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TECHNICAL REPORT

ASWEPS REPORT NO. 6

OCEAN CURRENTS OVER PLANTAGENET BANK, BERMUDA

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JUNE 1962

U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C.
Price 95 cents

ABSTRACT

This report contains the results of a study of the ocean currents over Plantagenet Bank, Bermuda from 1 to 15 August 1961. These current data, presented as central vector plots, hodographic plots, and progressive vector diagrams, reveal influences due to winds, thermal stratification, and bottom friction superimposed upon a net south-southeasterly flow. The current in the southern region of the Bank was clearly rotary and displayed somewhat irregular characteristics which were apparently associated with eddy turbulence. Obvious tidal influences were not revealed.

ACKNOWLEDGEMENTS

Advice and assistance of Mr. H. A. O'Neal, Director of Engineering Applications, Office of Naval Research, and Cdr. R. E. Tyler, U. S. N., Office of Naval Research, Project Officer Bermuda, is especially appreciated. Appreciation is also expressed for assistance provided by the following Oceanographic

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FOREWORD

More detailed studies of the marine environment than have been routinely conducted in the past are a necessary aspect of the development of accurate oceanographic prediction techniques. Fixed tower structures provide the stable platforms required for such studies. The necessity of locating these structures in relatively shallow water raises the question of how representative measurements at these locations will be of adjacent open ocean processes.

The unique location of the U. S. Navy's ARGUS ISLAND tower on a seamount southwest of Bermuda presents an outstanding opportunity to conduct such detailed studies. Effective utilization of this facility in support of the Antisubmarine Warfare Environmental Prediction System (ASWEPS) requires a knowledge of the oceanographic environment in the immediate vicinity of ARGUS ISLAND and the extent to which waters over Plantagenet Bank are representative of the surface layer of surrounding deep ocean waters.

This report deals only with current observations obtained during this survey and represents a significant contribution to the understanding of circulation phenomena over Plantagenet Bank.

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Commander

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OCEAN CURRENTS OVER PLANTAGENET BANK, BERMUDA

INTRODUCTION

The U. S. Navy Hydrographic Office* is currently engaged in a comprehensive environmental research program at the Navy's ARGUS ISLAND tower on Plantagenet Bank near Bermuda (Figure 1). This Texas-Tower-type structure (Figure 2) was constructed during the summer of 1959 in support of underwater acoustics research activities under the direction of the Office of Naval Research. Through cooperation of the Office of Naval Research, arrangements have been made for utilization of the tower by the Hydrographic Office as an oceanographic research platform. This research effort is associated with the development of the Antisubmarine Warfare Environmental Prediction System (ASWEPS) and is an outgrowth of experience gained by the Hydrographic Office at Texas Towers 2 and 4 (Carlson and collaborators, 1956; Gaul, 1961).

Prior to the initiation of oceanographic research at ARGUS ISLAND, it was necessary to consider the extent to which environmental studies on Plantagenet Bank would be descriptive of adjacent ocean processes. Such considerations must involve the question of distribution of oceanographic properties over the Bank as well as the influence of the Bank on currents which influence these properties. Thus, a current study in conjunction with a survey of the distribution of the oceanographic variables over Plantagenet Bank was considered of primary importance in determining the significance of future studies at ARGUS ISLAND.

Plantagenet Bank is situated atop a seamount which protrudes abruptly from the deep ocean floor approximately 20 miles southwest of Bermuda. The area of the Bank is approximately 15 square miles and is characterized by a relatively uniform 30-fathom depth. The bottom plunges sharply off the edge of the Bank to great depths.

The circulation over the Bank has recently been a subject of speculation based on a limited number of observations. Unpublished investigations by the Columbia University Geophysical Field Station, St. Davids, Bermuda have indicated that these currents are quite variable, with wind and tidal influences being difficult to recognize. Recent studies by the Woods Hole Oceanographic Institution (Bruce, 1961), however, have largely clarified the nature of the October circulation immediately <u>southwest</u> of the Bank.

Prior to undertaking detailed environmental studies at ARGUS ISLAND, supplementary observations of the circulation over the Bank were considered necessary. Current data contained in this report constitute a portion of the preliminary efforts to satisfy this requirement. These data were obtained through the utilization of the USS PREVAIL (AGS-20) between 1 and 15 August 1961.

* Redesignated U. S. Naval Oceanographic Office 10 July 1962

SURVEY DESIGN

Station Locations

Three anchor stations, designated A, B, and C (Figure 1), were occupied for consecutive 25-hour periods. Stations A and B were located on the southern periphery of the Bank, and Station C was located near its geometric center. Supplementary current information was acquired with a self-contained monitoring buoy, which functioned autonomously through the period of the survey (1-15 August). Station positions relative to ARGUS ISLAND, located one mile from the southern edge of the Bank, are as follows:

Station	Range (yd)	Bearing (°T) From Tower
Anchor Station A	2,000	135
Anchor Station B	2,000	270
Anchor Station C	3,000	020
Current Buoy	1,000	135

Instrumentation

Low-velocity Roberts current meters (Figure 3) were utilized for all current measurements except those obtained by the current-monitoring buoy. Modifications of the original Roberts radio current meter, including larger fins and impeller blades, were made by the U. S. Coast and Geodetic Survey and have been incorporated in the low-velocity instrument. These changes render the meter more sensitive to low-velocity currents by lowering the speed threshold to 0.1 knot. Accuracy of the instrument is evaluated at ±0.1 knot and ±10 degrees. An average error of ±5 degrees is somewhat more representative of the directional accuracy of the instrument.

Over-the-side suspension and electrical linkage of the current meter were accomplished with a series 600 electronic bathythermograph hoist (Figure 4) which considerably facilitated positioning of the instrument at desired depths.

