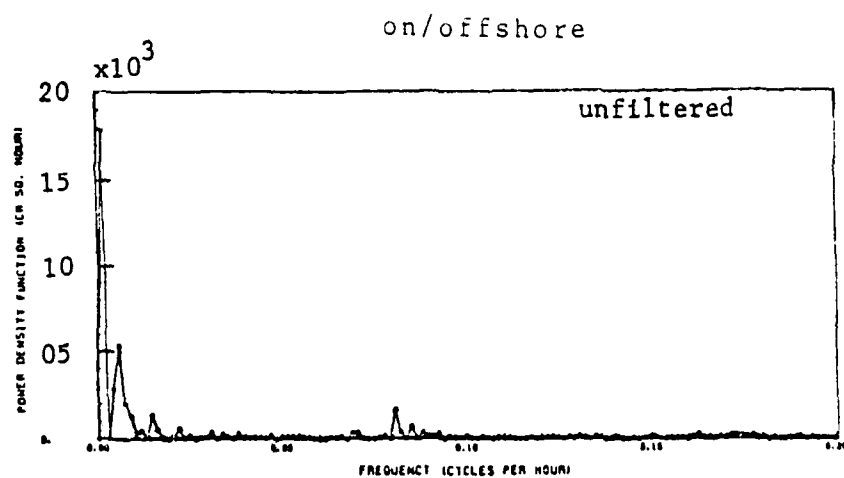


Figure 36. Energy density spectrum of current meter at 231 m depth at Station 7 deployed on 7 July 1979.

Station 7 Meter #762 Depth=356m 7 Jul 79

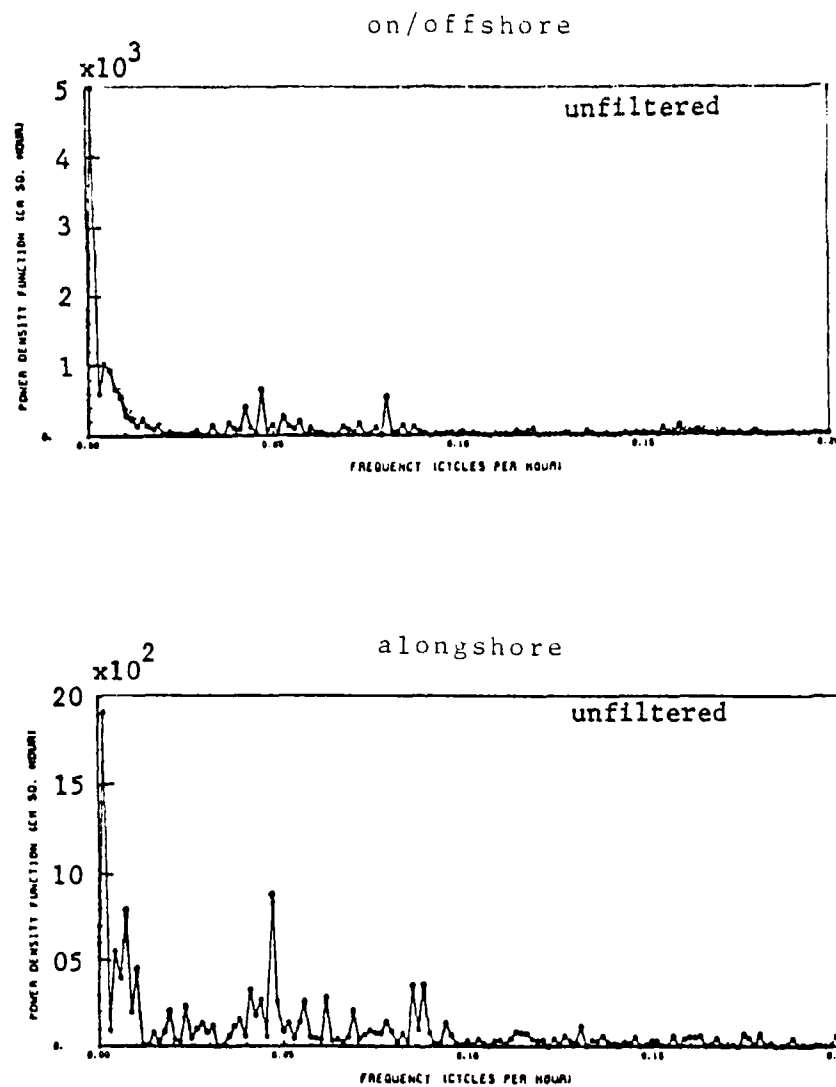


Figure 37. Energy density spectrum of current meter at 356 m depth at Station 7 deployed on 7 July 1979.

Station 2 Meter #1965 Depth=165m 21 Jul 79

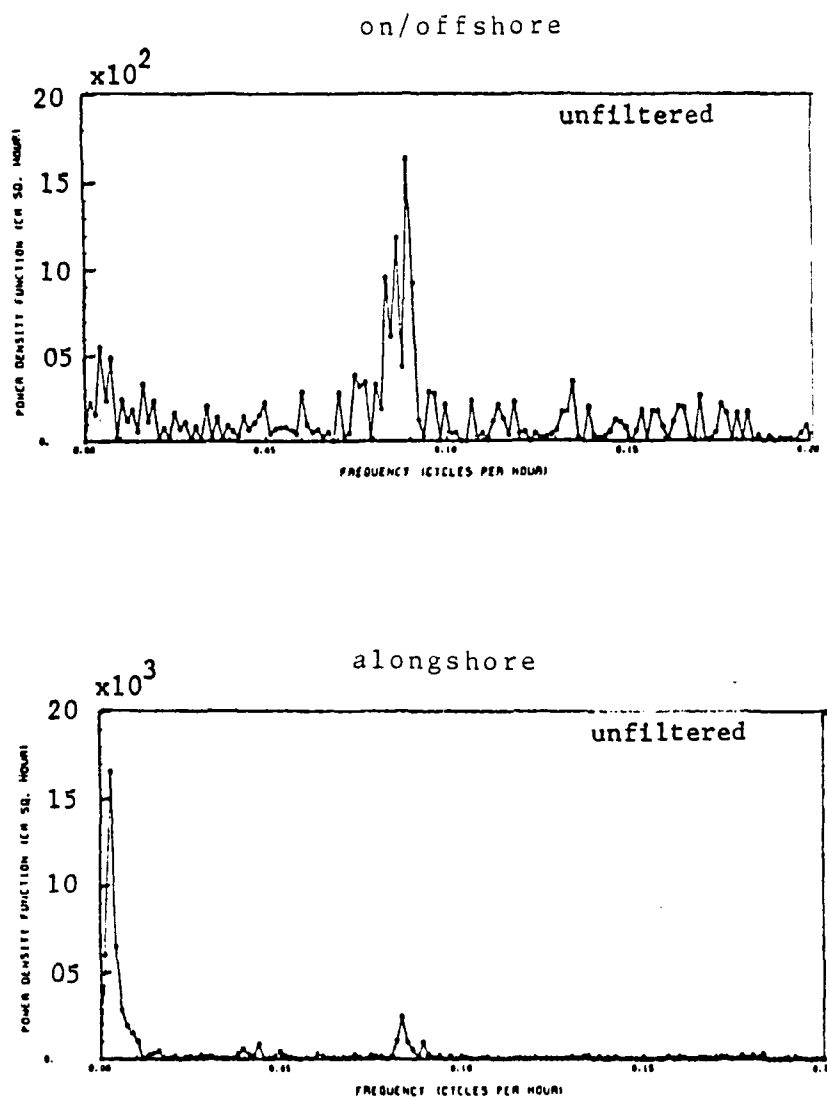


Figure 38. Energy density spectrum of current meter at 165 m depth at Station 2 deployed on 21 July 1979.

Station 2 Meter #1319 Depth=237m 21 Jul 79

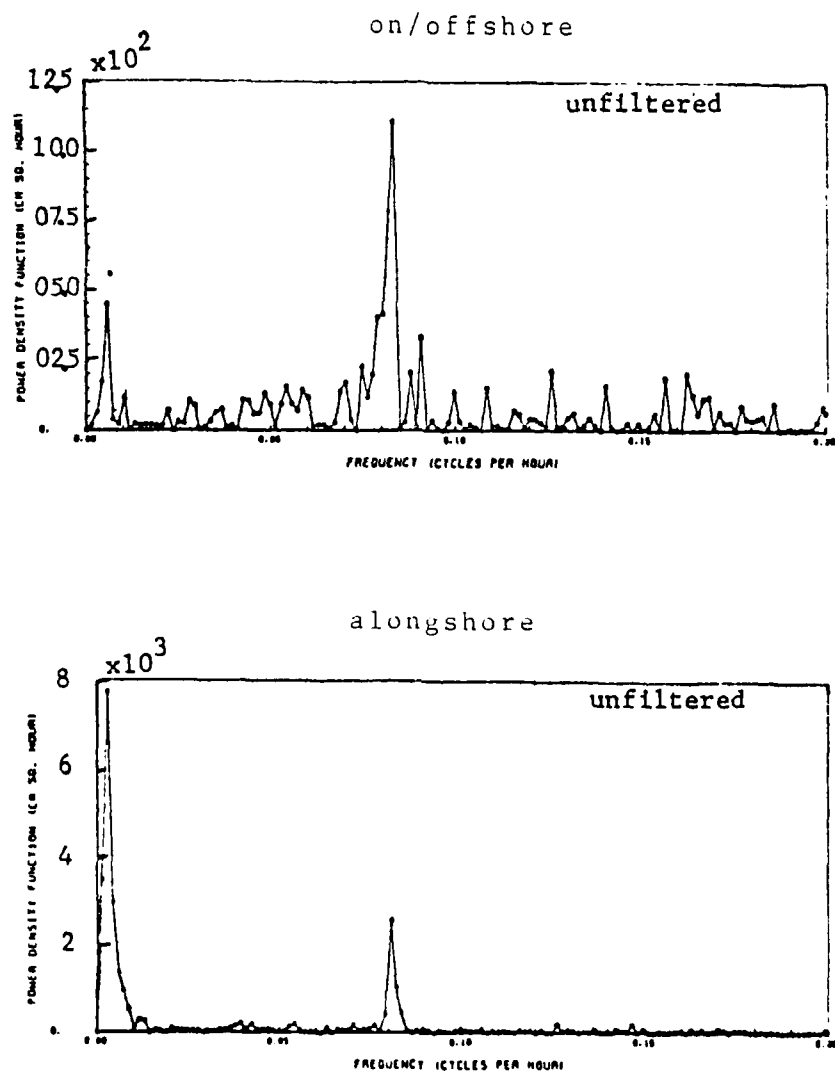


Figure 39. Energy density spectrum of current meter at 237 m depth at Station 2 deployed on 21 July 1979.

Station 7 Meter #2760 Depth=127m 7 Oct 79

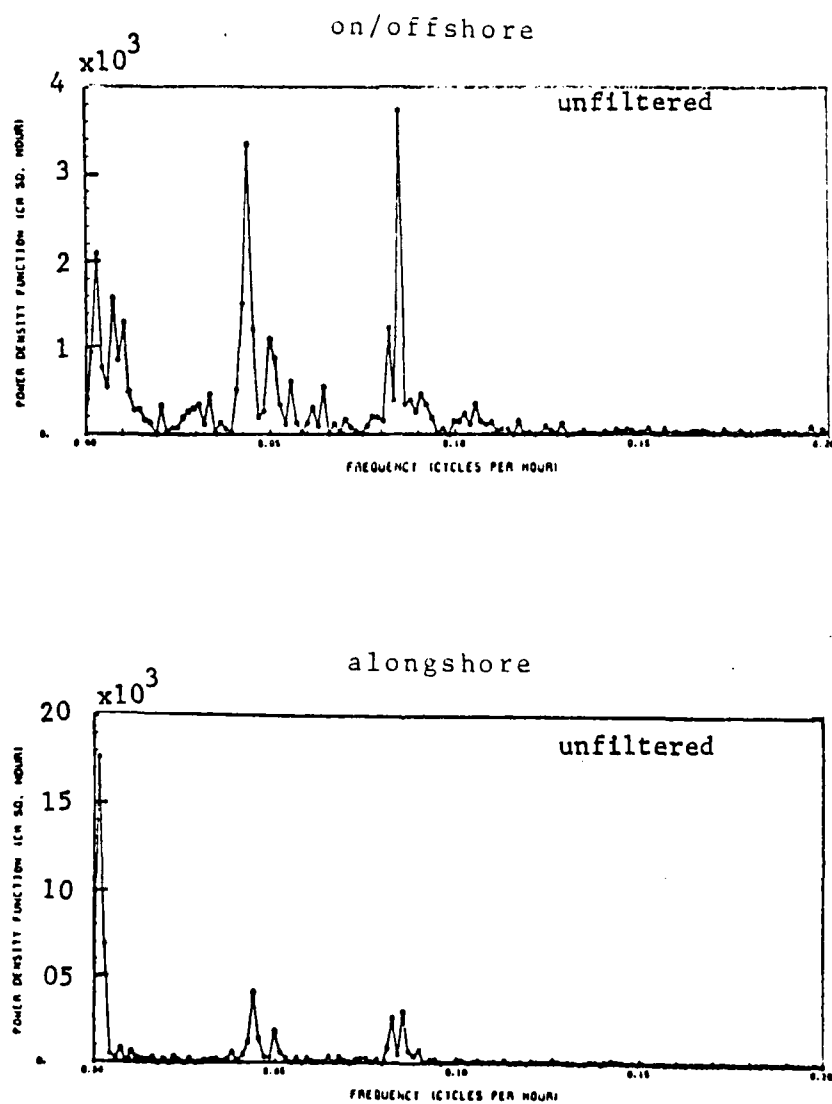


Figure 40. Energy density spectrum of current meter at 127 m depth at Station 7 deployed on 7 October 1979.

Station 7 Meter #842 Depth=200m 7 Oct 79

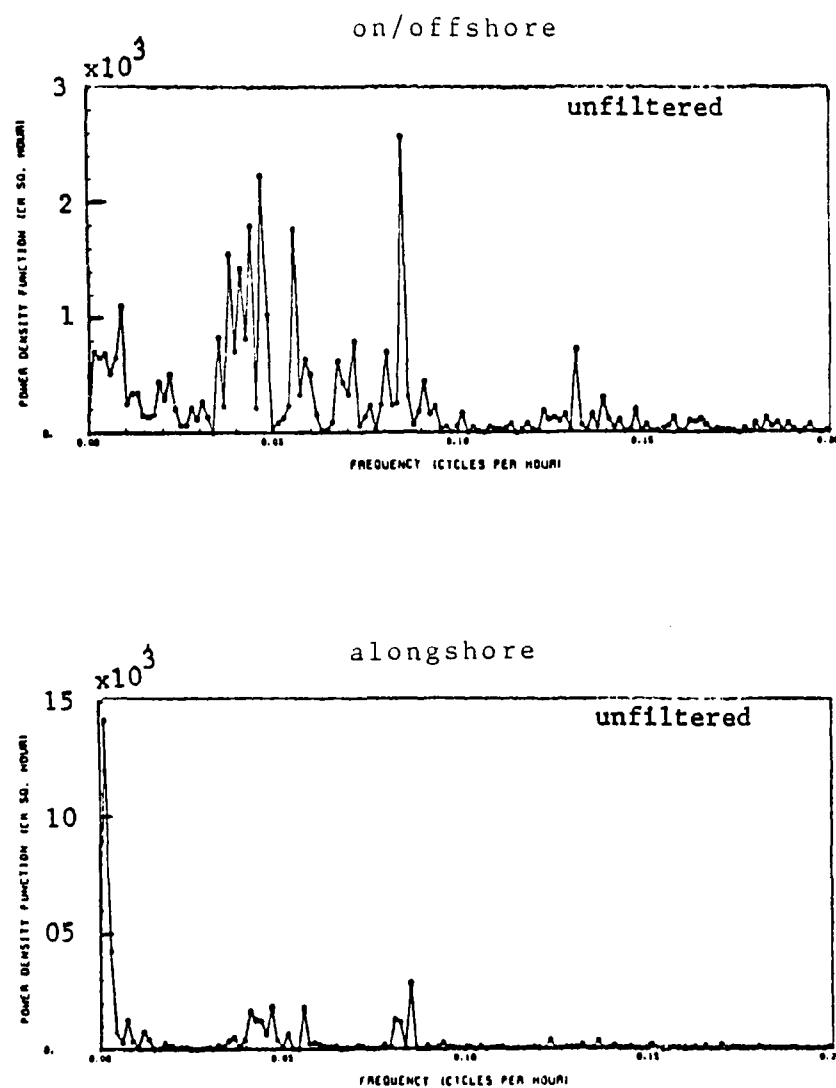


Figure 41. Energy density spectrum of current meter at 200 m depth at Station 7 deployed on 7 October 1979.

Station 2 Meter #1965 Depth=194m 24 Nov 79

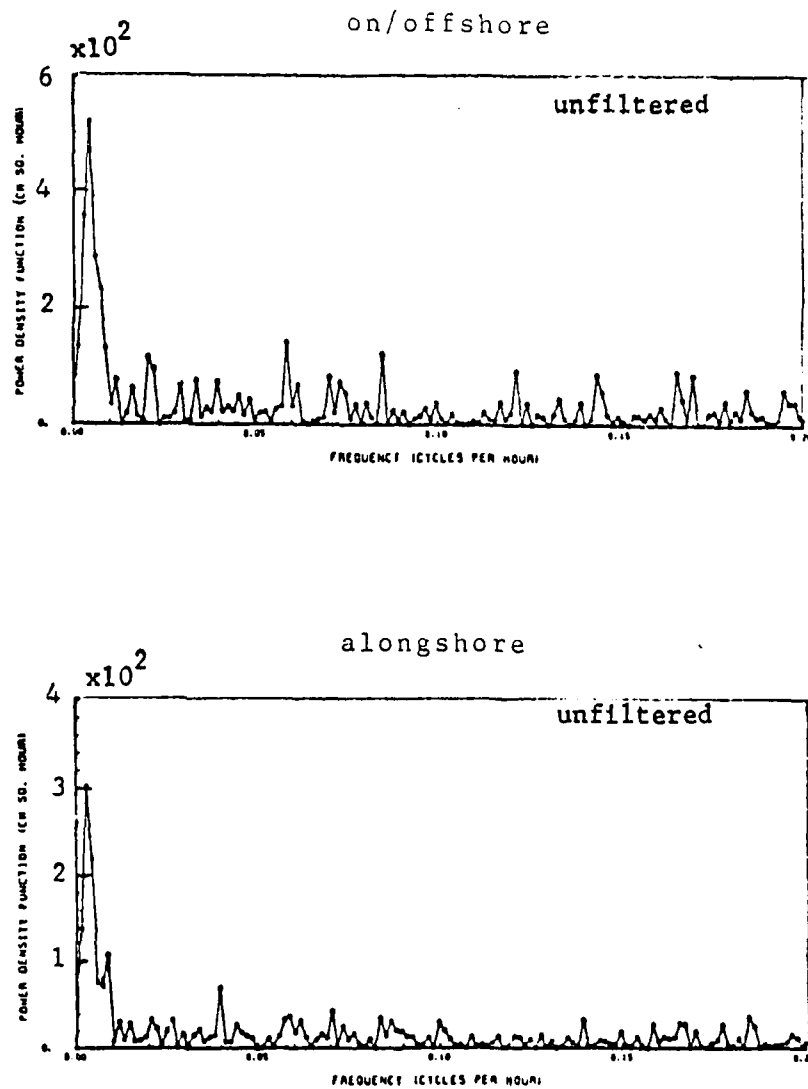


Figure 42. Energy density spectrum of current meter at 194 m depth at Station 2 deployed on 24 November 1979.

Station 2 Meter #1319 Depth=266m 24 Nov 79

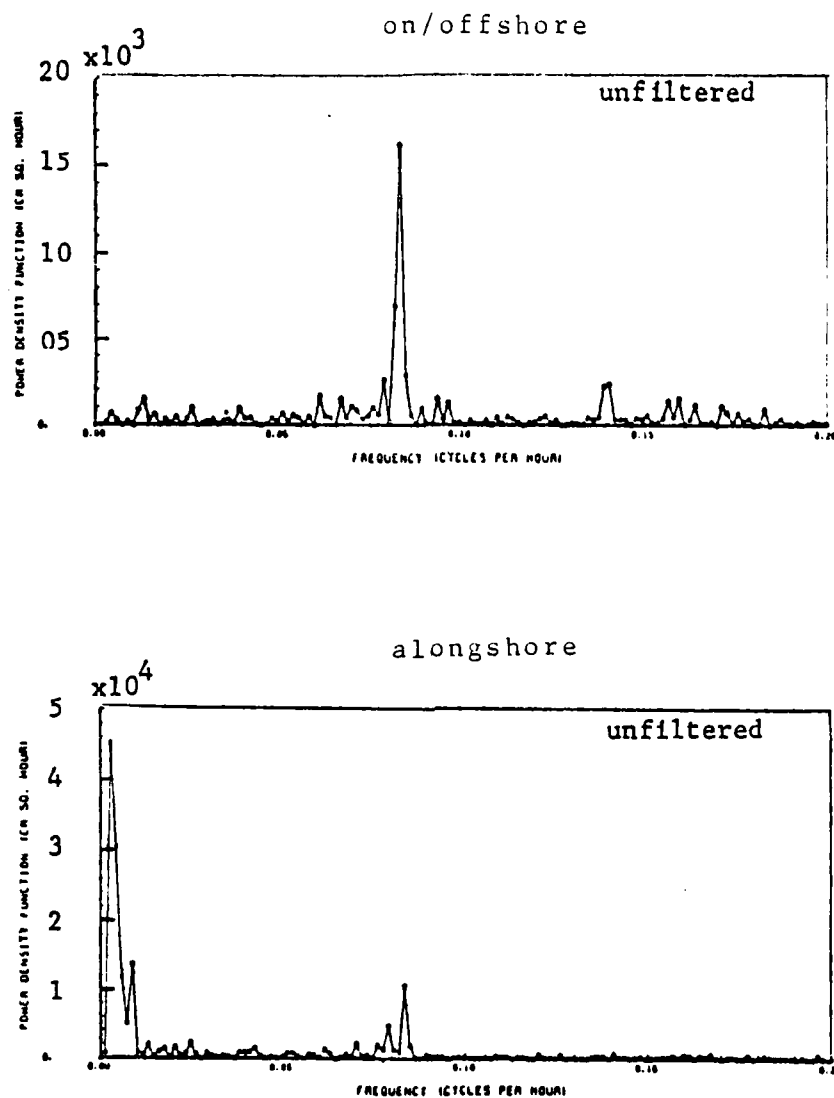
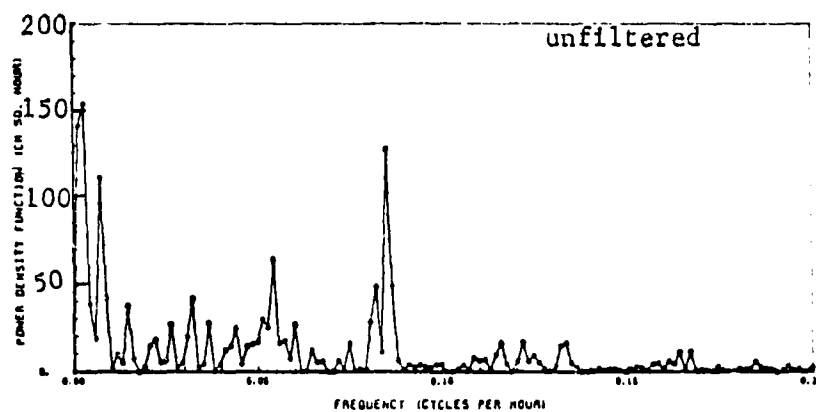


Figure 43. Energy density spectrum of current meter at 266 m depth at Station 2 deployed on 24 November 1979.

Station 7 Meter #2760 Depth=113m 3 Mar 80

on/offshore



alongshore

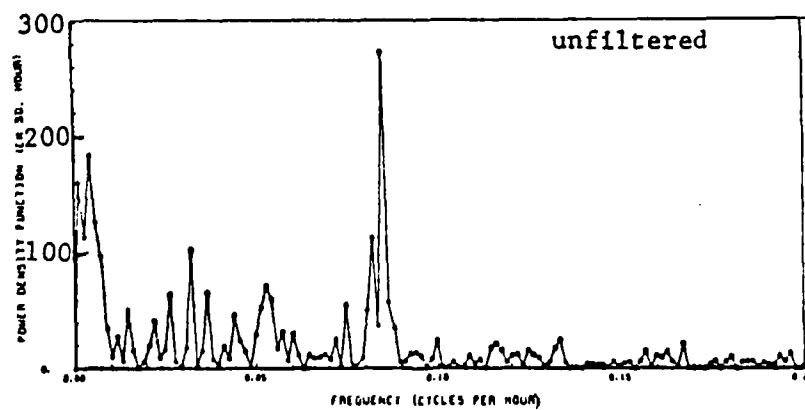


Figure 44. Energy density spectrum of current meter at 113 m depth at Station 7 deployed on 3 March 1980.

Station 7 Meter #842 Depth =186m 3 Mar 80

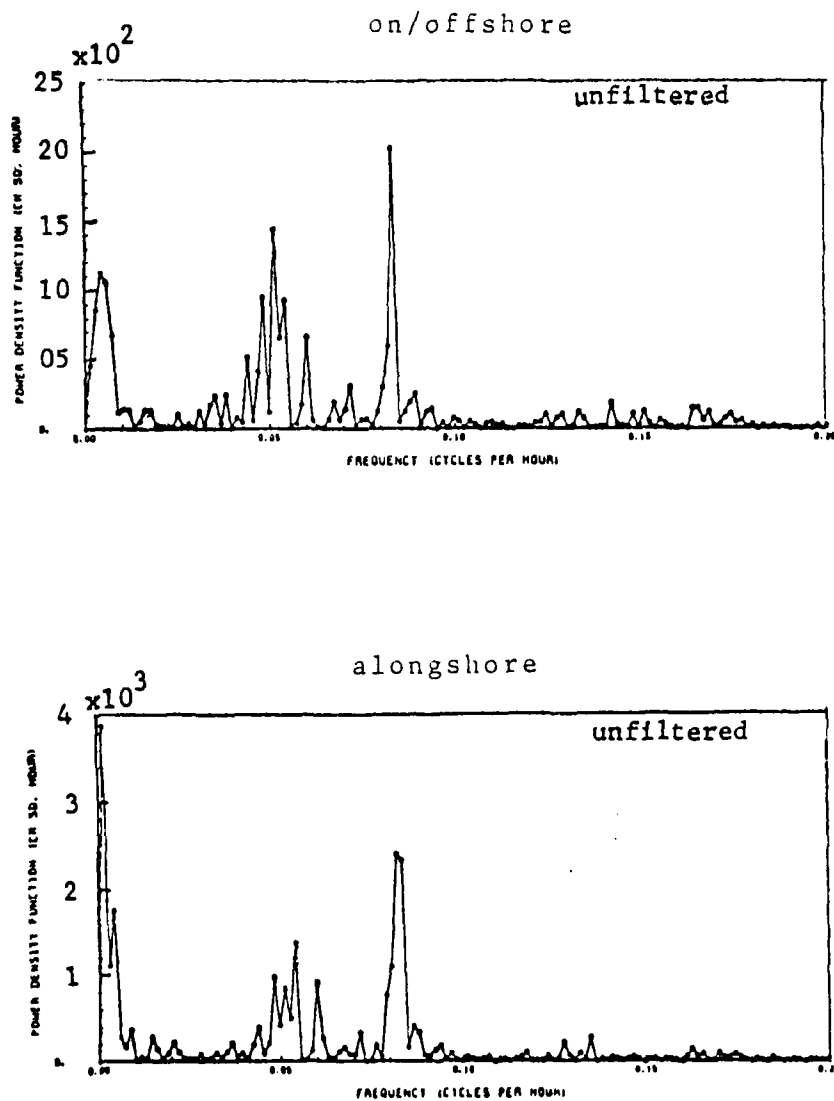


Figure 45. Energy density spectrum of current meter at 186 m depth at Station 7 deployed on 3 March 1980.

Station 7 Meter #762 Depth=311m 3 Mar 80

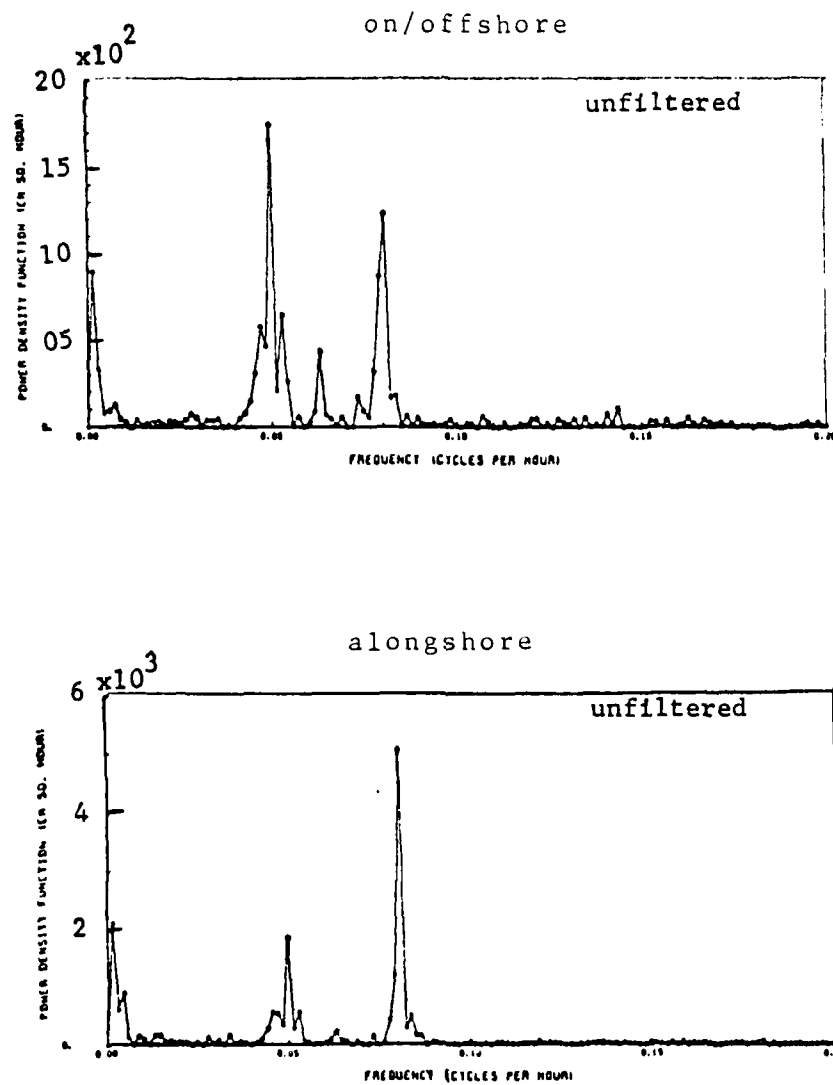


Figure 46. Energy density spectrum of current meter at 311 m depth at Station 7 deployed on 3 March 1980.

APPENDIX C: PROGRESSIVE VECTOR DIAGRAMS

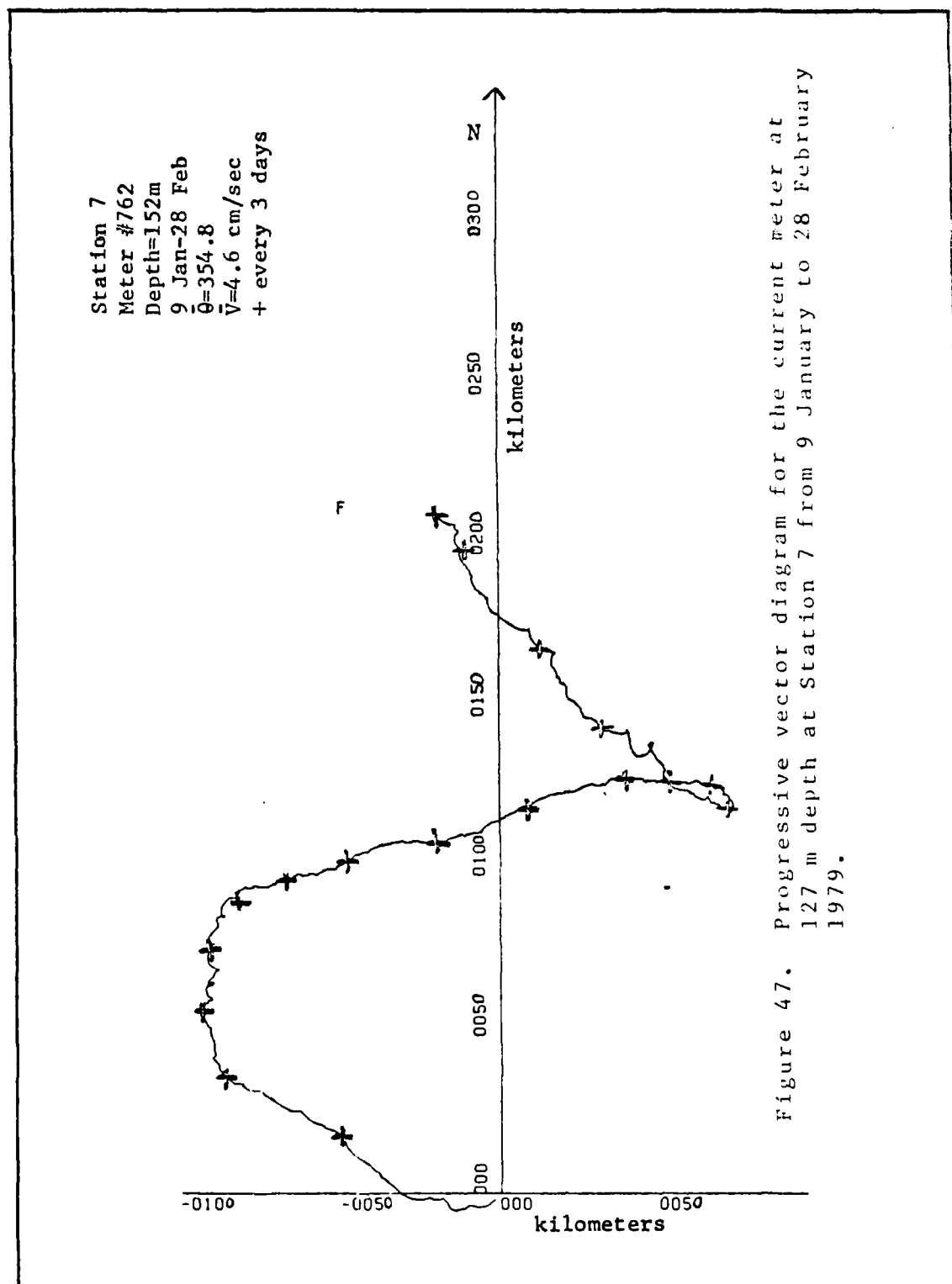
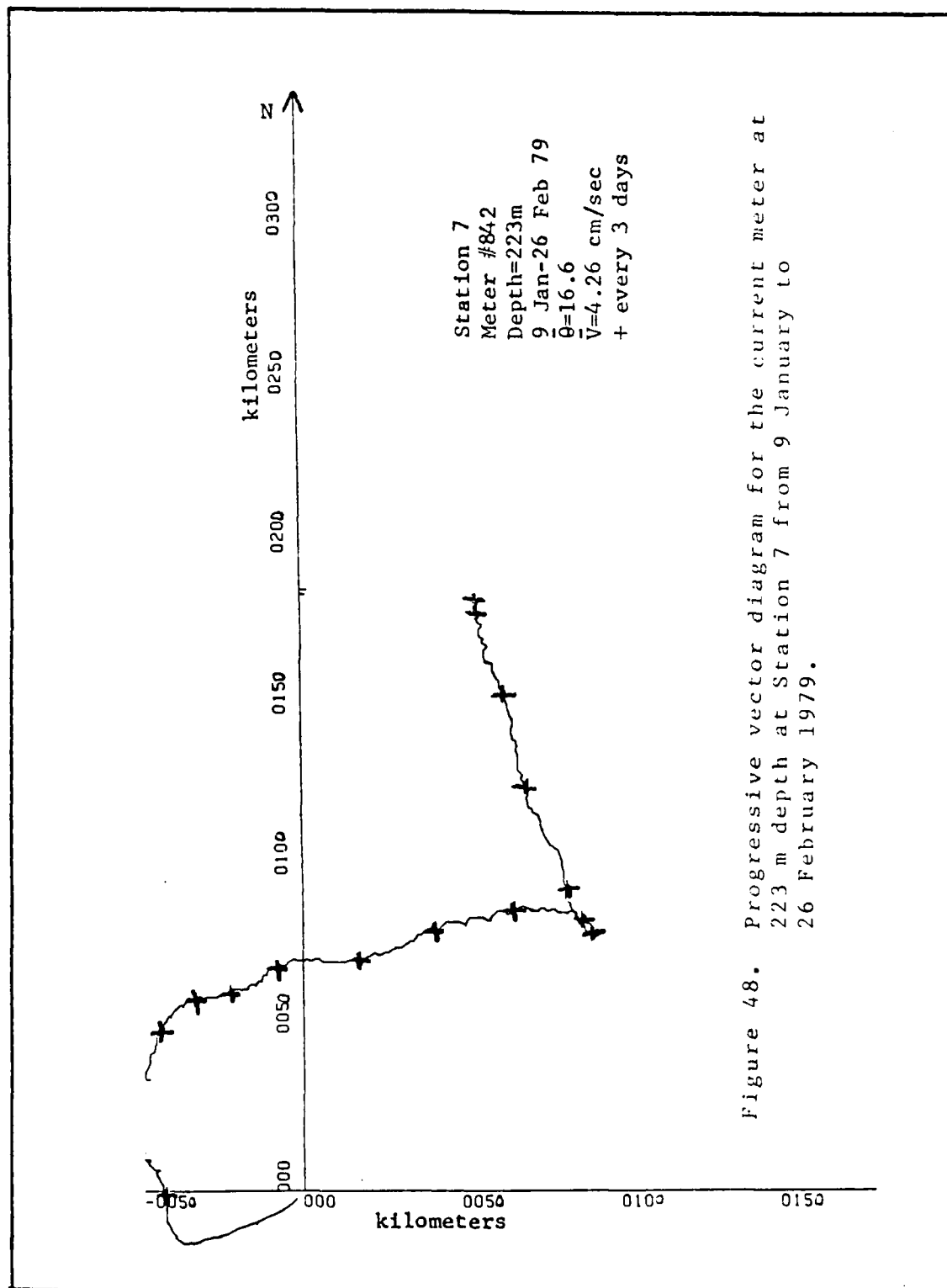


Figure 47. Progressive vector diagram for the current meter at 127 m depth at Station 7 from 9 January to 28 February 1979.