The buoyed current meter system, designed and built by the Hydrographic Office, was tested during the period of the survey. This system incorporates a Model CM-3 Japanese current meter suspended from a subsurface pressure-resistant float, as shown in Figure 5. A small, lighted marker buoy was attached by a short length of line to the main float for the purpose of locating and retrieving the buoy system.

Readout equipment associated with the Japanese current meter was arranged within the subsurface float as shown in Figure 6, so that dial readings could be automatically recorded on 16mm. photographic film. An electric-motor-driven cam periodically activated a flash camera which photographed temperature, current speed and direction, and clock dials (Figure 7). Modification of the original readout equipment enabled simultaneous speed and direction readouts thus eliminating the necessity for manual switching to obtain these readings individually. Estimates of the threshold and accuracy of the instrument are 0.2 knot and ±0.1 knot, respectively. Directional accuracy is within ±20 degrees; average error is ±12 degrees.

Observational Technique

At each anchor station the modified Roberts current meter was lowered to the following observational depths: 4, 10, 16, 22, 28, 34, 40, 46, and 52 meters. Approximately one hour was required to complete each vertical series of observations, after which the instrument was returned to the 4-meter depth to repeat the series. This procedure was followed through the 25-hour observation period at each station. The uppermost depth of 4 meters was selected in order to minimize the influence of surface wave action and ship motion which would otherwise be more pronounced if the observations had been made nearer the surface. These data, together with corresponding wind data, are presented in Appendix A.

The buoyed Japanese current meter was suspended at a depth of 18 meters, corresponding approximately to the 16-meter observational depth used at the anchor stations, and was located 1,000 yards southeast of ARGUS ISLAND from 1 to 15 August. This meter was installed mainly for testing purposes in the hope that supplementary current information would be obtained for correlation with observations taken at the nearby anchor stations. Comparisons of simultaneous current observations at the buoyed meter and each of the anchor stations are discussed below. The Japanese current meter data are presented in Appendix B.

Supplementary Observations

In addition to current observations used in this study, a considerable amount of oceanographic data was acquired in the region of the Bank during the period of this survey. These supplementary observations, too voluminous to be treated in this report, include:

Nansen casts, sound velocity measurements, and bathythermograph observations at 28 oceanographic stations over the Bank from 1 to 3 August and from 9 to 11 August.

Three-hourly Nansen casts, hourly bathythermograph observations, and continuous temperature records at 10-foot increments between the surface and bottom during the 25-hour observation period at each anchor station.

A study of these data in relation to the observed currents is in progress.

DATA ANALYSIS

Magnetic Corrections

Plantagenet Bank is well known as an area characterized by a pronounced magnetic anomaly. Airborne geomagnetic measurements made by the Hydrographic Office in January 1961 provide an accurate description of this magnetic disturbance. These measurements have been utilized to determine corrections for compass variation which have been applied to the magnetic current directions at each of the following stations:

Station	Correction (degrees)
A	-13.5
B	- 9.5
C	-13.5
Current Buoy	-12.5

Central Vector Diagrams

At each anchor station a series of current measurements varying in number from 19 to 25 was obtained at all observational depths. Central vector plots provide a vivid means of representing time changes of current speed and direction of such serial observations. These plots have been constructed for each depth, as well as for the surface winds (Appendix C).

Vectors are numbered in chronological order. Wind vectors are drawn in the direction toward which the wind was blowing.

Progressive Vector Diagrams

The progressive vector diagrams presented in Appendix D provide another means of depicting the series of current data available at a given depth. Such diagrams, constructed through successive graphic addition of observed hourly velocities, provide indications of net transport over the Bank.

A limitation of this technique results from the somewhat unequal time intervals between the consecutive observations at given depths. In order to compensate for this deficiency, interpolated hourly velocities have been introduced into several data gaps, thus providing a relatively undistorted displacement track. This technique is not intended to be absolutely representative of the actual water particle displacement but is intended to serve as an aid in the comparison of gross current characteristics from depth to depth and from station to station.

Appendix D also includes progressive vector diagrams of the current data obtained with the buoyed current meter plotted beside the simultaneous anchor station observations at a corresponding 16-meter depth. Approximately twice as many observations were available for the progressive vector plots of the buoyed current meter data than were available for similar plots of the anchor station observations. Therefore, the progressive vector diagrams plotted from the buoy data were adjusted to the same length as those of the anchor stations in order to facilitate comparison. Individual observations corresponding in time lie approximately side by side and are connected by broken lines.

Hodographs

At each anchor station, current observations were obtained at 6-meter intervals between 4 meters and the bottom. Although each vertical series required approximately one hour to complete, each is treated as a quasi-simultaneous vertical velocity profile. Hodographic plots of several series at Stations B and C are presented in Appendix E. Each plot includes the surface wind vector drawn in the direction of the air movement for comparison with the surface currents.

DISCUSSION OF RESULTS

The three basic methods of data analysis described in the previous section provide significant clues to the circulation patterns over Plantagenet Bank during the period of observation. The striking wind influence on the observed surface circulation is immediately apparent from comparison of the central vector plots of wind and surface currents at the 3 anchor stations. This effect is apparent in the plots for Stations B and C, where winds blew primarily toward directions within a 90-degree sector (045° to 135°T, Appendix C) and were relatively steady during the period of observation.