Station 2
 Meter #1965
 Depth=169m
 24 Apr-13 June 79
 $\bar{Q}=341.2$
 $\bar{V}=16.01$ cm/sec
 + every 3 days

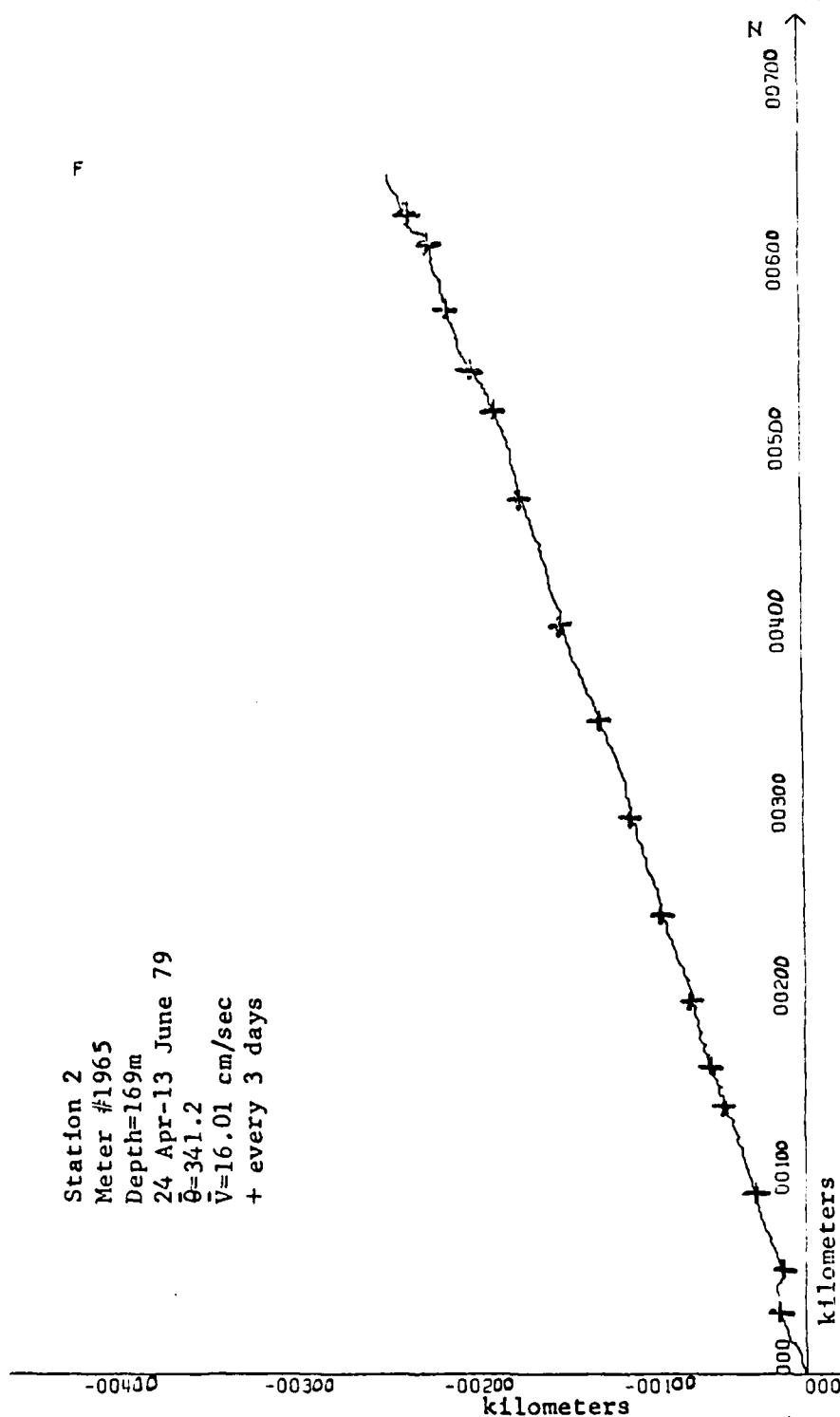


Figure 49. Progressive vector diagram for the current meter at 169 m depth at Station 2 from 24 April to 13 June 1979.

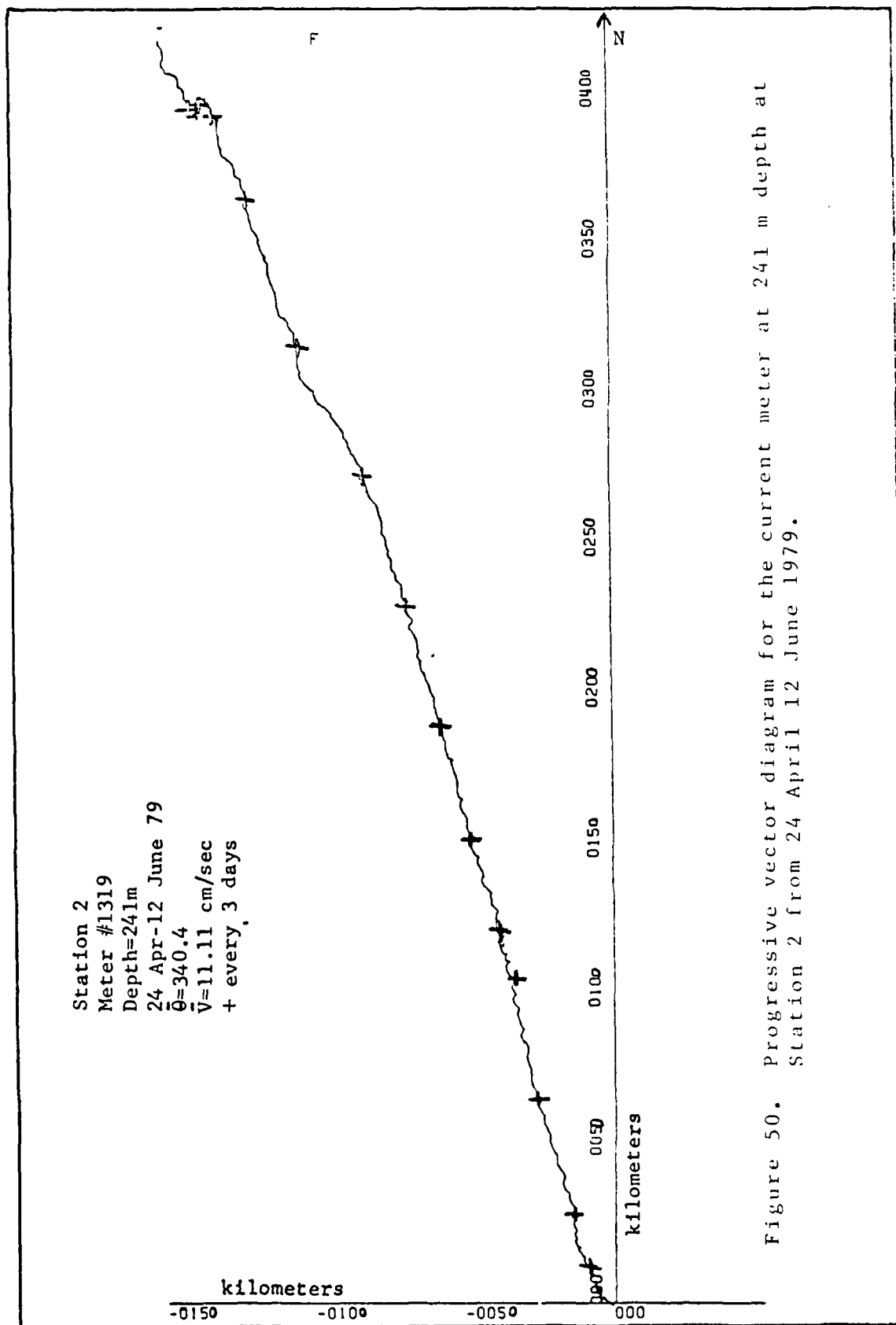


Figure 50. Progressive vector diagram for the current meter at 241 m depth at Station 2 from 24 April 12 June 1979.

Station 7
 Meter #2760
 Depth=158m
 9 Jul-30 Aug 79
 $\bar{\theta}=312.2$
 $\bar{V}=4.51$ cm/sec
 + every 3 days

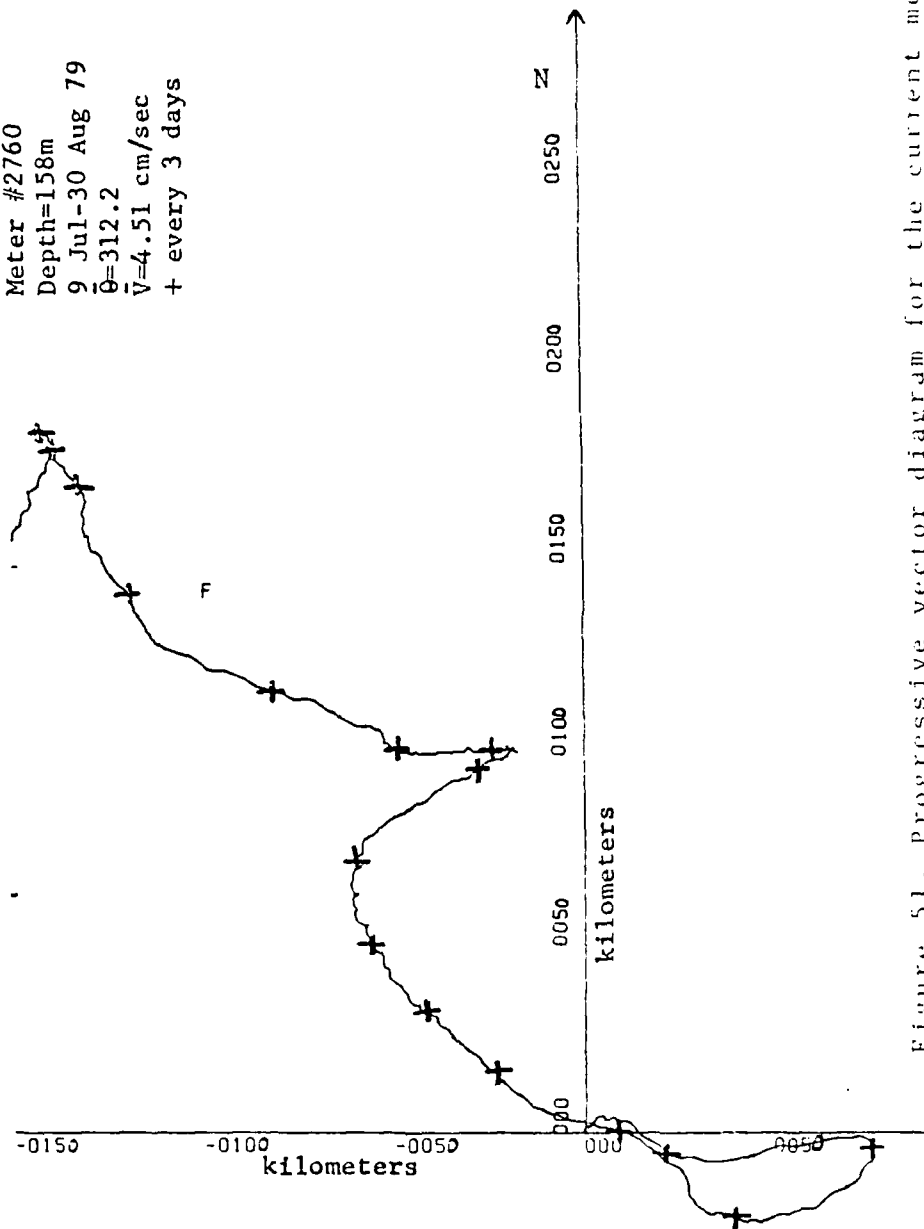


Figure 51. Progressive vector diagram for the current meter at
 158 m depth at Station 7 from 9 July to 30 August
 1979.

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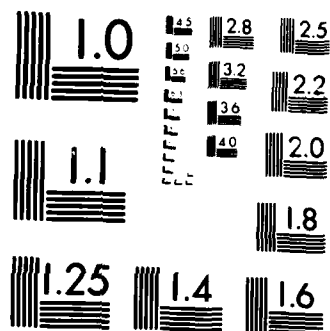
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Station 7
 Meter #842
 Depth=231m
 9 Jul-29 Aug 79
 $\bar{Q}=330.6$
 $\bar{V}=5.84$ cm/sec
 + every 3 days

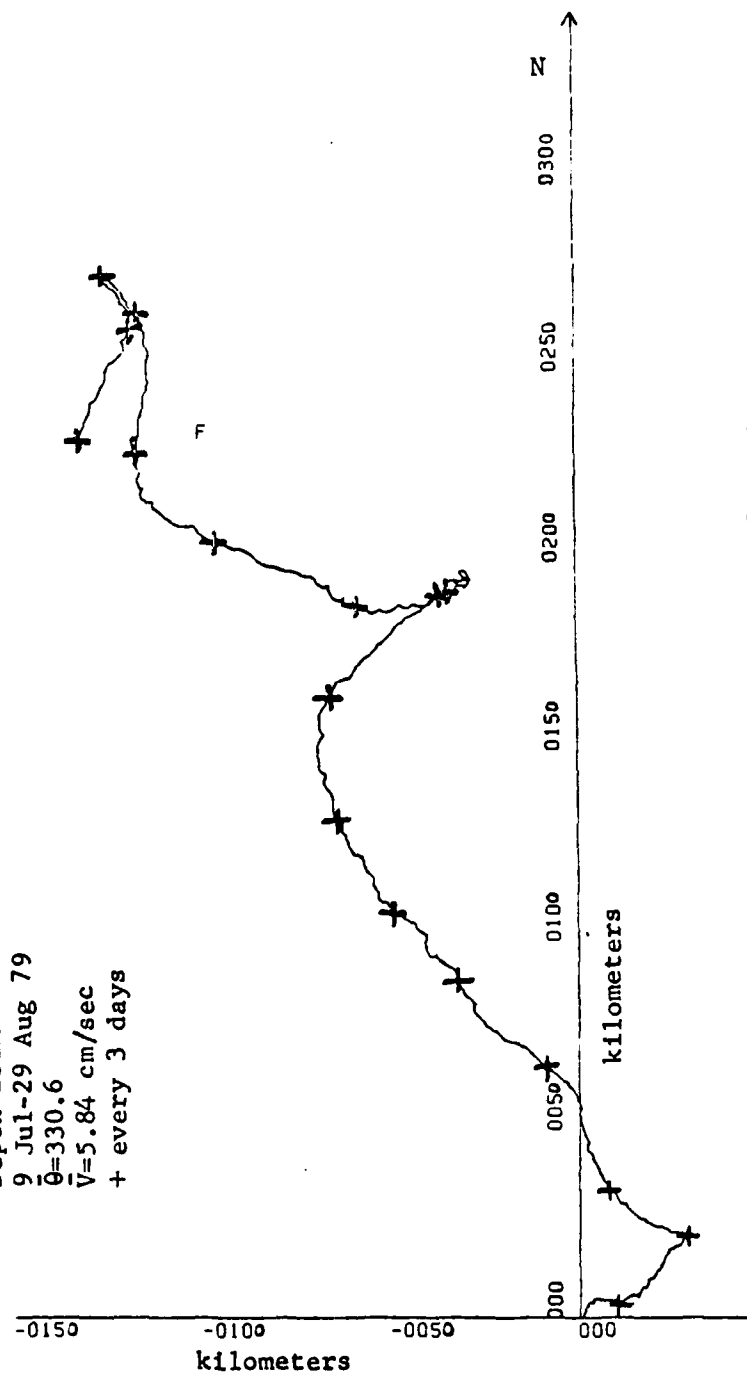


Figure 52. Progressive vector diagram for the current meter at 231 m depth at Station 7 from 9 July to 29 August 1979.

Station 7
 Meter #362
 Depth=356m
 9 Jul-30 Aug 79
 $\bar{\theta}=338.6$
 $\bar{V}=2.77$ cm/sec
 + every 3 days

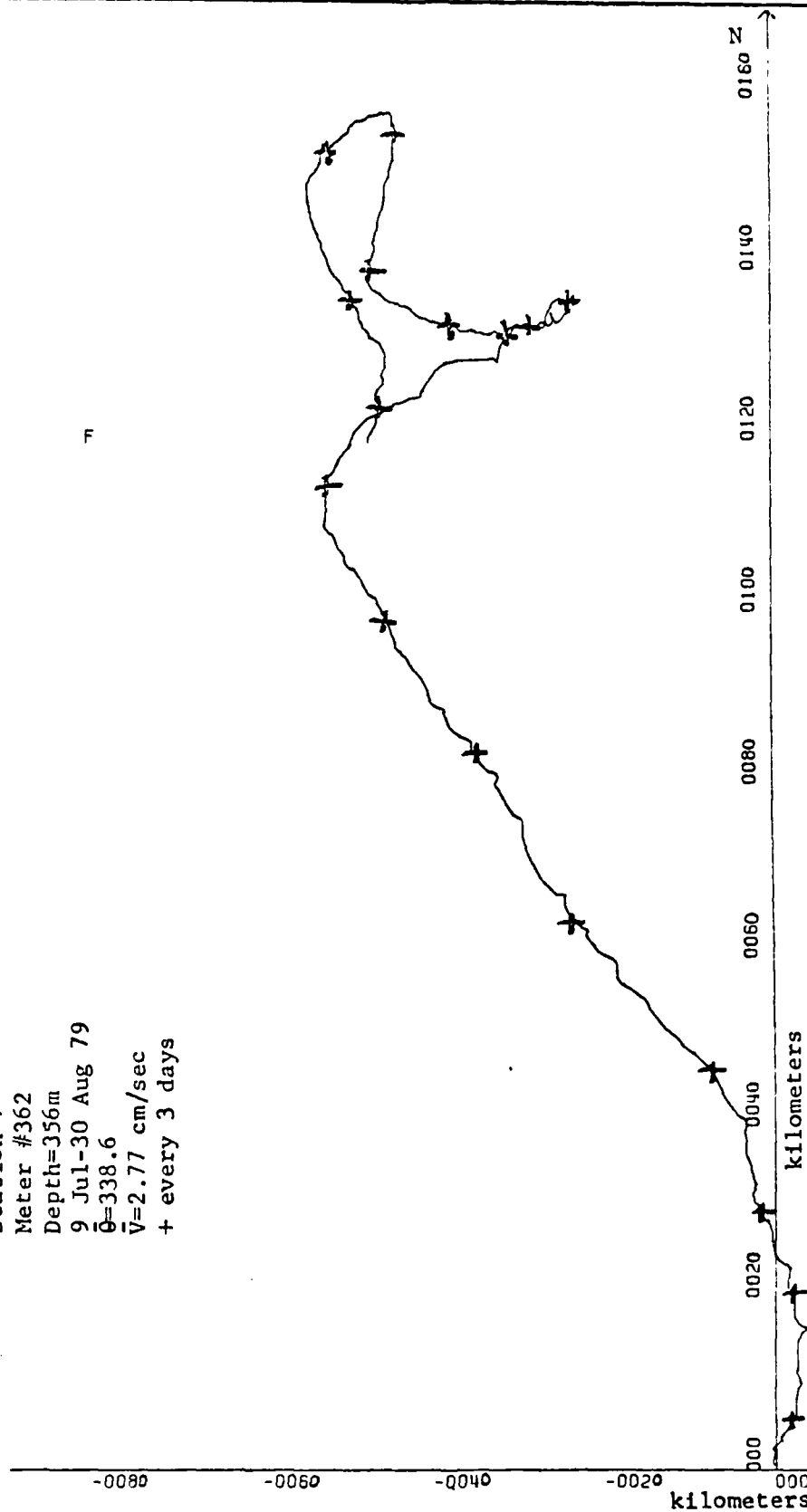


Figure 53. Progressive vector diagram for the current meter at 356 m depth at Station 7 from 9 July to 30 August 1979.