In agreement with Ekman's fundamental considerations of wind-driven ocean currents, the observed surface currents (Appendix C) fell largely in a sector rotated 45 degrees to the right of the primary wind direction. No clear relationship was apparent between winds and surface currents at Station A, since winds at this station were highly variable in both direction and speed. Anemometer wind velocities were recorded continuously at ARGUS ISLAND, as well as on board the survey vessel. Since wind stress on the sea surface is directed downwind and is approximately proportional to the square of the wind velocity measured at anemometer level (Sverdrup, 1942 and Holmboe, Forsythe, and Gustin, 1945), these measurements are considered an index of the direction and magnitude of sea surface stresses. Central vector plots with wind vectors drawn in the direction of air movement may then be used to represent the driving force of the surface currents.

Below the 4-meter depth, currents generally veered progressively toward the right, conforming to the Ekman spiral principle to depths varying between 10 and 34 meters. Hodographic plots (Appendix D), have been constructed for a few of the vertical series made at Stations B and C, where relatively unidirectional winds of appreciable speed had blown for several hours preceding the current observations. As might well be anticipated, similar plots of data from Station A where winds were highly variable showed no clearly defined wind-driven characteristics.

A marked thermal stratification existing during the survey may partly account for the departures of the observed vertical current profiles from theoretical current distributions derived for vertically homogeneous water. Defant (1961) and Nomitsu (1933) describe the influence of such stratification on a surface drift current. Their studies indicate that a larger deflection from the wind direction is experienced when an homogeneous surface layer of small thickness is developed, such as that existing during the period of the described observations. This effect, as well as the distortion produced by the net southeasterly transport over the Bank, may account for the greater deflection to the right of observed currents than would be expected for vertically homogeneous water. It is also postulated that the rather sharp cutoff of wind-driven characteristics of the vertical velocity profile at the approximate depth of the thermocline may be a further manifestation of the essentially two-layered system produced by the sharp density transition.

Despite certain pitfalls involved in the interpretation of progressive vector diagrams, it is felt that they materially improve illustration of the current phenomena treated here. An immediate application of such diagrams is the graphical approximation of the net water movement over the Bank based on observed currents. Further applications include the ready visualization of time changes and rotary characteristics.

Net hourly displacement, net daily displacement, and average observed currents have been computed for each observational depth at Stations A, B, and C. These values, presented in Appendix F, summarize the average features of water movement over the Bank based on one-day intervals of data from each station. Net daily displacements were graphically determined from the progressive vector diagrams by measuring the magnitude and direction of the resultant 24-hour vector. The net hourly displacements can be compared with observed velocities. It is noted that the mean observed hourly velocity closely approximates the net hourly displacement except at Station A, where the current displayed rotary characteristics and was considerably smaller in magnitude than it was at Stations B and C. Average current speeds at Stations B and C were nearly identical; however, net current directions at Station B were southerly, while those at Station C were approximately south-southeasterly. Average net directions at Stations A, B, and C are 141°, 183°, and 154° T, respectively.

The marked continuity of the current observations obtained during this study is revealed by comparisons of the progressive vector diagrams from depth to depth as well as from station to station. The characteristic shape of the displacement tracks at a particular station is replicated with certain minor distortions at each observational depth.

Frictional influence of the bottom is considered a major cause of the apparent shrinkage of the vector diagrams with increasing depth. The distinct loops occurring at depth below 28 meters at Station A are believed to be associated with large eddies on the lee side of the seamount. These current rotations were clockwise and were not found at Stations B and C. Since such rotations were only observed at Station A at depths below the sharp density transition, it is felt that their occurrence is not purely a manifestation of tidal forces, but that they are associated with a large eddy regime existing on the lee side of the Bank. Present data are insufficient for deducing the periodicity of the rotation, though at depths of 40 and 46 meters one rotation appears to have been completed in approximately 13 hours.

Considerable caution has been exercised in interpreting these rotations, since observations were obtained at only one station at any given time. Wider synoptic coverage will be required for determination of the absolute nature of the postulated eddy regime. Such rotations may be associated with vortices moving off the lee side of the Bank. Nevertheless, the possibility that such rotary characteristics were partially a consequence of tidal forces cannot be entirely eliminated.

Current speeds obtained by the experimental buoyed current meter should be viewed with a degree of reservation because of improper zero adjustment of the speed indicator. In view of the apparent accuracy of the directions obtained, as indicated by the agreement between these observations and those of the Roberts meter, it is felt that there is a sufficient degree of accuracy to warrant the consideration of these data.

The progressive vector diagrams of the current buoy data and the observations conducted simultaneously at the corresponding depth of 16 meters at Stations A, B, and C show close agreement. In like manner the 22-meter data of the anchor station plots are distinctly similar, though they have not been presented for comparison with the buoyed current meter data.

Recent current studies were conducted by the Woods Hole Oceanographic Institution (Bruce, 1961) with parachute drogues on Plantagenet Bank and in the deeper water adjacent to and southwest of the Bank from 5 to 18 October 1959. Of particular significance is the agreement between these observations and those presented in this report, though the two surveys are separated by a 22-month interval. These drogue studies also indicated the general direction of currents to be south-southeasterly with speeds of one knot or less. Indications of turbulence south of the Bank and seemingly non-tidal characteristics of the observed currents were also apparent through the Woods Hole investigation.

THEORETICAL CONSIDERATIONS

Based on the limited number of observations available through this and previous studies in the vicinity of Plantagenet Bank, it is perhaps reasonable to speculate as to possible mechanisms of current flow which may exist in this region. Theoretical considerations of the modifications which should occur to a surface current impinging on the Bank are simplified by regarding the current system as being comprised of two discrete regimes in which quite dissimilar mechanisms are operative. These seemingly obvious categories of flow in the immediate proximity of the Bank are: (1) flow over the Bank and (2) flow around the Bank.

The first category involves a surface deflection which is analogous to the frictional deflection of currents passing over a submarine ridge (Figure 8). In accordance with theory, a current moving over the upslope portion of the seamount is deflected toward the right; after passing over the seamount and while over the downslope portion, the current is theoretically deflected toward the left and thus may approximately resume its original direction. Such an influence would imply that impinging currents were in a more easterly direction prior to being deflected than the southeasterly flow observed over the Bank. It is possible that this hypothetical easterly direction is resumed by currents after passing over the Bank.

The second category involves flow around either side of the seamount similar to that experienced around a submerged cylinder (Lamb, 1945) at depths below the upper surface of the Bank (Figure 9). Superimposed upon these two mechanisms is an upward component of current flow caused by movement of the impinging current up the leading face of the seamount. Thus it is theorized that lateral spreading should occur in a manner similar to conditions discussed by Neumann (1940) and Wust (1940) in the vicinity of Altair Dome near the Azores. The existence of a rather large eddy regime on the lee side of the Bank must also be considered a distinct possibility.

These concepts have been incorporated into two grossly simplified models (Figures 8 and 9) which serve to illustrate theoretical current patterns which may have existed during the period of observation.

CONCLUSIONS

Based on these observations, the following characteristics of the ocean currents over Plantagenet Bank during the period of study (1-15 August 1961) are apparent:

1. Currents were primarily southeasterly with speeds ranging from 0 to 1.4 knots. Average speed was 0.45 knot.

2. The current was observed to be relatively constant in both speed and direction at all locations on the Bank except at the extreme

southern periphery. The rotary characteristics of the currents at this location appear to indicate an area of eddy turbulence on the lee side of the Bank with respect to the impinging current.

3. Wind is a significant factor influencing the direction of flow in the surface layer. Observed surface currents veer approximately 45 degrees from the direction of the wind during periods of steady, relatively high velocity winds.

4. Thermal stratification introduces a sharp cutoff of the wind-driven characteristics. The wind influence superimposed upon the net southeasterly flow is apparent above the thermocline. The wind-driven effect is absent below the thermocline and the net flow predominates.

5. Current speeds decrease with depth owing to frictional influence of the bottom.

6. Influence of tidal forces on currents near the Bank is not readily apparent though such effects undoubtedly exist.

7. Further studies involving simultaneous observations at several representative locations on the Bank are required for precise determination of the current regime over Plantagenet Bank. Such studies appropriately spaced through the year will also permit investigation of possible seasonal modifications of the currents in this region.