Station 2
 Meter #1965
 Depth=165m
 23 Jul-11 Sep 79
 $\theta=325.1$
 $\bar{V}=6.13$ cm/sec
 + every 3 days

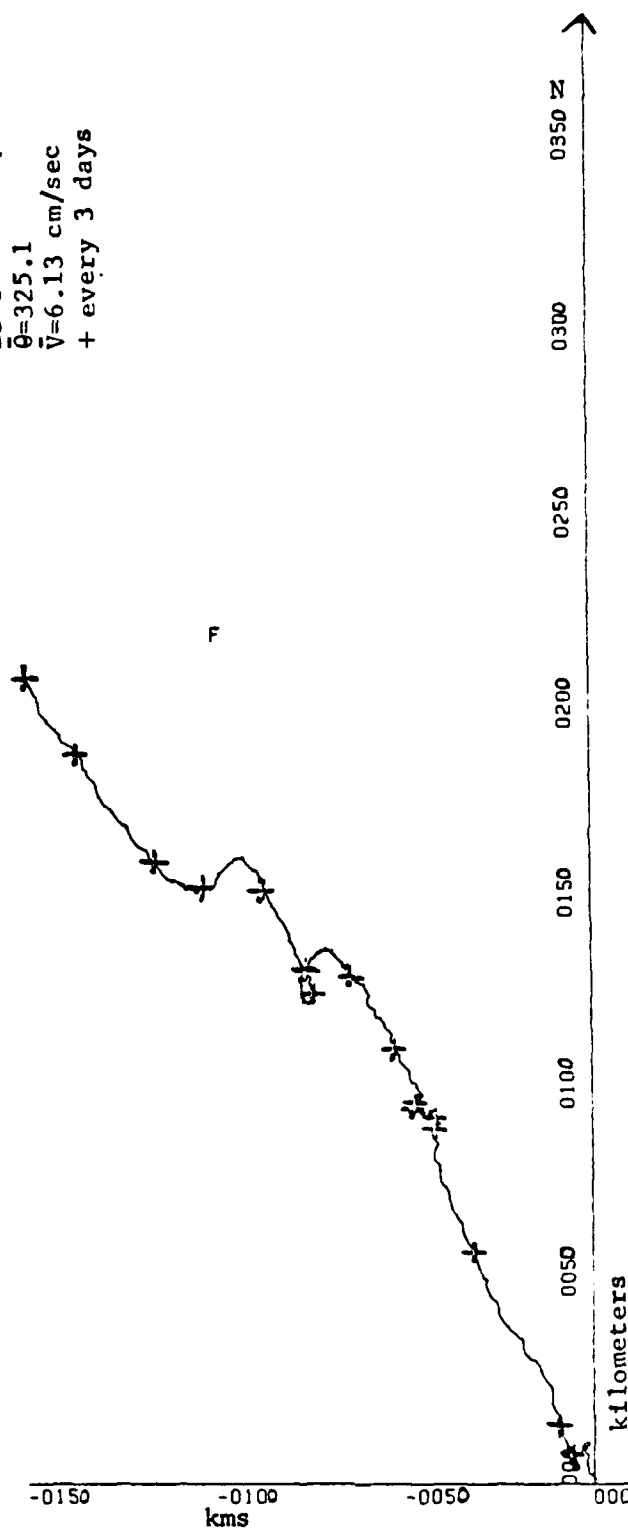
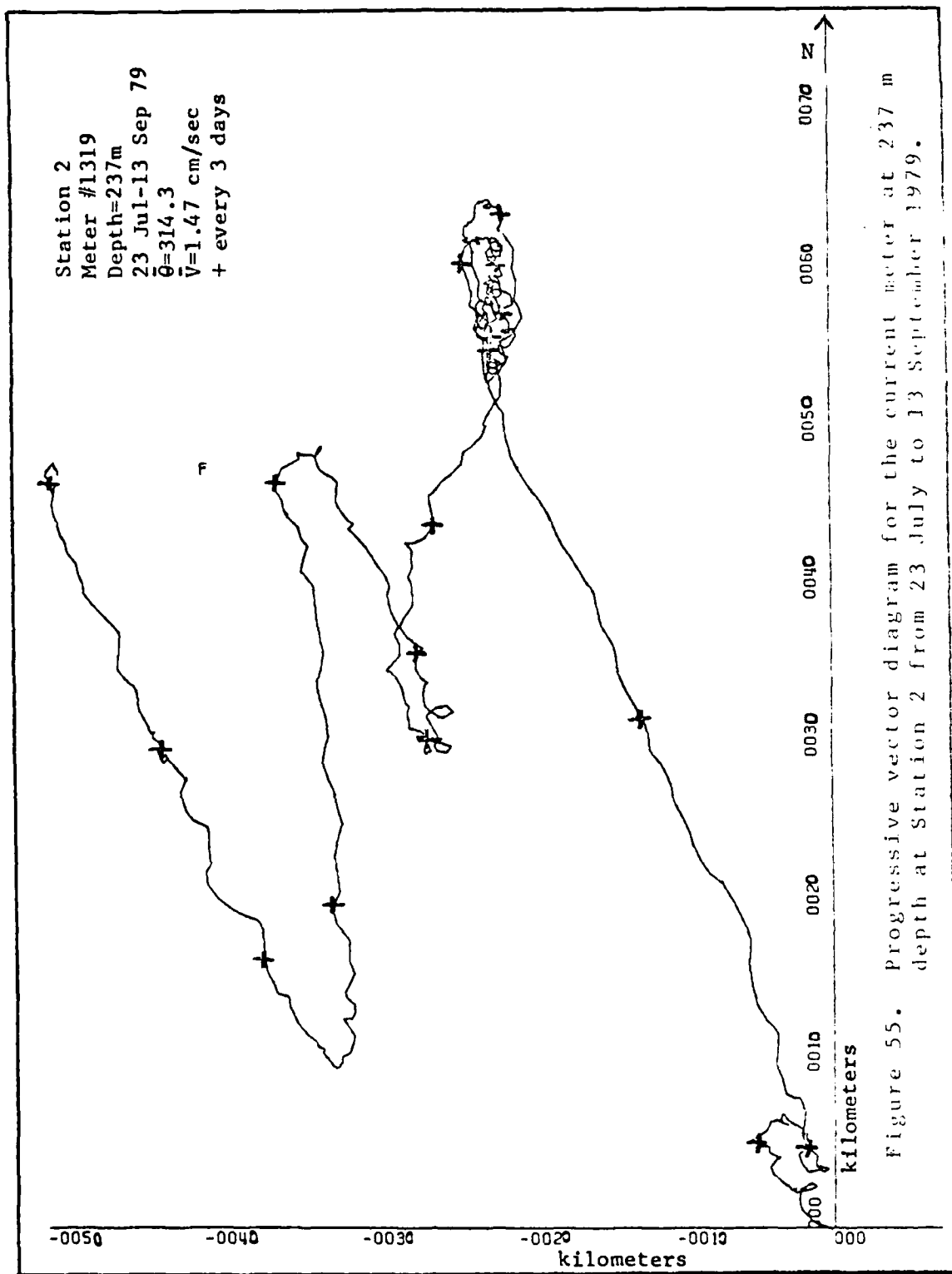
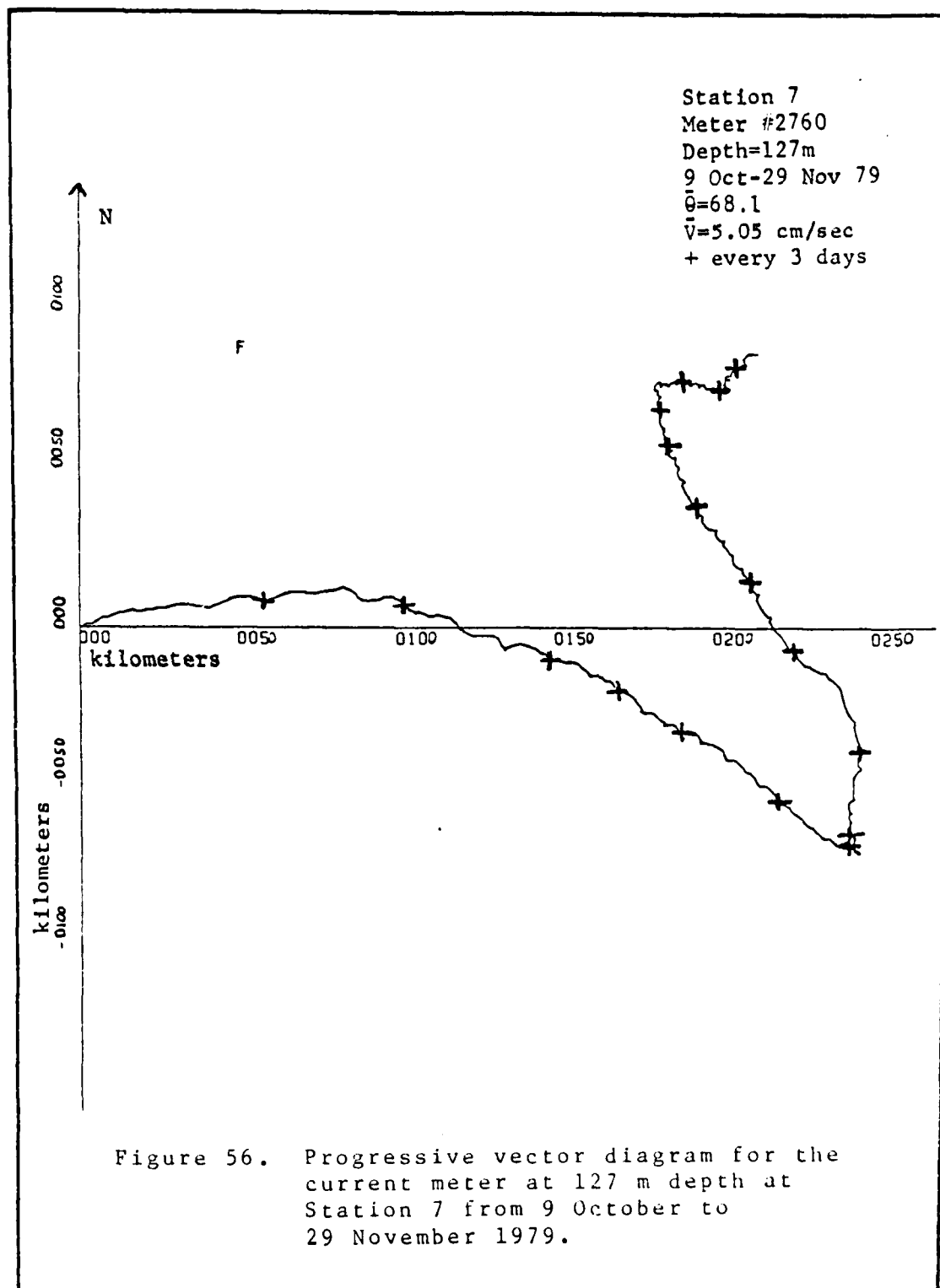


Figure 54. Progressive vector diagram for the current meter at 165 m depth at Station 2 from 23 July to 11 September 1979.







Station 2
 Meter #1965
 Depth=194m
 27 Nov 79-16 Jan 80
 $\bar{\theta}=279.8$
 $\bar{V}=6.24$ cm/sec
 + every 3 days

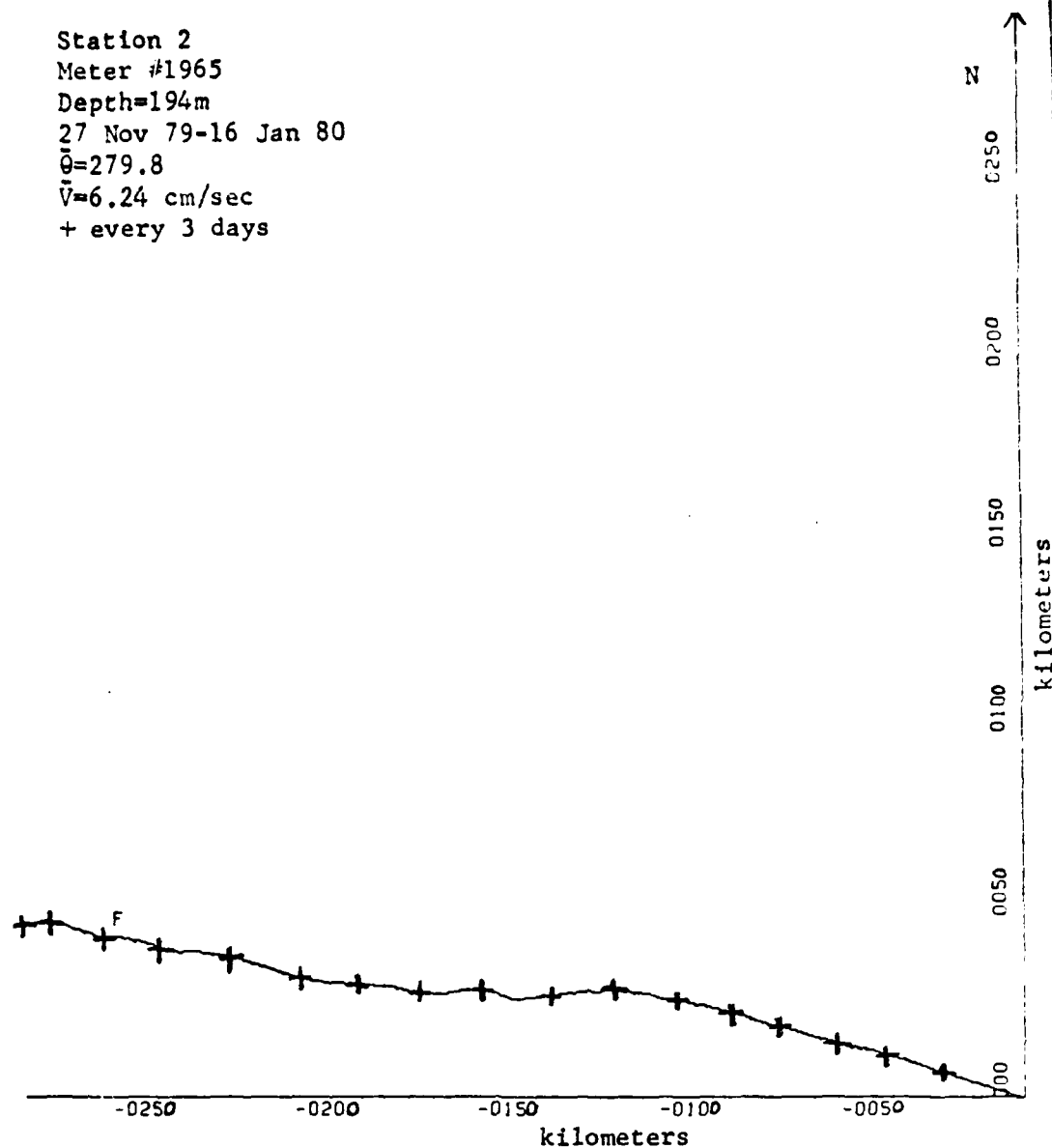


Figure 58. Progressive vector diagram for the current meter at 169 m depth at Station 2 from 27 November 1979 to 16 January 1980.

Station 2
 Meter #1319
 Depth=266m
 27 Nov 79-18 Jan 80
 $\bar{\theta}=3.1$
 $\bar{V}=2.66$ cm/sec
 + every 3 days

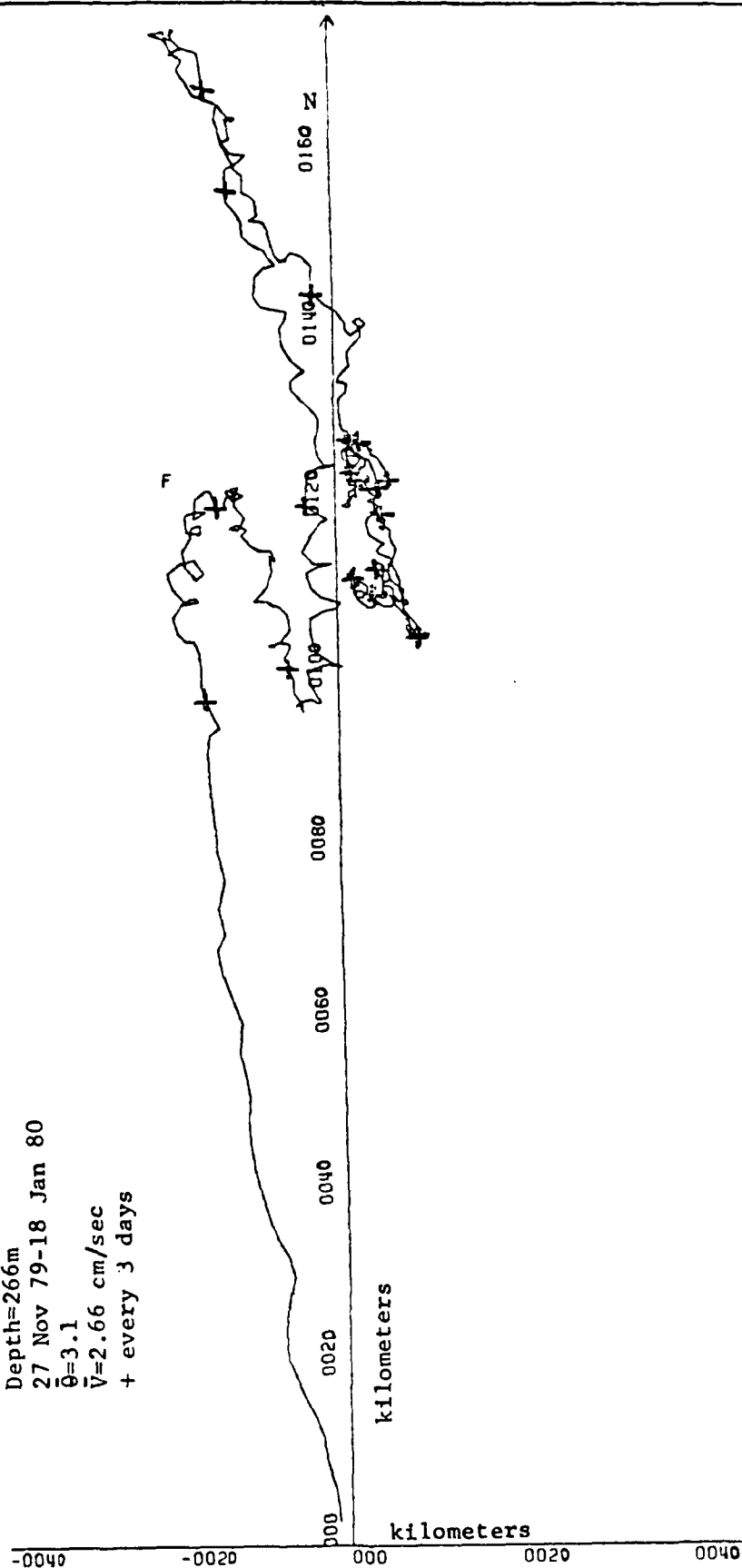


Figure 59. Progressive vector diagram for the current meter at 266 m depth at Station 2 from 27 November 1979 to 18 January 1980.