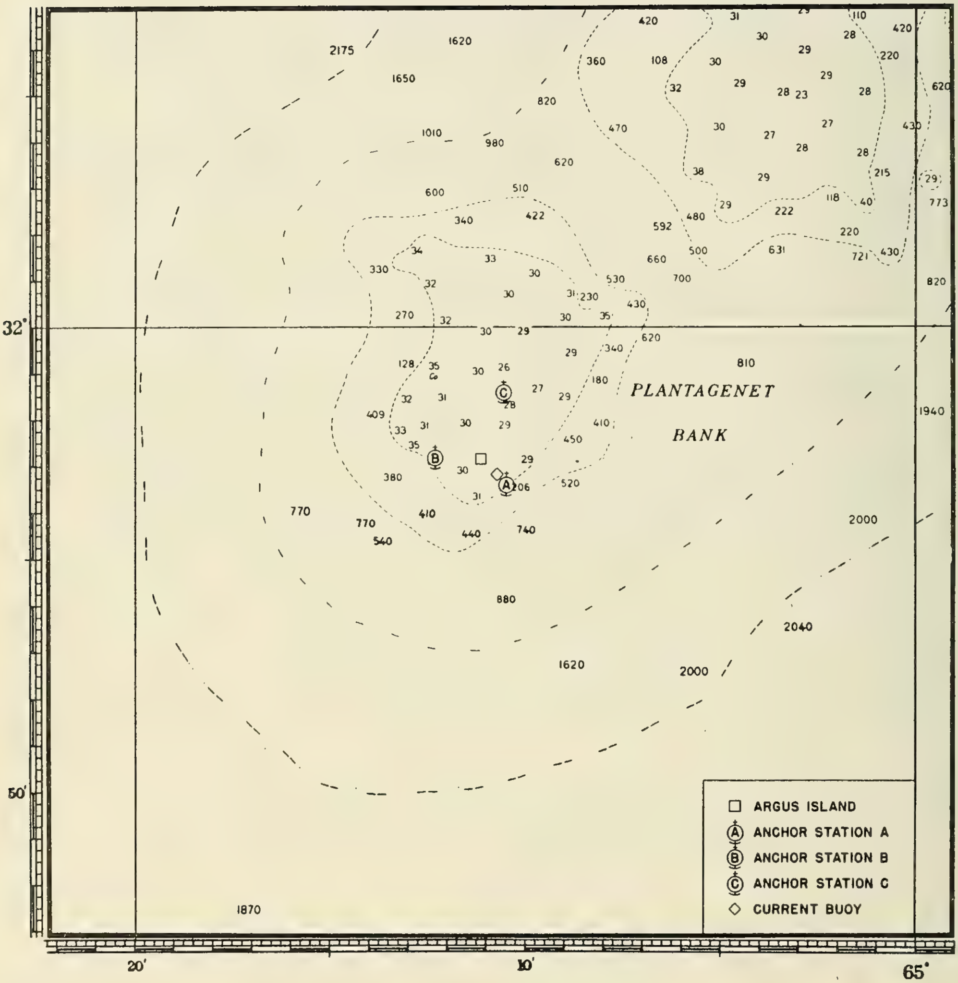


FIGURE I STATION LOCATIONS

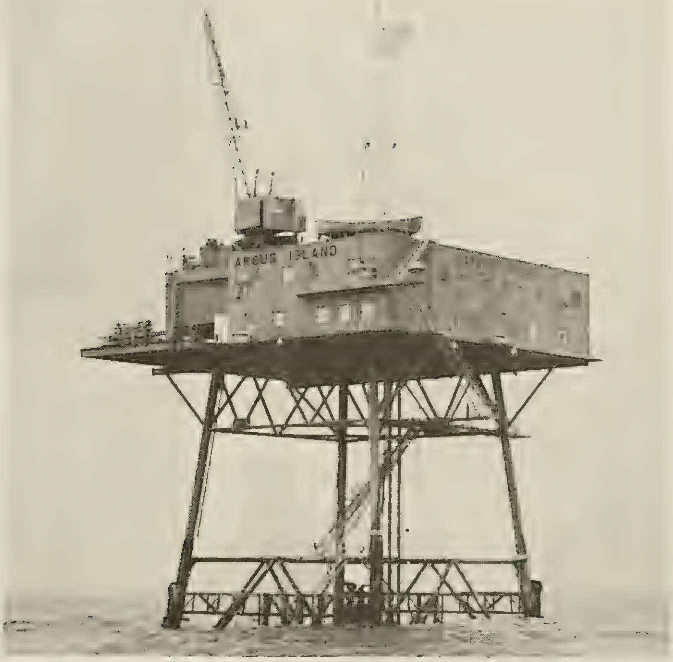


FIGURE 2 ARGUS ISLAND

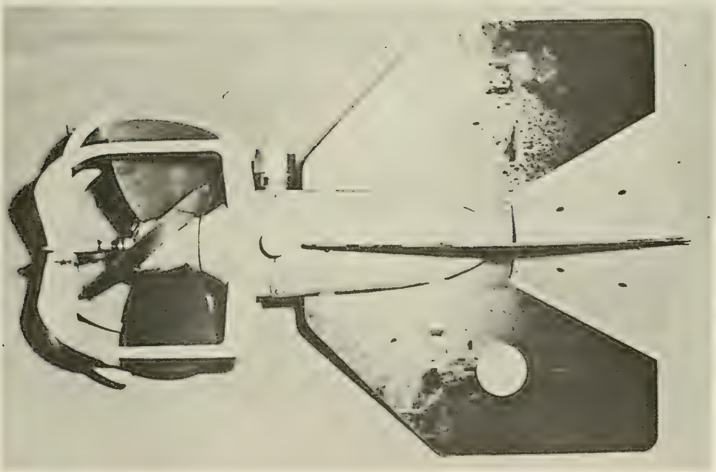
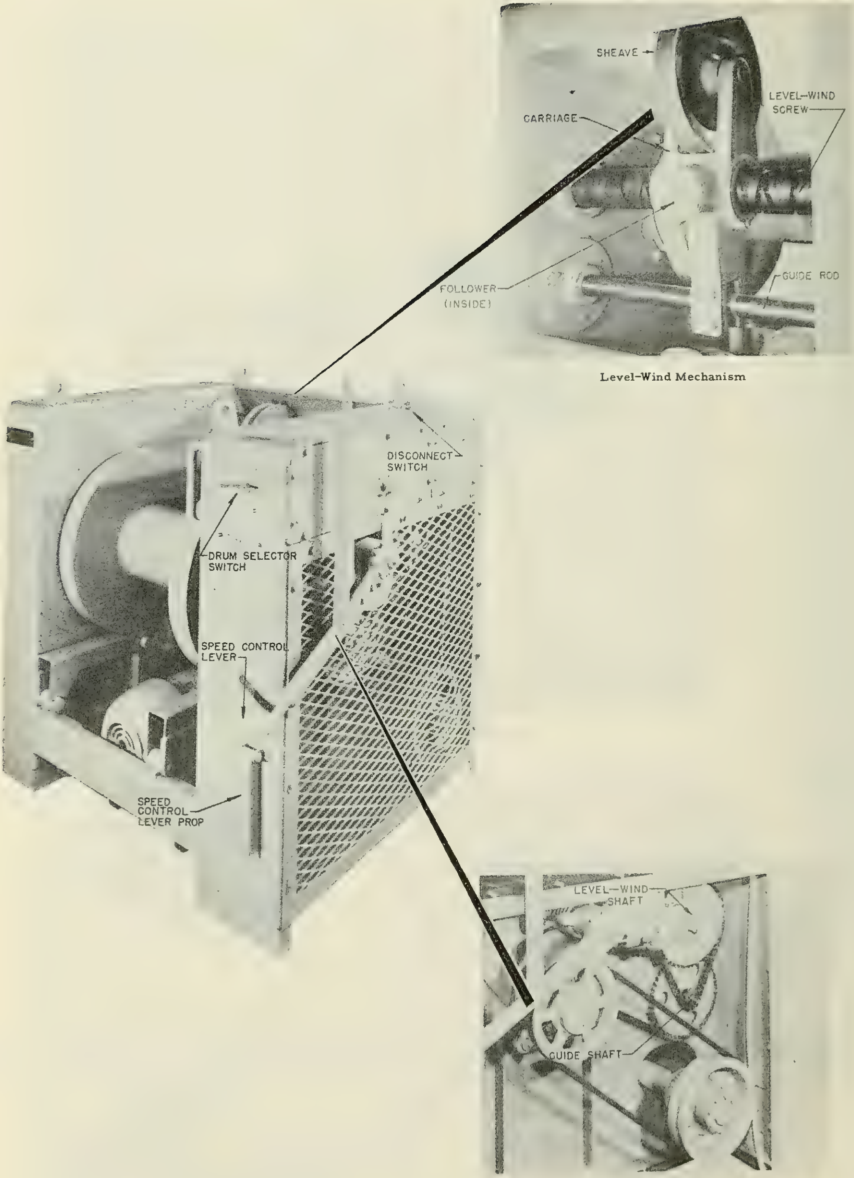


FIGURE 3 LOW-VELOCITY ROBERTS CURRENT METER



Level-Wind Mechanism

Level-Wind Sprocket Drive

FIGURE 4 ELECTRONIC BATHYTHERMOGRAPH HOIST — SERIES 600

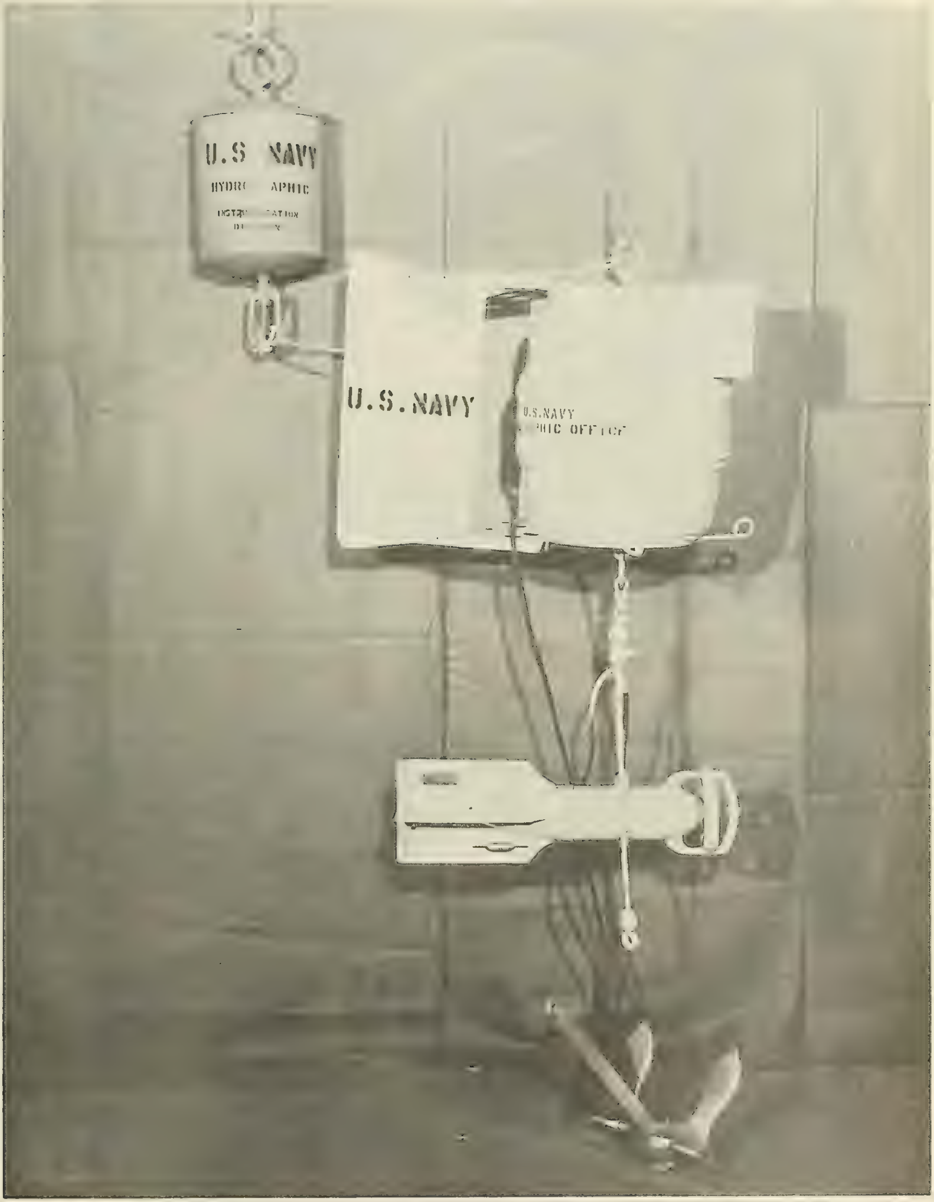


FIGURE 5 BUOYED JAPANESE CURRENT METER SYSTEM

FIGURE 6 SUBSURFACE FLOAT OPENED TO SHOW CAMERA, ELECTRONIC FLASH UNITS, AND READOUT DIALS

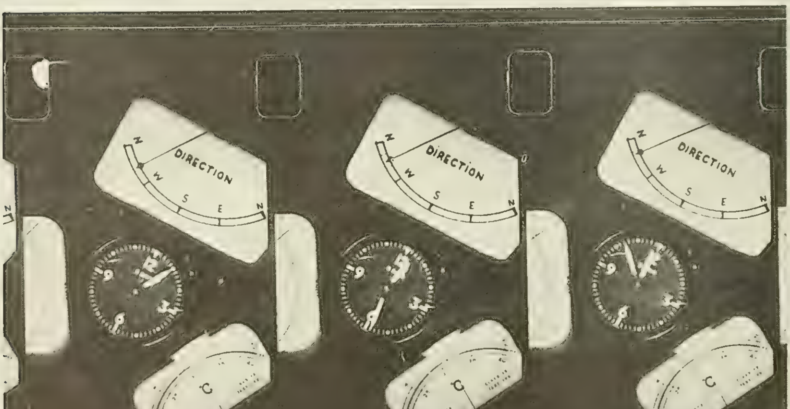


FIGURE 7 SAMPLE FILM RECORD SHOWING THREE CURRENT—TEMPERATURE OBSERVATIONS

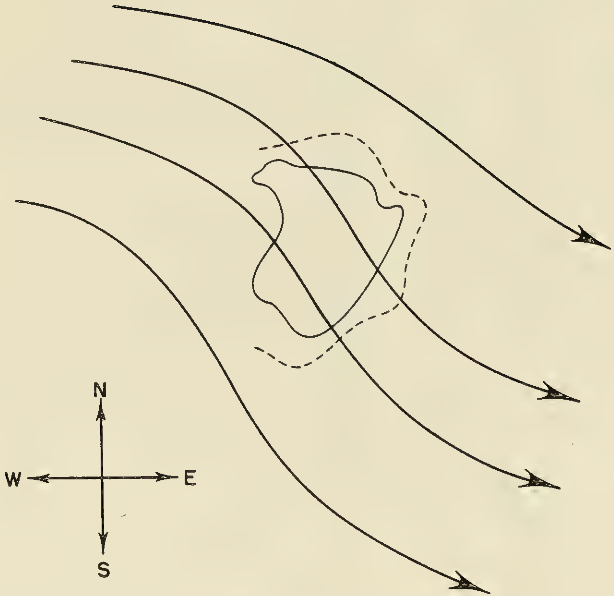


FIGURE 8 THEORETICALLY DEDUCED FLOW OVER PLANTAGENET BANK ABOVE 30 FATHOMS

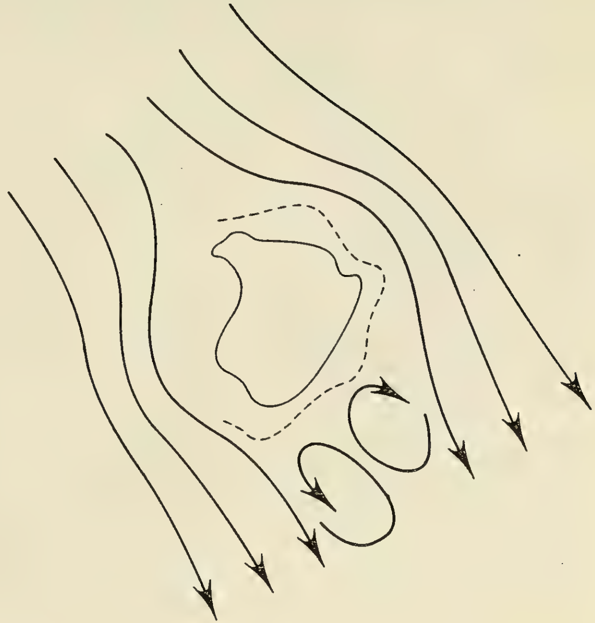


FIGURE 9 THEORETICALLY DEDUCED FLOW AROUND PLANTAGENET BANK BELOW 30 FATHOMS

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APPENDIX A

WIND AND CURRENT DATA
STATIONS A, B, AND C

APPENDIX A

WIND AND CURRENT DATA

Station A, (31°56'30", 65°10'45"W) 11-12 August 1961

Series	Wind Time GMT	Wind Dir °T	Wind Speed Knots	4 Meters Time GMT	4 Meters Dir °T	4 Meters Speed Knots	10 Meters Time GMT	10 Meters Dir °T	10 Meters Speed Knots	16 Meters Time GMT	16 Meters Dir °T	16 Meters Speed Knots	22 Meters Time GMT	22 Meters Dir °T	22 Meters Speed Knots
1	2058	055	6.0	2058	140	0.2	2118	143	0.6	2127	130	0.2	2136	154	0.3