Station 7
 Meter #2760
 Depth=113m
 4 Mar-15 Apr 80
 $\bar{\theta}=310.5$
 $\bar{V}=4.41$ cm/sec
 + every 3 days

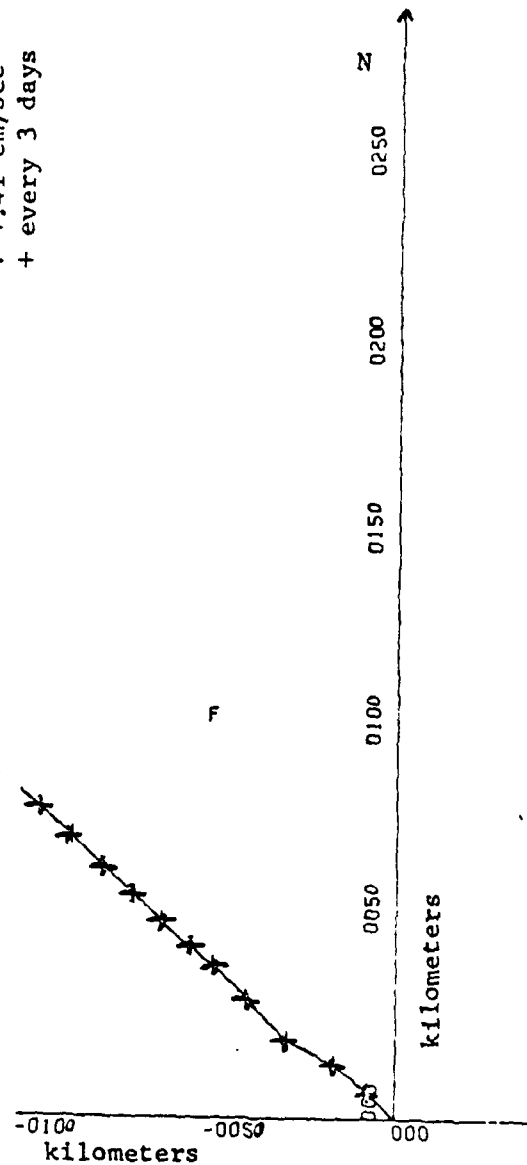


Figure 60. Progressive vector diagram for the current meter at 113 m depth at Station 7 from 4 March to 15 April 1980.

Station 7
 Meter #848
 Depth=186m
 4 Mar-12 Apr 80
 $\bar{\theta}=328.7$
 $\bar{V}=3.43$ cm/sec
 + every 3 days

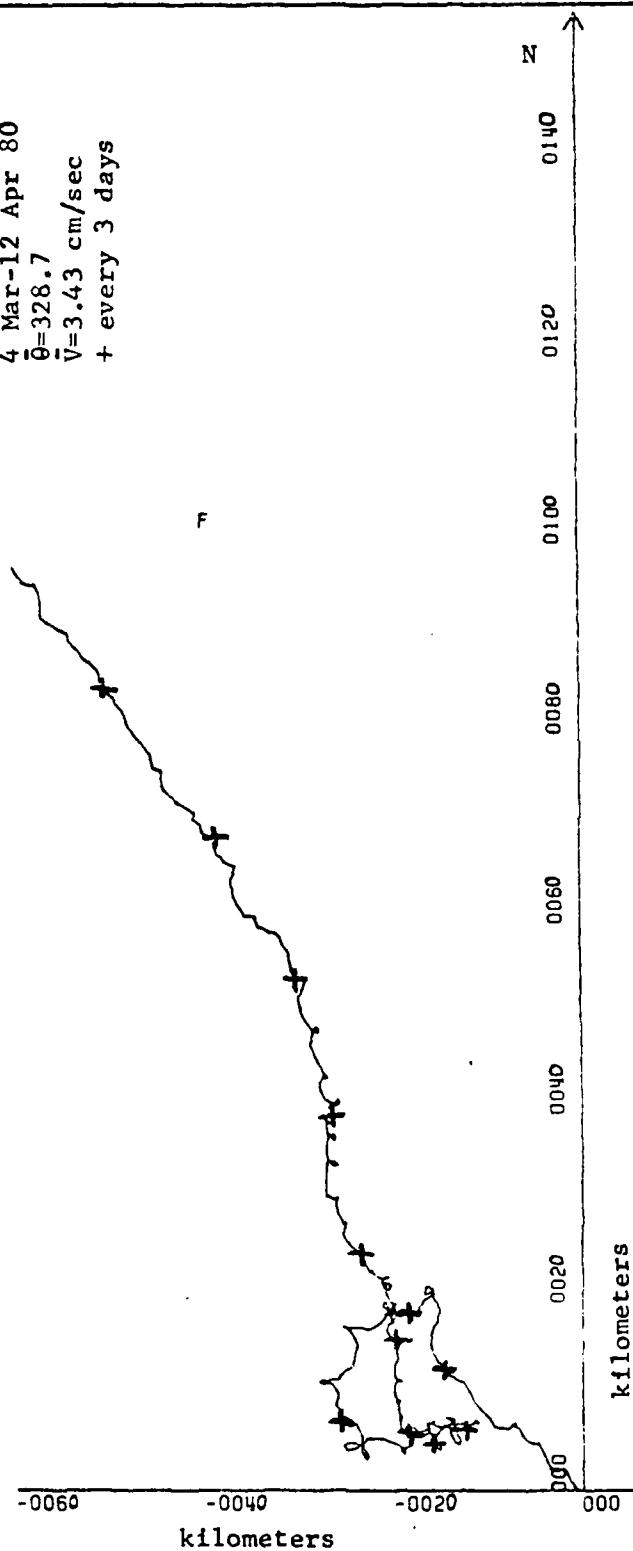


Figure 61. Progressive vector diagram for the current meter at
 186 m depth at Station 7 from 4 March to 12 April 1980.

Station 7
 Meter #762
 Depth=311m
 4 Mar-10 Apr 80
 $\bar{Q}=8.2$
 $\bar{V}=2.67$ cm/sec
 + every 3 days

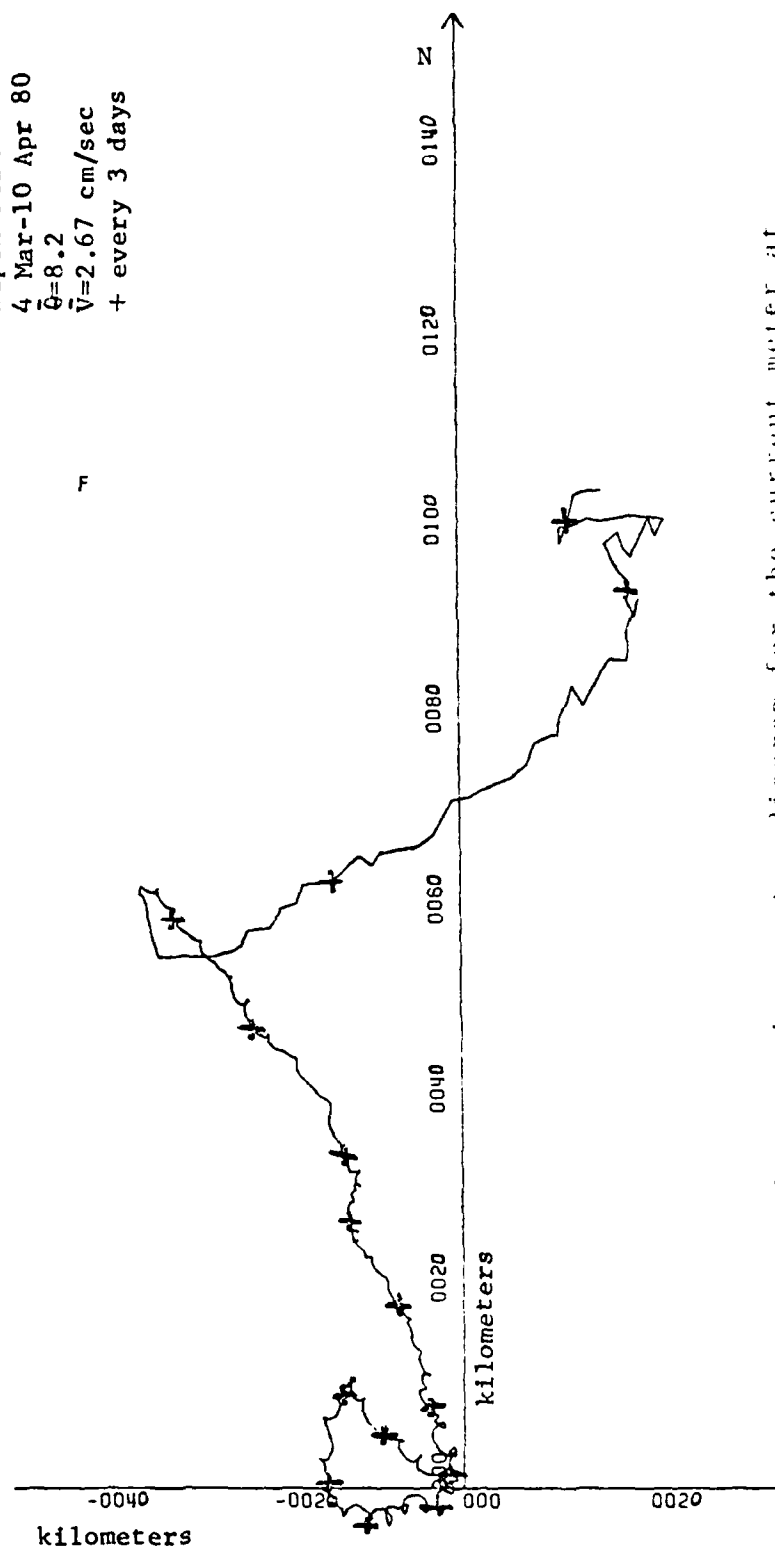


Figure 62. Progressive vector diagram for the current meter at 311 m depth at Station 7 from 4 March to 10 April 1980.

APPENDIX D: COMPUTER PROGRAM LISTINGS

```

C      PLS: ALL PROGRAM FORMATS ARE BASED ON CURRENT METER DATA INPUT
C      SO THAT IT IS FORTRAN READABLE. WRITTEN BY FANS OUELMAH NPS
C      COMPUTER CENTER.
C      BITS: PLS CPT (CNS MAIN);
C      DCL INPUT IF FILE RECORD ENV(CONSECUTIVE);
C      DCL OUTPUT IF FILE RECORD ENV(CONSECUTIVE);
C      DCL FIELDX CHAR(512) VARYING STATIC;
C      DCL FIELDY(512) CHAR(1) BASED(1);
C      DCL 1 SYNCBIT(512) BASED(1),
C           2 312 311(2),
C           3 SYNCBIT(1),
C           4 345576 BIT(5);
C      DCL (P,Q) POINTER STATIC;
C      CN STD FILE(SYSIN) GOTO NCKCOUNT;
C      DCL END IF FILE(INPUT) GOTO THEEND;
C      JCKCOUNT;
C      OPEN FILE (INPUT) INPUT;
C      OPEN FILE (OUTPUT) OUTPUT;
C      P = ADDR(FIELDX);
C      KJUL, KCOUNT = 0;
C      KK=C;
C      IAXK=133;
C      I=0;
C      IF (KK) THEN GOTO THEEND;
C      KK=KK+1;
C      READ FILE (INPUT) INTO (FIELDX);
C      N = LENGTH(FIELDX);
C      DO J=1 TO N;
C      IF I=0 I=1; IF I=1 THEN DO;
C      IF SYNCBIT.SYNCE(J) = '1' THEN DO;
C      I = 1;
C      END; /* IF SYNC.BIT */
C      IF SYNCBIT.SYNCE(J+1)='1' THEN DO;
C      GOTO XX;
C      END;
C      I = I+1; IF I=1 THEN DO;
C      IF I=1 THEN PUT SKIP(1);
C      P = ADDR(FIELDY(J));
C      CALL STOREY (P,I);
C      END; /* IF I < 7 */
C      J=J+1;
C      XX;
C      END; /* DC - = 1 TO K */
C      GOTO LOOP;
C      THEEND;

```

```

PUT EDIT (X$, 'BLOCKS READ',
          XOUT, 'RECORDS WRITTEN')
(SKIP(1), F(6), A, F(6), A);
STORED: P(1);
DCL CUTFIELD(6) BIT(16) STATIC;
DCL OUT(6) FIXED BIN(15) BASED();
DCL C_POINTER;
DCL P_POINTER;
DCL INFIELE BIT(16) BASED(P);
DCL INFIELE CUTFIELD(1) ;
DCL =ADDR(CUTFIELD(1),1,6) = 'CCCCC)'B;
DO I=1 TO 6;
  SUBSTR(CUTFIELD(1),I+1,1)=SUBSTR(INFIELE,I+3,1);
  SUBSTR(CUTFIELD(1),I+6,1)=SUBSTR(INFIELE,I+11);
END;
PUT EDIT(CUTFIELD(1))(X(4),F(6));
IF I = 6 THEN DO;
  XOUT = XOUT + 1;
  WRITE FILE(CUTF(1)) FROM(CUTFIELD);
END; /* IF I = 6 */
END; /* STOP */
END; /* THE PROGRAM */

```

```

C C THIS PROGRAM APPLIES CALIBRATION PARAMETERS TO AMCERAA CURRENT
C C METER DATA, ACCORDING TO EACH INDIVIDUAL CURRENT METER'S
C C SPECIFICATIONS.
C C INTEGER * 2 AR(50000)
C C REAL XXX(6) / 6 * 5. /
C C
C C READ IN RAW DATA.
C C
22 READ(2,2),END=90)(AR(1),I=11,12)
23 FORMAT(6A2)
11=12+1
12=12+6
GO TO 22
C C
C C LOCATE REF NUMBER IN THE RECORD.
C C USE A WINDOW OF APPROXIMATELY 20, IN CASE SYNCBIT SLIPS.
C C
90 IF (AR(M).LE.970.AND.AR(M).GE.990) GO TO 5
M=M+1
GO TO 90
C C
C C IF REF# OUTSIDE WINDOW, DATA CONSIDERED FAULTY. ZERO OUT ALL
C C VALUES.
C C
5 IF (AR(M).GE.971.AND.AR(M).LE.999) GO TO 10
C C
C C CALIBRATION PARAMETERS APPLIED. FORMULAS ARE FROM AMCERAA
C C OPERATION MANUAL. SALINITY AND PRESSURE SENSORS ARE NOT USED.
C C
1 T=-2.7922+ (.02277*AR(M+1))- (.1344*(10.**(-5))*(AR(M+1)*2))+
1 (.1337*(10.**(-8))*(AR(M+1)*3))
S=0.0
P=1.0
D=C.3322*AR(M+4)
IF (AR(M+5).EQ. 0.) GO TO 50
V=1.033+ 168*AR(M+5)/60
C) TO EC
V=J.0
50 REF=AR(N)
WRITE (6,150) IR,REF,T,S,P,V
150 FORMAT(1,4X,I6,6(4X,F7.2))
WRITE CALIBRATED DATA VALUES (10 MINUTE) TO MASS STORAGE.
WRITE (1) IR,REF,T,S,P,V
P=0.0+6
IR=IR+1
IF (M.GT.50000) GO TO 100
GO TO 3

```

```

10  WRITE (6,150) IR,XXX
    WRITE (1) IR,XXX
    IR=IR+1
    IF (N.(1.50000) GE 10 100
    N=N+6
    GO TO 1
100 ENDFILE 1
    STOP
    END

```

```

C THIS PROGRAM USES TEN MINUTE CALIBRATED DATA VALUES AS INPUT.
C MISSING RECORDS ARE FILLED IN AND A BINOMIAL FILTER IS USED TO
C CREATE FAULTY VALUES. FAULT PLOTS ARE PRODUCED; CURRENT DIRECTION
C VS SPEED VS TIME, U COMPONENTS VS TIME, V COMPONENT VS TIME, AND
C TEMPERATURE VS TIME.
C DIMENSION I(10000), CIR(10000), SPD(10000), AR(6), REF(10000),
C LU(10000), V(10000), I(10000), PRSP(1700), TRU(10000), THETA(10000),
C FOUR(1700), HOURV(1700), FOURI(1700), TEM(10000)
C FORMAT (1X,110,2F10.2)
C J=0
C
C READ DATA FROM MASS STORAGE
C
20 READ(1,END=25) 11,AR
C   IK(11)=11
C   REF(11)=AR(1)
C   TEM(11)=AR(2)
C   SAL=AR(3)
C   PRSP=AR(4)
C   CIR(11)=AR(5)
C   SPD(11)=AR(6)
C   GU TC 20
C 25 CONTINUE
C   NPIS=IR(11)
C
C CREATE ARTIFICIAL VALUES FOR MISSING RECORDS. (THIS SUBROUTINE
C LEAVES THE REFERENCE NUMBER ZERO FOR READY IDENTIFICATION OF
C ARTIFICIAL VALUES.)
C
C   MPTS=NPIS-2
C   GU 7 123, MPTS
C   WARNING: CURRENT SPEEDS GREATER THAN 100 CM/SEC ARE NOT ACCEPTED
C   HERE BUT SUBSTITUTED WITH INTERPOLATED VALUES.
C   IF (SPC(1).GE.100) GO TC 6
C   IF (REF(1).NE.0.) GO TC 5
C   CALL FILLER(1,SPD,CIR,SPCUT,JROUT)
C   SPC(1)=SPCUT
C   CIR(1)=CROUT
C   INSURE TEMPERATURE VALUES ARE WITHIN ACCEPTABLE LIMITS. AVG10
C   INTERPOLATION: FAULTY DATA BY SEARCHING DOWN THE RECORD FOR AN
C   ACCEPTABLE VALUE.
C   5 IF (TEM(1).GE.5.0.AND.TEM(1).LE.12.0) GO TC 7
C   J=1
C   IF (TEM(J+1).GE.5.0.AND.TEM(J+1).LE.12.0) GO TC 3
C   J=J+1
C   GO TO 2
C   3 TEM=(TEM(1-1)+TEM(J+1))/2.
C   TEM(1)=TEM