2	2250	090	8.0	2250	161	—	2300	119	0.3	2315	122	0.3	2325	104	0.3
3	0050	130	6.0	0050	214	0.3	0105	179	0.4	0112	160	0.3	0120	184	0.2
4	0230	140	7.0	0230	224	0.2	0242	241	0.2	0300	187	0.2	0305	089	0.2
5	0412	145	7.0	0412	—	—	0433	078	0.2	0446	069	0.3	0520	064	0.2
6	0718	170	4.0	0718	351	0.3	0742	082	0.3	0749	079	0.3	0805	115	0.2
7	0912	175	3.0	0912	078	0.3	0937	084	0.3	0950	115	0.3	0959	166	0.3
8	1053	230	2.0	1053	067	0.2	1059	062	0.3	1105	090	0.2	1112	146	0.2
9	1203	200	2.0	1203	108	0.2	1209	118	0.4	1212	119	0.3	1223	153	0.3
10	1306	180	2.0	1306	093	0.2	1311	075	0.2	1318	085	0.3	1319	144	0.2
11	1356	185	2.0	1356	079	0.4	1400	084	0.4	1405	083	0.3	1409	145	0.3
12	1438	200	2.0	1438	075	0.3	1443	071	0.3	1447	077	0.4	1456	132	0.2
13	1539	245	2.0	1539	078	0.3	1544	084	0.3	1553	081	0.2	1604	101	0.2
14	1640	275	2.0	1640	145	0.2	1651	110	0.3	1702	089	0.3	1710	109	0.2
15	1755	335	2.0	1755	088	0.1	1800	071	0.3	1808	077	0.2	1813	056	0.3
16	1842	330	2.0	1842	099	0.1	1847	092	0.2	1850	133	0.2	1853	071	0.2
17	1947	315	2.0	1947	230	0.3	1957	180	0.2	2005	181	0.2	2012	138	0.3
18	2052	030	2.0	2052	264	0.2	2100	204	0.2	2112	185	0.3	2116	149	0.2
19	2152	030	3.0	2152	168	0.1	2200	177	0.2	2207	162	0.3	2222	146	0.3

APPENDIX A

Station A (con.)