```

```

7  CCUTLAGE
CC  CREATE A REPRESENTATIVE FOURLY CURRENT VALUE FROM THE 10 MINUTE
CC  RECORDS.
      NPIS6=NPIS/6)
      CALL RMEAN(NPIS,NPIS6,SPJ,OIR,HKSPD,U,V,T,TRU,THETA,IEM,
1    FOURC,HOURC,HOURT,RHOF)
CC  CREATE DATA PLOTS.
      NPIS=NPIS6
      NPIS2=NPIS+2
      CALL STKFLT(NPIS,NPIS2,IF,HRSPC,HOURU,FCURV,FCURT,RHUT)
      STOP
      END
SUBROUTINE FILLER (I,SPC,CIR,SPDOUT,CIRCUT)
CC  SUBROUTINE FILLER CREATES SPEED AND DIRECTION VALUES FOR THE CURRENT
CC  METER RECORD. THIS IS DONE TO PROVIDE REASONABLE APPROXIMATIONS
CC  FOR THE OCCASIONAL RECORD MISSED DUE TO INSTRUMENT (METER)
CC  MALFUNCTION. THE AVERAGING ROUTINE AVOIDS INCORPORATING FAULTY
CC  DATA.
      DIMENSION CIR(1),SPD(1)
      IF (SPD(J+1).LE.100.)GC IC 5
      J=J+1
      SPDOUT=(SPD(I-1)+SPD(J+1))/2.
      IF (CIR(I-1).LE.90..AND.CIR(I+1).GT.270.) GC IC 10
      IF (CIR(I-1).GT.270..AND.CIR(I+1).LE.90.) GC IC 10
      IF (CIR(I-1)-CIR(I+1).GT.180.) GC IC 15
      IF (CIR(I+1)-CIR(I-1).GT.180.) GC IC 15
      CIRCUT=(CIR(I-1)+CIR(I+1))/2.
      GO TO 20
10  CIRCUT=(CIR(I-1)-CIR(I+1))/2.+CIR(I+1)+180.
      IF (CIRCUT.GE.360.) CIRCUT=CIRCUT-360.
      IF (CIRCUT.LE.0.) CIRCUT=CIRCUT+360.
      GO TO 20
15  CIRCUT=(CIR(I-1)+CIR(I+1))/2.+180.
      GO TO 20
20  CONTINUE
      RETURN
      END
SUBROUTINE RMEAN(NPIS,NPIS6,SPC,OIR,HRSPC,U,V,T,TRU,THETA,

```

```

C C C C
1 TEM, HCURU, HCURV, HCURT, PRCTI)
SUBROUTINE FMEAN: CREATES HOURLY CURRENT VALUES AND TEMPERATURE
VALUES FROM A 9-POINT WEIGHTED BINOMIAL FILTER.
C
C DIMENSION SPD(NPTS), CIR(NPTS), H:SPD(NPTS), HCURU(NPTS),
HCURV(NPTS), HCURT(NPTS), U(NPTS), V(NPTS), T(NPTS), TRU(NPTS),
T(NPTS), TEN(NPTS)
NPTS=NPTS-8
DO 10 I=1, NPTS
APPLY VARIANCE CORRECTION TO MAGNETIC DIRECTIONS.
VAR=1.0/
TRU(I)=CIR(I)+VAR
IF (TRU(I).GE.360.) TRU(I)=TRU(I)-360.
CONVERT TO RADIANS.
THETA(I)=TRU(I)*(.017453)
U(I)=SPD(I)*SIN(THETA(I))
V(I)=SPD(I)*COS(THETA(I))
WRITE TO MINUTE U & V COMPONENTS TO MASS STORAGE.
XRITE (2,250) U(I),V(I)
FORMAT (2F12.5)
250 CONTINUE
10
J=0
N=0
FUT=0.
DO 20 I=1, NPTS, 6
J=J+1
U1=1.*U(I)
U2=0.*U(I+1)
U3=28.*U(I+2)
U4=59.*U(I+3)
U5=79.*U(I+4)
U6=56.*U(I+5)
U7=28.*U(I+6)
U8=8.*U(I+7)
U9=1.*U(I+8)
FUTR U (J)=(U1+U2+U3+U4+U5+U6+U7+U8+U9)/
1 V1=1.*V(I)
V2=8.*V(I+1)
V3=28.*V(I+2)
V4=59.*V(I+3)
V5=79.*V(I+4)
V6=56.*V(I+5)
V7=28.*V(I+6)
V8=8.*V(I+7)
V9=1.*V(I+8)

```

```

100 HCURV(1) = (V1+V2+V3+V4+V5+V6+V7+V8+V9)/
11 (2.*1.+2.*8.+2.*28.+2.*56.+70.)
12 T1=1.*TEM(1)
13 T2=2.*TEM(1+1)
14 T3=3.*TEM(1+2)
15 T4=56.*TEM(1+3)
16 T5=70.*TEM(1+4)
17 T6=56.*TEM(1+5)
18 T7=23.*TEM(1+6)
19 T8=3.*TEM(1+7)
20 T9=1.*TEM(1+8)
21 HCURT(1) = (T1+T2+T3+T4+T5+T6+T7+T8+T9)/
22 (2.*1.+2.*8.+2.*28.+2.*56.+70.)
23 HRSPD(J) = SQR((HOURU(J))**2 + (HCRV(J))**2)
24 IF (HCURT(J).LE.5.5) GC IC 2
25 IF (HCURT(J).GE.10.0) GO TO 20
26 K=K+1
27 HCT=HCURT(J)+HCT
28 CCNT=CCNT+1
29 COMPUTE MEAN TEMPERATURE FOR THE RECCR. (VALUE IS SCALED FOR
30 SUBSEQUENT PLOTTING.)
31 RHCT = ((HCT/K)*2.0)-14.
32 WRITE(6,50) RHCT
33 FORMAT(IX,F6.2)
34 RETURN
35 END
36 SUBROUTINE STKPLT(NPTS,NPTS2,IR,HRSPD,HCURL,FCURV,HOURV,RHCT)
37
38 SUBROUTINE STKPLT CREATES A PLOT OF CURRENT VECTORS AS A
39 FUNCTION OF TIME, FOLLOWED BY PLOTS OF U COMPONENTS, V
40 COMPONENTS, AND TEMPERATURE VS TIME. THE USER SHOULD REFER TO
41 THE NAVAL POSTGRADUATE SCHOOL TECHNICAL NOTE NO. 6141-24 IN REGARDS TO
42 PLOTTING PARAMETERS.
43
44 DIMENSION IR(NPTS),HRSPD(NPTS2),HOURU(NPTS),FOURV(NPTS),
45 HCURT(NPTS)
46 INTEGER*4 Z1111/Z1111/
47 NPTS2=NPTS
48 KLEN=(NPTS/20.)*2.
49 YLEN=2.
50 FORMAT(10,8X,1HJ,11X,2H1R,4X,5HHRSPD,5X,
51 1HUR,2X,1HV,9X,1HT,7X,2H1L,8X,2H1V)
52 FORMAT(1X,1S,3X,1IC,6F10.2)
53 SET UP THE STICKPLT
54 CALL PLCTS(0,0,0)
55 CALL FACTOR(0.35)

```

```

      HRSPC(NPTS+1)=-40.
      HRSPC(NPTS+2)=10.
      FVALS=HRSPC(NPTS+1)
      DVS=HRSPC(NPTS+2)
      CALL PLOT(3,10,5,-3)
      CALL AXIS(0,,-4,13,XLEN,0,0,20,1)
      CALL AXIS(0,,-4,13,SPEC(CY/SEC),13,YLEN,9C,FVALS,DVS)
      CALL HLINE(0,XLEN,0,21111)
      WRITE(6,100)
      J=0
      IF DATA.
      PLUT
      DO 10 I=1,NPTS
      J=J+1
      CALL PLOT(3,10,5,-3)
      XI=HOURV(I)/DVS
      YI=HOURV(I)/DVS
      CALL PLOT(XI,YI(2),HRSPC(I),HOURV(I),HOURT(I),XI,YI
      WRITE(6,200) J,I(2),HRSPC(I),HOURV(I),HOURT(I),XI,YI
      CONTINUE
      CALL PLOT(0,0,555)
      SET UP THE U COMPONENT PLOT.
      CALL PLOTS(0,0,0)
      CALL FACTOR(0.35)
      HRSPC(NPTS+1)=-40.
      FVALS=HRSPC(NPTS+1)
      DVS=HRSPC(NPTS+2)
      CALL PLOT(3,10,5,-3)
      CALL AXIS(0,,-4,13,XLEN,0,0,20,1)
      CALL AXIS(0,,-4,13,SPEC(CY/SEC),13,YLEN,9C,FVALS,DVS)
      CALL HLINE(0,XLEN,0,21111)
      CALL PLOT(0,0,-3)
      B=0.
      PLUT THE DATA.
      DO 11 I=1,NPTS
      B=B+.35
      XI=B
      YI=HOURV(I)/DVS
      CALL PLOT(XI,YI,2)
      CONTINUE
      CALL PLOT(0,0,555)
      SET UP THE V COMPONENT PLOT.
      CALL PLOTS(0,0,0)
      CALL FACTOR(0.35)
      HRSPC(NPTS+1)=-40.
      FVALS=HRSPC(NPTS+1)
      DVS=HRSPC(NPTS+2)

```

```

C
CALL PLOT(3.,10.,-3)
CALL AXIS(0.,-5.,SAMPLE NUMBER,-13,XLEN,C.,0.,20.)
CALL AXIS(0.,-4.,SPEED(C4/SEC),13,YLEN,90.,FVALS,DVS)
CALL HLINE(3.,XLEN,C.,Z1111)
CALL PLOT(0.,0.,-3)
R=0.
PLOT THE DATA.
DO 12 I=1,NPTS
  B=0+.05
  X1=3
  Y1=HOUR(I)/CVS
  CALL PLOT(X1,Y1,2)
  CONTINUE
  CALL PLOT(0.,0.,555)
  SET UP THE TEMPERATURE PLOT.
  CALL PLOT(3.,0.,0)
  CALL PLOT(0.,0.,35)
  CALL PLOT(3.,10.,-3)
  CALL AXIS(0.,-5.,SAMPLE NUMBER,-13,XLEN,C.,0.,20.)
  CALL AXIS(0.,-4.,TEMPERATURE),13,16.,90.,5.,5)
  CALL HLINE(0.,XLEN,RHGT,Z1111)
  CALL PLOT(0.,RHGT,+3)
  B=0.
  PLOT THE DATA.
  DO 13 I=1,NPTS
    E=0+.05
    X1=3
    Y1=(HOUR(I)*2.0)-14.
    CONTINUE
    CALL PLOT(X1,Y1,2)
  CALL PLOT(0.,0.,555)
  RETURN
END
12
C
13
C

```

```

        DIMENSION REF(10000),DIR(10000),SPD(10000),AR(6),
        1 ALONG(10000),CROSS(10000),YY(10000),FI(10000),PERIOD(10000),
        2 FREQU(10000),U(10000),V(10000),TRI(10000),HT(10000)

PROGRAM TO EVALUATE THE ENERGY DENSITY SPECTRUM OF OBSERVED CURRENTS
THROUGH THEIR ALONGSPHERE AND CROSS SHELF COMPONENTS.

10 FORMAT (IX,I10,2F10.2)

JDATA IS THE (HOURLY) DATA POINT AT WHICH THE ENERGY SPECTRA
PROGRAM SHOULD BEGIN TO LOOK AT DATA. IT DOES NOT ALWAYS START AT
1 SINCE SOME METERS HAVE A LONG LEADER WITH NO RELEVANT VALUES.

```

JDATA=5

READ RAW DATA FROM MAGNETIC TAPE.

```

20 READ(1,END=25) II,AR
   NPTS=II
   REF(1)=AR(1)
   TEM=AR(2)
   SAL=AR(3)
   PRES=AR(4)
   DIR(1)=AR(5)
   SPD(1)=AR(6)
   GO TO 20

```

25 CONTINUE

CREATE ARTIFICIAL VALUES FOR MISSING RECORDS. (THIS SUBROUTINE
LEAVES THE REFERENCE NUMBER ZERO FOR READY IDENTIFICATION OF
ARTIFICIAL VALUES.)

```

MPTS=VPTS-2
DO 5 I=3,NPTS
  IF (SPD(I).GE.100) GO TO 6
  IF (REF(I).NE.0.) GO TO 5
  CALL FILLER (I,SPD,DIR,SPDCUT,CIRCUIT)
  SPD(I)=SPDCUT
  DIR(I)=CIRCUIT
5 CONTINUE
  GO 11 I=1,NPTS
  VAR=30.17
  TRI(I)=DIR(I)+VAR
  IF (TRI(I).GE.360.) TRI(I)=TRI(I)-360.
  HT(I)=TRI(I)*(.017453)
  U(I)=SPD(I)*SIN(HT(I))
  V(I)=SPD(I)*COS(HT(I))
  CROSS(I)=U(I)

```

```

11  ALONG(I)=V(I)
    CONTINUE
    GO TO 40
    IF (J.EQ.1) GO TO 40
    IF (J.EQ.2) GO TO 50
    IF (J.EQ.3) GO TO 40
    IF (J.EQ.4) GO TO 60
    CALL ECXCAR(ALONG,NPTS,24,1,NOUT1)
    CALL ECXCAR(ALONG,NPTS,24,1,NOUT1)
    CALL ECXCAR(ALONG,NPTS,25,1,NOUT1)
    GO TO 40
    CALL ECXCAR(CROSS,NPTS,24,1,NOUT1)
    CALL ECXCAR(CROSS,NPTS,24,1,NOUT1)
    CALL ECXCAR(CROSS,NPTS,25,1,NOUT1)
40  M=1
    MS=1
    DT=1./6.
    JSTART=JDATA
    GO 45
    IF (J.GE.3) GO TO 41
    YYY(I)=ALONG(JSTART)
    GO TO 43
    YYY(I)=CROSS(JSTART)
    JSTART=JSTART+1
    CONTINUE
    IF (J.GE.3) GO TO 70
    CALL PREPFA(M,MS,DT,YYY,FL,PERIOD,FREQUE,NF)
    IF (J.EQ.1) GO TO 80
    CALL FLET(0.0,C.C,555)
    GO TO 80
    CALL PREPFA(M,MS,DT,YYY,FL,PERIOD,FREQUE,NF)
    CONTINUE
    CALL FLET(C.C,0,C.C,559)
    STOP
    END
    SUBROUTINE FILLER (I,SPEC,CIR,SPOUT,CIRCUT)

```

SUBROUTINE FILLER CREATES SPEED AND DIRECTION VALUES FOR THE CURRENT
METER RECORD. THIS IS DONE TO PROVIDE REASONABLE APPROXIMATIONS
FOR THE OCCASIONAL RECORD MISSED DUE TO INSTRUMENT (METER)
MALFUNCTION.

```

      DIMENSION CIR(1),SPEC(1)
      J=1
      IF(SPEC(J+1).LE.100.0)CC TO 3
      J=J+1

```

```

9      GO TO 3
      SPDCUT=(SPC(I-1)+SPC(J+1))/2.
      IF (CIR(I-1).LE.5C.) AND (CIR(I+1).GT.27J.) GC TO 10
      IF (CIR(I-1).GT.27C.) AND (CIR(I+1).LE.5C.) GC TO 1C
      IF (CIR(I-1)-CIR(I+1).GT.13.) GO TO 15
      IF (CIR(I+1)-CIR(I-1).LT.13.) GO TO 15
      CIRCU=(CIR(I-1)+CIR(I+1))/2.
      GO TO 2C
10      CIRCU=(CIR(I-1)-CIR(I+1))/2.+JIR(I+1)+1EC.
      IF (CIRCU.GE.360.) CIRCUT=CIRCU-360.
      IF (CIRCU.LT.360.) CIRCUT=CIRCU+360.
      GO TO 20
15      CIRCU=(CIR(I-1)+CIR(I+1))/2.+180.
      GO TO 2C
20      CONTINUE
      RETURN
      END
      SUBROUTINE BOXCAR (SL,NIN,LTH,IDEC,NCUT)
      REAL*4 SL(6200)
      NCUT=3
      ISTART=1
      IEND=ISTART+LTH-1
      IF (IEND.GT.NIN) RETURN
      SUM=0.
      DO 30 I=ISTART,IEND
      SUM=SUM+SL(I)
      NCUT=NCUT+1
      SL(NCUT)=SUM/FLJAT(LTH)
      ISTART=ISTART+IDEC
      GO TO 2C
      END
      SUBROUTINE PREPEA(N,YS,EI,YYY,FL,PERIC,FREQUE,NF)
      DIMENSION YYY(5000),INV(5000),S(5000),FIS(5000),C(5000),F1(5000)
      DIMENSION ART(5000),PERIC(5000),FREQUE(5000)
      FLJAT(1),,POWER,SPECIFY,IS,CALCULAT,/,/ TOTAL NUMBER OF SAMP
      LES=,15,IX,THE TIME INCREMENT=,F5.3,1),THE NUMBER OF DEGREE
      2S OF FREQUENCY FOR EACH SPECTRAL ESTIMATE=,14,///)
      25C FORMAL(,),STATISTICS OF SAMPLE NUMBER=,14)
      260 FORMAL(,),MEAN VALUE=,F12.3,3X,VARIANCE=,F12.3,3X,SKEWNESS
      1=,F12.3,3X,KURTOSIS=,F13.3,3X,STD DEVIATION=,F12.3)
      270 FORMAL(,C,T10,F12.3,T25,F12.3,T40,F12.3)
      NMI=2*2*2
      NMI=NMI-1
      NMI=NMI*5
      NF=2*2*2*2*2
      NF=NMI*2
      T=NCUT
      WRITE(6,240) N, UT, NFREC

```

```

510      CU 510 I=1,NF
      F1(I)=0.
      IZ=0
      K=0
      DO 21 IZ=1,N
      ART(I27)=YV(I27)
21      CONTINUE
      CALL AVERAGE(ART,N,AMEAN)
      DO 22 IZ=1,N
      C(I28)=ART(I28)-AMEAN
22      CONTINUE
      CU 520 MI=1,MS
      K=K+1
      DO 530 J=1,NM
      IZ=IZ+1
      FIS(J)=C(I2)
      WRITE (6,250) K
      CALL TREND(FIS,NM,CT,U11,U21,U41,URMS1)
      CALL SPEC(FIS,M,INV,S,(FEFF)
      WRITE (6,260) U11,U21,U31,U41,URMS1
      DO 540 I=1,NF
      F1(I)=FIS(I)+F1(I)
      CONTINUE
540      DO 550 I=1,NF
      F1(I)=F1(I)*1/(I2.*MS)
      IF(I.EQ.1)GC TO 23
      PERIOD(I)=((FLCAT(NM))*C(I))/FLOAT(I-1)
      FREQUE(I)=1.0/PERIOD(I)
      IF(F1(I).LE.10.0)GC TO 550
      GO TO 24
      PERIOD(I)=FLOAT(NM)
23      FREQUE(I)=0.0
      WRITE (6,270)F1(I),PERIOD(I),FREQUE(I)
24      CONTINUE
550      CALL FCTG(FREQUE,F1,NF,I,1,'FREQUENCY (CYCLES PER HOUR)',27,'FC
      POWER DENSITY FUNCTION (CM S2. HOUR)',36,0.0,0.2,0.0,0.0,13.0,6.0)
      RETURN
      END
      SUBROUTINE SPEC (F1,M,INV,S,IFERR)
      SUBROUTINE TO CALCULATE THE POWER SPECTRUM OF A SIGNAL USING RHARM
      DIMENSION INV(515),S(515),F1(515)
      CALL RHARM(F1,M,INV,S,IFERR)
      NP=2*#N-1
      NF=2*#N+1
      NX=2*#N+1
      NL=N*#N+1

```

```

500      F1(I)=F1(I)*F1(I)
        DO DOO I=1,NP
          J=2*I+1
          U=I+1
          XR=F1(J)*F1(J)
          XI=F1(J+1)*F1(J+1)
          F1(I)=XR+XI
        CONTINUE
        F1(NP)=F1(NL)*2
        RETURN
      END
      SUBROUTINE TREND(FX,NTS,CF,FMEAN,U2,U3,U4,UFMS)
      SUBROUTINE TREND EDITS CALCULATES AND DETRENDS DATA
      DIMENSION FX(NTS)
      EDITING DATA

      NTS=NTS
      COMPUTING THE LINEAR TREND
      SUMF=C.C
      DO 101 I=1,NTS
        SUMF=SUMF+FX(I)
      SUMF1=C.C
      DO 102 I=1,NTS
        XI=I
        SUMF1=SUMF1+XI*FX(I)
        XNMI=NTS-I
        XI*PI=N1S+1
        XI=(1.0/CI)*(12.0*SUMF1/(FNTS*XNMI*XNPI)-6.0*SUMF/(XNMI*FNTS))
        B=SUMF/FNTS-XI*SUMF1/CI/2.0
        FMEAN=SUMF/FNTS

      WRITE (6,9) FMEAN,XM,B
      FOR1AF(3X,'MEAN=',F1C.5,3X,'SLIPE =',F1C.5,3X,'INTERCEPT =',F1C.5
1,//)
      DO 103 I=1,NTS
        XI=I
        FX(I)=FX(I)-(3*XI*XI*BI)
      SUBROUTINE FOR CALCULATING VARIANCE, STD DEV, SKEWNESS, KURTOSIS
      U2=0.0
      U3=0.0
      U4=0.0
      SUMU2=C.C
      SUMU3=C.C
      SUMU4=C.C
      DO 151 I=1,NTS
        U2=FX(I)*FX(I)

```

```

151      U3=J2*F1*(1)
          U4=U3*F1*(1)
          SUMU2=SUMU2+U2
          SUMU3=SUMU3+U3
          SUMU4=SUMU4+U4
          CONTINUE
          FNTS=J1*F2/FNTS
          U2=SUMU2/FNTS
          LRMS=SQRT(U2)
          U3=SUMU3/(FNTS*U2*LRMS)
          U4=SUMU4/(FNTS*U2*U2)
          RETURN
        END
        SUBROUTINE PAGE
          FORMAT (1,1)
          WRITE (6,10)
          RETURN
        END
        SUBROUTINE AVERA (A,NPTS, A-MEAN)
          DIMENSION A(NPTS)
          SUM=C*0
          DO 100 I=1,NPTS
            SUM=SUM+A(I)
          CONTINUE
          A-MEAN=SUM/FLOAT(NPTS)
          RETURN
        END
100
122

```

```

-----TRAJECT-----
PROGRAM TRAJECT TO PLCT PROGRESSIVE VECTOR DIAGRAMS OF CURRENT
METER DATA. IF COMPONENTS ARE GIVEN, WE SET COMPT=1. IF SPEED
AND DIRECTION ARE GIVEN, WE SET COMPT=F AND READ SPEED INTO U AND
DIRECTION INTO V. THE NUMBER OF POINTS IS GIVEN AS N. WE PLCT
EVERY NP POINTS AND PUT A + CN EVERY NX OF THE NP POINTS. THE TIME
PLOTTED POINTS CANNOT EXCEED 500 IF OBJECT IS CALLED. THE TIME
INTERVAL IN HOURS IS DELT. WE USE DELT TO SET THE NP*NX
VECTOR SUMS ARE STORED IN CU AND CV. IT IS DESIRABLE THAT NP*NX
CORRESPOND TO AN INTEGRAL FRACTION OF ONE DAY. IF PLT IS TRUE,
A LINE FLOTTING FROM THE DATA AND THE TREATMENT IS REPEATED.
MEAN IS SUBTRACTED FROM THE DATA AND DISCARDING NSTRT POINTS AT THE
PROVISION IS MADE FOR READING AND DISCARDING NSTRT FILES IF NFILE
BEGINNING. 2 OR MORE. A COMPLETE SET OF DATA CARDS MUST THEN BE
IS SET TO 2 OR MORE.
SUPPLIED FOR EACH FILE.
THIS VERSION PROVIDES FOR READING FROM FILE TO FILE SEQUENTIALLY.
IF THEY ARE SEQUENTIAL, THE RIGHT FILE NUMBER WILL BE WRITTEN IF
NFILE IS SET AS ONE LESS THAN THE FILE NUMBER WITH WHICH ONE
STARTS CN ENPLT.
NFILE MUST BE THE FILE NUMBER ON WHICH YOU WANT TO STOP.

DIMENSION L(5000),V(5000),FMT(10),PU(200),PV(200),CU(900),
1CV(900),PT(9000),JF(5000)
REAL*3 TITLE1(12),LABEL1/'
LOGICAL COMPT,PLT,RPT
NAMELIST/INPUT/COMPT,N,NP,NX,DELT,RPT,PLT,NSTRT,NFILE/INPUT1/MFILE

RAD=3.141592/180.
NFILE=1
NPT=.FALSE.
PLT=.FALSE.
NSTRT=C
NFILE=C
READ(5,INPLT1)
4 READ(5,INPLT)
WRITE(6,INPLT)
READ(PLCT,TITLE)
READ(5,6) TITLE1
6 FORMAT(10A8/2A8)
WRITE(6,10)
10 FORMAT(1FC)

IREPT=C

READ AND DISCARD NSTRT FCINTS

```

```

C C
IF(NSTRT.EQ.O) GC TC 120
DO 11 J=1,NSIRT
11 READ(2,12) JUNK
12 FORMAT(14)
C C
READ DATA
NJ=O
13 DO 13 J=1,N
END=200,ERR=353) U(J),V(J)
875 FORMAT(2F12.5)
13 NJ=J
C C
IF(CCMF.IS.FALSE, FIND THE EAST AND NORTH COMPONENTS AND PUT
THEM IN U AND V.)
14 IF(CCMF) GC TC 16
DO 15 J=1,N
UX=U(J)
VX=V(J)*RAC
U(J)=UX*SIN(VX)
15 V(J)=UX*CCS(VX)
C C
PARAMETERS FOR COMPRESSING DATA
NPTS=N/NPTS
NXI=N/NPIS
JEVNPT=NPTS*NXI
JEVN=N-JEVNPT
KEVN=JEVN/NP
LEVN=JEVN-KEVN*NP
WRITE MESSAGE
WRITE(6,16) NP,NPTS,LEVN,JEVN
FORTRAN(/PX,PLOTTING IS DONE EVERY ,I2,' POINTS; A CROSS IS PLOT
TED EVERY ,I3,' POINTS; THERE ARE ,I3/5x,' POINTS NOT PLOTTED AND
2 ,I3,' POINTS AFTER THE LAST CROSS.//)
C C
SUM THE COMPONENT DISPLACEMENTS IN KILOCENTERS AND STORE NP POINTS
IN CU AND CV
17 SUMJ=C.
SUMV=C.
L=O
K=1
CU(1)=C.
CV(1)=C.
XD=LI=CELLI*3600.*1.E-5
CO 27 N=1,NXI
CO 26 LL=1,NX
20 CO 25 L=L+1
CO 24 K=K+1

```



```

55 FORMAT(3,2X,F7.2,2X,F7.2,2X,F7.2)
   INCREMENT TIME
   TIM1=TIM1+DELTIM
   TIM2=TIM2+DELTIM
   TIM3=TIM3+DELTIM
50 IF((TIME-GE.TOTIM) TIM3=ICLIM
   CC1PLIE VECTOR MEAN CURRENT,ETC.
   PI=3.141592
   PI2=2.*PI
   DIST=SQRT((SUMU*SUMU+SUMV*SUMV)
   ANG=ARCSIN((SUMU/DIST)
   PUT THE ANGLE IN THE RIGHT QUADRANT
   IF(ANG.GT.C.) GO TO 60
   IF(SUMV.GT.C.) GO TO 56
   ANG=ABS(ANG)+PI
   GO TO 62
56 ANG=ANG+PI2
   GO TO 62
60 IF(SUMV.LI.G.) ANG=PI-ANG
   CONVERT ANGLE TO DEGREES
62 ANG=ANG/RAC
   COMPUTE MEAN VECTOR SPEED IN C1/SEC
   VMN=DIST*.1.E5/(3600.*ICLIV)
   WRITE(6,65) DIST,ANG,ICLIM,VMN
65 FORMAT(//5X,'DIST=',F6.1,' KM, DIR=',F5.1,' DEG., ELAPSED TIME=
   1.,F6.1,' HRS, VECTOR MEAN SPEED=',F6.2,' CM/SEC'//)
   DIAGNOSTIC
   WRITE(6,68)
68 FORMAT(3X,'NP NX NXI JEVAPT KEVN*/3X,'K L M NT NPRT
   1 IEVN')
   WRITE(6,70) NP,NX,NXI,JEVAPT,KEVN,K,L,M,NT,NPRT,IEVN
70 FORMAT(2X,I4,I4,I4,I4,I4,I4,I4,I4,I4,I4,I4,I4,I4,I4,
   12X,I4,2X,I4//)
   PLUT FCLTIME
   IF(.NOT.PLT) GO TO 8C
   CALL CHAM(NT,CU,CV,1,0,LABEL1,TITLE1,0.,0.,0,0,0,6,C9,C,LAST)
   WRITE(6,76) LAST
76 FORMAT(5X,'LAST=',I2)
   PUT IN THE CRUSSES
   CALL DRAW(NXI,PJ,PV,3,2,LABEL2,TITLE1,C.,0.,0,0,0,0,0,0,LAST)
   WRITE(6,76) LAST
8C IF(I-REPT-GE.1) GO TO 955
   IF(.NOT.PFT) GO TO 959
   SUBTRACT THE MEAN COMPONENTS FROM THE ARRAYS AND REPEAT
   IREPT=1

```

```

UMN=SUMU*1.E9/(ICTIM*3600.)
VMN=SUMV*1.E9/(ICTIM*3600.)
DO 35 J=1,N
  U(J)=U(J)-VMN
  V(J)=V(J)-VMN
85 WRITE(6,66) UMN,VMN
86 FORMAT(15X,'SUBTRACT MEAN U AND MEAN V. ',F6.2,2X,F6.2,' AND REPEA
  11.//')
  GO TO 17
C
  WE CHANGE N AND PROCESS AS USUAL
C 200 N=J
  NFILE=NFILE+1
  WRITE(6,205) MFILE,NJ
  205 FORMAT(5X,'DETECTED EOF ',I2,' BEFORE REACHING N; RESET IC ',
  115,' AND PROCESS.//')
  SET IEND=1 TO PREVENT THE READ AND DISCARD OPERATION
  IEND=1
  GO TO 14
C
  300 MFILE=NFILE+1
  WRITE(6,205) MFILE,NJ
  305 FORMAT(5X,'END OF FILE ',I2,' AFTER RECCRD NC. ',I5//')
  IF(MFILE.GE.NFILE) GO TO 1000
  GO TO 4
  350 WRITE(6,355) NJ
  355 FORMAT(5X,'PEAD ERROR AFTER RECORD ',I5)
  GO TO 1000
C
  READ AND DISCARD TO END OF FILE
  999 IF(MFILE.EQ.1) GO TO 1000
  IF(MFILE.GE.NFILE) GO TO 1000
  IF(IEND.EQ.1) GO TO 4
  DO 900 J=1,10000
    NJ=NJ+1
  900 READ(2,FMT,END=300,ERR=350) XJUNK
  1000 STOP
C
  THIS VERSION OF DRAW SCALES BOTH AXES THE SAME ON AUTOSCALE.
  SEE CHANGES BEGINNING LABEL 2054. R.G. PACLETTE, FEB. 1974.
  SUBROUTINE DRAW(NUMPTS, X,Y, MDCUR, ITYPE, LABEL,
  1 TITLE, EASCAL, YSCALE, IXLF, IYRIGH,
  2 MDCXAX, MDCVAX, INICE, IHIGH, IGRID,
  3 LAST)
  DIMENSION X(900), Y(900), TITLE(24), JXTIT(12),
  1 TITLE(14), ICURV(1340), GRIC(100), ICONT(1)
  DATA ITEST/C/
  INTEGER IDATA(2)/1F,1FY/, LABEL(2)

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```

REAL*8 ICODE, BLANK/8F
REAL*8 ITIT, ICAT8(1E)/5HIMIDE, 5HIMHIGH, 8FMODEXAX., 5HIXUP.,
1 8H4CODEYAX., 8H4YRIGHT., 8H4X-SCALE=, 8F UNITS 1, 8HNGCH., 8HY-SCALE=
2, 8H UNITS 1, 8HNO ALL X, 8F ACC -, 8H ACC +, 8HVALUES., 8HC ALL Y
3, 8H CHECK PREVIOUS OPERATION OF ROUTINE, IF ANY. CODES ARE
14, 8F ITTEST = 0 IF PREVIOUS GRAPH, IF ANY, COMPLETED
11/ ITTEST = 1 IF PREVIOUS GRAPH NOT COMPLETED
11/ ITTEST = 2 IF ERROR FOUND WHILE MCCURV WAS CNE, CR IF
MCCURV WAS ILLEGAL.

IPCNT = ITYPE
IF(ITEST - 2) 1000, 1001, 1003
IF(MCCUR) 1003, 1002, 1001
1001 ITTEST = 0
1002 GO TO 1000
1003 IF(MCCUR - 1) 1004, 1002, 1004
1004 LAST = 3
RETURN

SET UP ERROR RETURN ROUTINE. ENTRY AT STATEMENT 1005.
1005 IF(ITEST) 1005, 1006, 1005
1006 IF(MCCUR) 1007, 1008, 1007
1007 PRINT 1100
1100 CNE = 1
1 CNE = 1
ITEST = 2
LAST = 2
RETURN 1101
PRINT 1101
FORMAT ( 30H THIS PLOT WILL NOT BE CULPT. ,/)
LAST = 1
RETURN

MCCUR - 2) 1010, 1008, 1010
1010 IF(MCCUR - 3) 1007, 1011, 1007
1011 ITTEST = 3
GO TO 1008

CHECK LEGALITY OF INPUT ARGUMENTS.
1000 IF(NUMPTS - 2) 1, 2, 2
1001 PRINT 900
FORMAT (/, 32H NUMPTS MUST NOT BE LESS THAN 2. )
GO TO 1005
2 IF(ICPNT) 9100, 9004, 9001
9000 PRINT 9100
FORMAT (/, 15H ILLEGAL IYPE. )
GO TO 1005
9001 IF(ICPNT - 5) 9002, 9002, 9000
9002 IF(NUMPTS - 3) 9003, 9003, 9003
9003 PRINT 9101
FORMAT (/, 46H NUMPTS MUST NOT EXCEED 30 FOR PCINT PLOTTING. )
9101

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9034 GO TC 1005 - 900)3,3,5005
9005 IF(NLMPTS - 900)3,3,5005
9102 PRINT 9102 28H NUMPTS MUST NOT EXCEED 900. )
3 GO TO 1005
IX=ICATA(1)
IY=ICATA(2)
AMAXX=X(1)
AMAXY=Y(1)
AMINX=X(1)
AMINY=Y(1)
CC 1020 I=2,NLMPTS
AMAXX=AMAXI(X(I),AMAXX)
AMAXY=AMAXI(Y(I),AMAXY)
AMINX=AMINI(X(I),AMINX)
AMINY=AMINI(Y(I),AMINY)
1020 IF (AMAXX-AMINX) 1025,1021,1025
1022 IF (AMAXY-AMINY) 1025,1024,1025
1024 PRINT 1103
1103 FORMAT (/ , 33F ALL FCINTS HAVE THE SAME COORDINATES. )
1025 GO TO 1005
IF(ITEST14,7,4
4 IF(MOCCUR-5)5,2240,5
5 IF(MOCCUR-3)6,2240,6
6 PRINT 101
101 FORMAT (/ , 17H ILLEGAL MOCCUR. )
7 GO TO 1005
IF(MOCCUR)6,9,8
8 IF(MOCCUR - 1)6,9,6
9 IF(IWLE)10,11,12
10 ITIT=ICAT8(1)
102 PRINT 102, ITIT, ITIT
102 FORMAT (/ , 5H = 8: ,/)
11 JWIDE = 3
12 GO TC 14 - 5)13,12,10
13 IF(IWLE) IWICE
14 JWIDE= IWICE
15 IF(HIGH)15,16,17
16 ITIT=ICAT8(2)
17 PRINT 102, ITIT, ITIT
18 HIGH = 2
19 GO TO 19
CCNT INCE
2240 BACKSPACE 45
C GO TO 24)
17 IF(IWICE - 15)18,18,15
18 JWIDE = HIGH

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```

19 NDCXAX = MCCXAX
   IF(MOD(XAX)20,21,21
20 IIT=ICAT8(3)
   PRINT 104, IIT, IX
104 FOR IAT (/; 9H ILLEGAL ,A3, 32+ GRAPH WILL BE PLOTTED WITH MODE,
      1 A1, 7HAX = 0. ;/)
      NDCXAX = 0
      GO TO 27
21 IF(MCCXAX - 2127,22,20
22 IF(IXUP - JHIGH)24,24,23
23 IIT=ICAT8(4)
   PRINT 104, IIT, IX
      NDCXAX = 0
      GO TO 27
24 IF(IXUP)23,26,26
26 JXUP = IXUP
27 NDCYAX = MCCYAX
   IF(MOD(YAX)28,35,29
28 IIT=ICAT8(5)
   PRINT 104, IIT, IY
      NDCYAX = 0
      GO TO 35
29 IF(MCXYAX - 2135,30,28
30 IF(IYRIGH - JWIDE)32,32,31
31 IIT=ICAT8(6)
   PRINT 104, IIT, IY
      NDCYAX = 0
      GO TO 35
32 IF(IYRIGH)31,34,34
34 JYRIGH = IYRIGH
   INITIALIZE PRICR TO SCALING AND AXIS LOCATING.
   IFLAG = 0 FOR PASS WITH XDATA. IFLAG = 1 FOR PASS WITH YDATA.
35 IFLAG = 0
   BETA = C
   SCALE = EXSCAL
   IAXIS = JYRIGH
   MODE = NDCYAX
   ISIZE = JWIDE
   IXY = IX
   IYX = IY
   AMAX = AMAXX
   AMIN = AMINX
   GO TO 52
50 IFLAG = 1
   BETA = C
   SCALE = YSCALE
   IAXIS = JXUP
   MODE = NDCXAX

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ISIZE = JFICH
AMAX = AMAXY
AMIN = AMINY
IXY = IY
IYX = IX
C CHECK SCALE AND GO TO FIXED OR AUTOC SCALE ROUTINES.
52 IF (SCALE) 53, 59, 58
53 PRINT 114, IYX, IYX
114 FORMAT (/, 5H ILLEGAL, A1, 35HSCALE. GRAPH WILL BE PLOTTED WITH AL
1 TO A1, 7H-SCALE. //)
GO TO 59
C EXPRESS FIXED SCALE IN E FORMAT WITH ONE FIGURE SIGNIFICANCE.
58 CALL SCALIT(SCALE, ISCLD, FACTOR, I)
SCALE = FACTOR*10.*#ISCLD
C CHECK AND COMPUTE AXIS LOCATION IF NECESSARY. FIXED SCALE
CASE: ITAG = 0 IF CRIGIN ON GRAPH OR 1 IF IT IS SUPPRESSED.
IF (ICCE = 1) 1032, 1031, 1030
1030 ITAG = C
GO TO 203
1031 PRINT 1104, IYX, IYX, IYX
1104 FORMAT (/, 5H MUDE, A1, 24HAX MUST NOT BE 1 UNLESS, A1, 57HSCALE IS C
1 (AUTOC-SCALE). GRAPH WILL BE PLOTTED WITH AUTOC, A1, 7H-SCALE. //)
GO TO 59
1032 IF (AMAX - AMIN) 1036, 1035, 1038
1039 IF (AMAX) 1036, 1034, 1037
1034 IAXIS = ISIZE/2
GO TO 1030
1036 IAXIS = ISIZE
GO TO 1030
1037 IAXIS = 0
GO TO 1030
1038 IF (SIGN(1., AMIN)) 1040, 1039, 1040
1040 ASIZE = ISIZE
IAXIS = -AMIN/(AMAX - AMIN)*ASIZE + 0.5
GO TO 1030
C AUTOC SCALE ROUTINE.
55 IF (MCDE = 1) 60, 64, 65
60 AMAX = AMAX1(0., AMAX)
AMIN = AMIN1(0., AMIN)
64 IF (AMAX - AMIN) 68, 65, 68
65 PRINT 115, IYX, IYX, IYX
115 FORMAT (/, 5H ALL, A1, 47H VALUES EQUAL. AUTOC SCALE POSSIBLE ONLY
1 IF THE, A1, 25H VALUES ARE NON-ZERO AND MCDE, A1, 7HAX = 2. )
GO TO 1035
68 ASIZE = ISIZE
SCALE = (AMAX - AMIN)/ASIZE
GO TO 33
69 IF (AMAX - AMIN) 74, 70, 74

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70 IF (AMAX) 74,71,74
71 PRINT 112, IYX
118 FORMAT (/, 5H ALL ,A1,3EH VALLES ZERC. AUTC SCALE NOT POSSIBLE. )
72 GO TO 1005
74 IF (AMAX) 76,76,75
75 IF (ISIZE - IAXIS) 77,76,71
76 SCALE1 = C.
77 GO TO 18
77 AXIS = IAXIS
78 ASIZE = ISIZE
79 SCALE1 = AMAX/(ASIZE - A)IS)
80 IF (AMIN) 79,79,80
81 IF (IAXIS) 81,80,81
82 SCALE2 = C.
83 GO TO 82
81 AXIS = IAXIS
82 SCALE2 = -AMIN/AXIS
83 IF (SCALE1 + SCALE2) 1984,1982,1984
1982 PRINT 1122, IYX, IYX
1983 FORMAT (/, 56H NONE OF THE PLOT LIES ON THE GRAPH WITH THIS SPECIF
1122 ,A1,47H-AXIS LOCATION. GRAPH WILL BE PLOTTED WITH MODE,A1,
2 7HAX = C. ,/)
MODE = C
GO TO 6C
1984 SCALE = AMAX1(SCALE1,SCALE2)
83 CALL SCALIT(SCALE,ISCL10,FACTOR,3)
84 IF (FACTOR - 5.05) 85,85,84
84 FACTOR = 1
ISCL10 = ISCL10+1
GO TO 5C
85 IF (FACTOR - 2.02) 87,87,86
86 FACTOR = 5
GO TO 5C
87 IF (FACTOR - 1.01) 89,89,89
88 FACTOR = 2
GO TO 5C
89 FACTOR = 1
SCALE = FACTOR*10.**ISCL10
89 COMPUTE IAXIS LOCATION IF NECESSARY. AUTC SCALE CASE.
90 IF (MODE - 1) 92,91,93
91 IF (SIGN(1.,AMAX) - SIGN(1.,AMIN)) 92,94,92
92 IAXIS = -AMIN/SCALE + 0.5
93 ITAG = C
GO TO 203
94 IF (AMAX) 95,95,200
95 IAXIS = ISIZE
96 PETA = -MAX/SCALE
IF (BETA - 1.E+12) 99,99,96

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56 PRINT 120, IX, IY
120 FOR I=1, 15H THE ORIGIN OF ,AL, 43H CANNOT BE OFFSET MORE THAN 1
   L.05+12 INCHES. )
   GO TO 1005
99  IHEIA = IHEIA + 0.5
   BETA = -IBETA
      BETA IS THE NUMBER OF INCHES OF ORIGIN SUPPRESSION, POSITIVE IF
      TRUE ORIGIN IS BELOW OR TO LEFT OF THE GRAPH.
      IF (BETA + 1.) > 97, 97, 93
97  ITAG = 1
   GO TO 203
200  IAXIS = AMIN/SCALE
   IF (BETA - 1.E+12) 201, 201, 95
201  IHEIA = BETA + 0.5
   BETA = IBETA
   IF (3BETA - 1.) > 93, 202, 202
202  ITAG = 1
      RELEASE RESULTS TO REMAINING PART OF PROGRAM. START SECOND
      PASS FOR Y VALUES IF NOT YET COMPUTED.
203  IF (IFLAG) 205, 204, 205
204  SCALEX = SCALE
   IXFACT = IFACT
   IXSCLIO = ISCLIO
   IAXIS = IAXIS
   ITAGX = ITAG
   ISIZEX = ISIZE
   BETAX = BETA
   GO TO 50
205  BETA = BETA
   SCALEY = SCALE
   IYFACT = IFACT
   IYSCLIO = ISCLIO
   IYAXIS = IYAXIS
   ITAGY = ITAG
   ISIZEY = ISIZE
      MAKE THE SCALING THE SAME ON THE TWO AXES .
2054  IF (SCALEX.GT.SCALEY) GOTO 2055
   SCALEX = SCALEY
   IXFACT = IYFACT
   IXSCLIO = IYSCLIO
   BETAX = BETAY
   GO TO 204
2055  SCALEY = SCALEX
   IYFACT = IXFACT
   IYSCLIO = IXSCLIO
   BETAY = BETAX
      END OF CHANGES
   C

```

ETC. NOW GENERATE

ETC. NOW GENERATE
.

ETC. NOW GENERATE
.

ETC. NOW GENERATE

ETC. NOW GENERATE
.

```

          C
          240
          2007
          9700
          9701
          242
          9241
          9242
          241
          9243

JV = I3IMGX
LV = I3IZEY*100
IVL = IV - 3
JVL = IBIMGX + I3IZEY*100 - 107
JVL2 = -100
IVV2 = (I3IZEY - IYAXIS - 1)*IYFACT
INV = I3IZEY
I3V = ICA18(18)
      NUM GENERATE CURVES.
SCX = 100./SCALEX
SCY = 100./SCALEY
EXAXIS = IYAXIS*100
YAXIS = IYAXIS*100
ALFMGN = LFTMGN
BTMGN = IBTMGN
SHIFTX = EXAXIS - BETAX*100. + ALFMGN
SHIFY = YAXIS - BETAY*100. + BTMGN
EXSIZE = I3IZEY*100 + LFMGN + 63
SIZEX = LFTMGN - 60
YSIZE = I3IZEY*100 + IBTMGN + 70
SIZEY = IBTMGN - 70
IF(IPOINT)SCIC,9007,SCIC
IF(MCC(NUMPTS,2)) 9700,9701,9700
      I3W ICF=1
      GO TO 242
      I3W ICF=2
      INUM=((NUMPTS+1)/2)*4
      C1=X((1+1)/2)*SCX+SHIFTX
      C2=Y((1+1)/2)*SCY+SHIFY
      IF (1+3-INUM) 241,9241,241
      GO TO 9242,241,I3W ICF
      C3=C1
      C4=C2
      GO TO 9243
      C3=X((1+1)/2+1)*SCX+SHIFTX
      C4=Y((1+1)/2+1)*SCY+SHIFY
      C1=AMIN1(C1,EXSIZE)
      IC1=AMAX1(C1,SIZE)
      C2=AMIN1(C2,SIZE)
      IC2=AMAX1(C2,SIZE)
      C3=AMIN1(C3,EXSIZE)
      IC3=AMAX1(C3,SIZE)
      C4=AMIN1(C4,SIZE)
      IC4=AMAX1(C4,SIZE)
      ICURV(1)=IC1
      ICURV(1+1)=IC2

```

```

244 ICURV(I+2)=IC3
246 ICURV(I+3)=IC4
C CONTINUE
246 C  WRITE RECORDS.
9010 IF (MODCUR-1)26C,26C,5015
260 CALL PLOTS (0,0,0)
XAXIS=C.
YAXIS=C.
261 CALL SYMBOL(XAXIS,YAXIS,.14,JXIT,0.,72)
YAXIS=YAXIS-.24
261 CALL SYMBOL(XAXIS,YAXIS,.14,JYIT,0.,72)
YAXIS=YAXIS-.31
9268 CALL SYMBOL(XAXIS,YAXIS,.21,ITITLE,0.,48)
YAXIS=YAXIS-.31
9270 CALL SYMBOL(XAXIS,YAXIS,.21,ITITLE(13),C.,48)
9271 XAXIS=FLOAT(IH)/100.
YAXIS=FLCAT(JH)/100.
CALL PLOT(XAXIS,YAXIS,3)
XAXIS=FLOAT(IH+LH)/100.
CALL PLOT(XAXIS,YAXIS,2)
CALL SPECNO(IH,IVH2,NH,XAXIS,YAXIS,1)
XAXIS=FLOAT(IV)/100.
YAXIS=FLCAT(JV)/100.
CALL PLOT(XAXIS,YAXIS,3)
XAXIS=FLCAT(JV+LV)/100.
YAXIS=FLCAT(XAXIS,YAXIS,2)
CALL SPECNO(IV,IVV2,INV,XAXIS,YAXIS,2)
9015 IF (FCINT)9020,270,9020
270 CALL SUB1(ICURV,INLM)
CALL WFERE(XAXIS,YAXIS)
9020 CALL SYMBOL(XAXIS,YAXIS,.C7,LABEL,0.,4)
272 IF (MODCUR-1)272,272,9025
272 IF (MODCUR-1)9025,273,9025
C  GENERATE GRID IF CALLED FOR.
IX100 = ISIZEY*100
IY100 = ISIZEX*100
NEXT1 = IFTMGN + IX100
NEXT2 = IFTMGN + IY100
DO 1274 J=1,80,8
JGRID(J)=LFTMGN
JGRID(J+1)=NEXT1
JGRID(J+2)=NEXT2
JGRID(J+3)=NEXT1
IF (NEXT1 - IFTMGN - IY100)1273,1275,1275
1273 NEXT1 = NEXT1 + 100
JGRID(J+4)=NEXT2
JGRID(J+5)=NEXT1
JGRID(J+6)=LFTMGN

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JGRID(J+7)=NEXT1
IF(NEXT1 - IBTMGN - IX10C)1274,1276,1276
1274 NEXT1 = NEXT1 + 100
1275 JGRID(J+4)=NEXT12
JGRID(J+5)=NEXT11
JGRID(J+6)=NEXT12
JGRID(J+7)=NEXT1
CONTINUE
1276 NUMGRD=J+7
CALL SUB1(JGRID,NUMGRD)
1277 NEXT1 = IBTMGN + IX10C
DO 1279 J=1,48,8
JGRID(J)=NEXT1
JGRID(J+1)=IBTMGN
JGRID(J+2)=NEXT1
JGRID(J+3)=NEXT12
IF(NEXT1 - IBTMGN - IX10C)1278,1280,1280
1278 NEXT1 = NEXT1 + 100
JGRID(J+4)=NEXT1
JGRID(J+5)=NEXT12
JGRID(J+6)=NEXT1
JGRID(J+7)=IBTMGN - IX10C)1279,1281,1281
1279 NEXT1 = NEXT1 + 100
1280 JGRID(J+4)=NEXT1
JGRID(J+5)=NEXT12
JGRID(J+6)=NEXT1
JGRID(J+7)=NEXT12
CONTINUE
1281 NUMGRD=J+7
CALL SUB1(JGRID,NUMGRD)
9025 IF(IPCINT)5030,276,5030
C GENERATE PCINT PLOT RECORDS IF CALLED FCM.
9030 IOUT = C
DO 9050 I=1,NUMPTS
C1 = X(I)*SCX + SHIFTX
C2 = Y(I)*SCY + SHIFTY
IF(C1 - EXSIZE)9031,5031,5034
9031 IF(C2 - YSIZE)5032,5032,5034
9032 IF(C1 - SIZE)5033,5033,5035
9033 IF(C2 - SIZE)5034,5034,5035
9034 IOUT = IOUT + 1
GO TO 5050
9035 ICL = C1
ICL = C2
GO TO 5036,9037,9038,9039,5040,IPCINT
C GENERATE CROSS.
C

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9036 ICURV(1)=IC1-5
      ICURV(2)=IC2-5
      ICURV(3)=IC1+5
      ICURV(4)=IC2+5
      ICURV(5)=IC1
      ICURV(6)=IC2
      ICURV(7)=IC1-5
      ICURV(8)=IC2+5
      ICURV(9)=IC1+5
      ICURV(10)=IC2-5
      ICURV(11)=IC1+5
      ICURV(12)=IC2-5
      INUM=12
      GO TO SC41
C 9037 GENERATE PLUS.
      ICURV(1)=IC1
      ICURV(2)=IC2-5
      ICURV(3)=IC1
      ICURV(4)=IC2+5
      ICURV(5)=IC1
      ICURV(6)=IC2
      ICURV(7)=IC1-5
      ICURV(8)=IC2+5
      ICURV(9)=IC1+5
      ICURV(10)=IC2
      ICURV(11)=IC1+5
      ICURV(12)=IC2
      INUM=12
      GO TO SC41
C 9038 GENERATE SQUARE.
      ICURV(1)=IC1+4
      ICURV(2)=IC2-4
      ICURV(3)=IC1+4
      ICURV(4)=IC2+4
      ICURV(5)=IC1-4
      ICURV(6)=IC2+4
      ICURV(7)=IC1-4
      ICURV(8)=IC2-4
      ICURV(9)=IC1+4
      ICURV(10)=IC2-4
      ICURV(11)=IC1+4
      ICURV(12)=IC2-4
      INUM=12
      GO TO SC41
C 9039 GENERATE DIAMOND.
      ICURV(1)=IC1+5
      ICURV(2)=IC2
      ICURV(3)=IC1

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ICURV(4)=IC2+5
ICURV(5)=IC1-5
ICURV(6)=IC2
ICURV(7)=IC1
ICURV(8)=IC2-5
ICURV(9)=IC1+5
ICURV(10)=IC2
ICURV(11)=IC1+5
ICURV(12)=IC2
INUM=12
GO TO SC41
C GENERATE TRIANGLE.
9040 ICURV(1)=IC1+5
ICURV(2)=IC2-3
ICURV(3)=IC1
ICURV(4)=IC2+6
ICURV(5)=IC1-5
ICURV(6)=IC2-3
ICURV(7)=IC1+5
ICURV(8)=IC2-3
INUM=8
CALL SUB1(ICURV,INUM)
9041 IF(1-NLPRINTS)9043,SC42,9043
9042 CALL WHERE(XAXIS,YAXIS)
CALL SYMELL(XAXIS,YAXIS,.C7,LABEL(2),0.,4)
GO TO SC46
9043 IF(1-1)SC45,SC44,SC45
9044 CALL WHERE(XAXIS,YAXIS)
CALL SYMELL(XAXIS,YAXIS,.C7,LABEL(1),0.,4)
GO TO SC46
9045 CONTINUE
9046 CONTINUE
9050 CALL SUB1(ICURV,INUM)
CALL INCL
CALL INCL
IF(100)SC4E,276,SC4E
9048 PRINT 91C4, IOUT
91C4 FORMAT (/ , IX, I2, 29H POINT(S) WERE OFF THE GRAPH. ,/)
C
276 IF(MCOCUR-3)275,27E,275
277 IF(MCOCUR-3)275,27E,275
278 ITES=0
YAXIS=PIGH+4
CALL PLCT(0.0,YAXIS,-3)
CALL PLCT(0.0,955)
WRITE(130) TITLE
FORMAT (/13H GRAPH TITLEC/2(5X,12A4/),18H HAS BEEN PLOTTED.)
130 IDUMMY=ITYP2(10UMMY)
GO TO 2E

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[illegible]

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2 CALL SCALIT(BNUMBER,ISCLIC,FACTOR,3)
  ISGNSC=ISIGN(1,ISCL10)
  ISCLIC=IABS(ISCLIC)
  IFACT=FACTOR*100.CC1
  II(8)=NCC (ISCL10,10)
  II(7)=ISCL10/10
  IF(ISGNSC) 4,3,3
3 II(6)=IFLLS
  GO TO 5
4 II(6)=IMINUS
5 II(5)=IE
  II(4)=NCC(IFACT,10)
  II(3)=(NCC(IFACT,100))/10
  II(2)=IPEP
  II(1)=IFACT/100
  CALL ENCCCE(8,ICCODE,II)
  RETURN
END
FUNCTION IYIP2 (ICL,MY)
  TYPE WGRD GRAPH.
  RETURN
END
SUBROUTINE SUB1(IA,N)
  DIMENSION IA(2)
  IPEN=3
  DO 100 I=1,N,2
    X=IA(I)
    X=X/100.
    Y=IA(I+1)
    Y=Y/100.
    CALL PLCT(X,Y,IPEN)
  IPEN=2
  CONTINUE
100 RETURN
END
SUBROUTINE SPECNO(IVF,IVF2,NH,XAXIS,YAXIS,IA)
  DATA MINUS/4H000-/
  DIMENSION II(4)
  MINUS=-252645280
  GO TO (100,200),IA
100 TH=0.
  GO TO 300
200 TH=90.
  STH=SIGN (TH*.0174533)
  CTH=COS (TH*.0174533)
  X=XAXIS-1.*CTH-1.*STH
  Y=YAXIS-1.*CTH-1.*STH
  INCLAS=IVF

```

```

DO 700 K=1,NH
I=0
INUM=INUMS
IF (INUM) 400,500,500
400 I=1
    II(1)=MINUS
    INUM=-INUM
500 I=I+1
    II(1)=INUM/100
    INUM=INUM-II(1)*100
    I=I+1
    II(1)=INUM/10
    INUM=INUM-II(1)*10
    I=I+1
    II(1)=INUM
    CALL ENCCDE(I,IS,II)
    CALL SYM3CL(X,Y,.C7,IS,IF,I)
    INUMS=INUMS+IVH2
    X=X-I.*CTH
    Y=Y-I.*STF
700 RETURN
END

```

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