Series	28 Meters			34 Meters			40 Meters			46 Meters			52 Meters		
	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots
1	2147	117	0.2	2155	056	0.4	2210	102	0.3	2225	118	0.4	2230	098	0.3
2	2335	113	0.4	2345	070	0.5	2352	129	0.4	2358	132	0.7	0015	106	0.4
3	0135	176	0.1	0145	284	0.2	0205	249	0.2	0210	209	0.5	0213	184	0.8
4	0315	130	0.2	0330	208	0.2	0345	219	0.4	0350	249	0.4	0355	205	0.4
5	0540	088	0.3	0600	047	0.2	0642	332	0.2	0651	325	0.3	0701	282	0.3
6	0815	131	0.2	0827	018	0.2	0835	001	0.4	0850	346	0.3	0900	317	0.4
7	1009	171	0.4	1015	120	0.3	1022	056	0.2	1028	067	0.2	1038	104	0.1
8	1118	162	0.4	1123	117	0.3	1131	063	0.3	1143	067	0.2	1152	186	0.1
9	1230	165	0.3	1238	148	0.4	1251	105	0.4	1255	126	0.5	1259	141	0.4
10	1329	164	0.3	1336	149	0.4	1341	165	0.4	1346	152	0.6	1350	160	0.4
11	1413	162	0.3	1418	206	0.3	1422	118	0.4	1427	180	0.4	1432	166	0.3
12	1508	288	0.1	1515	226	0.4	1523	147	0.4	1528	166	0.4	1533	171	0.4
13	1613	136	0.1	1615	236	0.2	1625	251	0.2	1632	182	0.4	1636	148	0.6
14	1715	080	0.3	1735	044	0.1	1736	257	0.3	1743	229	0.4	1746	200	0.5
15	1818	028	0.3	1840	017	0.2	1825	260	0.2	1832	253	0.4	1835	246	0.2
16	1905	113	0.2	1915	069	0.2	1930	241	0.2	1937	239	0.2	1940	256	0.3
17	2016	107	0.3	2025	201	0.1	2030	242	0.2	2036	259	0.2	2043	289	0.2
18	2125	177	0.2	2132	046	0.1	2135	247	0.2	2142	207	0.3	2145	266	0.2
19	2215	166	0.2	2232	211	0.2	2235	261	0.3	2242	229	0.3	2250	184	0.3

APPENDIX A

Station B, (31°57'00"N, 65°12'00"W) 13-14 August 1961

Series	Wind			4 Meters			10 Meters			16 Meters			22 Meters		
	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots
1	0145	200	5.0	0145	175	0.7	0155	182	0.8	0206	201	0.7	0213	199	0.4
2	0255	185	8.0	0255	175	0.7	0300	202	0.8	0305	202	0.9	0307	205	0.6
3	0340	190	8.0	0340	188	0.6	0345	209	0.7	0355	202	0.7	0401	207	0.6
4	0436	200	7.0	0436	220	0.5	0439	217	0.6	0443	222	0.7	0448	210	0.7
5	0526	220	8.0	0526	250	0.5	0531	225	0.6	0536	251	0.7	0541	241	0.6
6	0632	235	9.0	0632	257	0.6	0638	225	0.7	0643	205	0.7	0646	212	0.6
7	0722	245	9.0	0722	228	0.3	0726	251	0.5	0730	241	0.6	0736	247	0.5
8	0818	255	8.0	0818	171	0.3	0823	208	0.3	0830	209	0.5	0834	195	0.5
9	0912	270	6.0	0912	161	0.4	0916	168	0.5	0920	185	0.5	0923	185	0.5
10	0956	270	5.0	0956	167	0.4	1000	186	0.5	1005	171	0.6	1007	171	0.7
11	1047	270	4.0	1047	180	0.4	1057	154	0.7	1050	154	0.7	1105	154	0.7
12	1142	265	5.0	1142	174	0.3	1150	176	0.6	1152	155	0.7	1157	164	0.7
13	1320	260	5.0	1320	118	0.7	1322	151	0.5	1427	158	0.6	1435	172	0.6
14	1510	255	6.0	1510	168	0.7	1515	138	0.7	1520	159	0.7	1525	180	0.6
15	1724	285	10.0	1724	128	0.7	1734	163	0.7						
16							1905	206	0.9	1910	196	0.9	1915	214	0.8
17	2009	280	11.0	2009	170	0.8	2014	198	0.9	2019	190	0.8	2024	198	0.8
18	2100	275	11.0	2100	171	1.0	2104	191	0.8	2106	154	0.8	2110	183	0.8
19	2150	270	11.0	2150	193	0.9	2156	166	1.0	2205	176	0.9	2209	192	0.8
20	2245	275	11.0	2245	169	0.8	2248	186	0.8	2251	172	0.8	2254	191	0.6
21	2325	285	11.0	2325	163	1.0	2330	187	0.9	2333	167	0.9	2337	163	0.8
22	0005	290	11.0	0005	143	1.0	0008	146	0.9	0013	149	0.8	0016	144	1.0
23	0049	285	9.0	0049	153	0.9	0053	150	0.9	0057	155	0.9	0101	148	0.9
24	0139	280	9.0	0139	179	0.9	0151	149	0.9	0156	155	0.7	0200	169	0.9
25	0231	275	9.0	0231	156	0.8	0235	164	0.8	0239	144	0.9	0240	108	0.7
26	0309	270	9.0	0309	155	0.9	0314	156	0.8	0318	162	0.8	0322	151	0.7

APPENDIX A

Station B (con.)

Series	Time GMT	28 Meters Dir °T	28 Meters Speed Knots	Time GMT	34 Meters Dir °T	34 Meters Speed Knots	Time GMT	40 Meters Dir °T	40 Meters Speed Knots	Time GMT	46 Meters Dir °T	46 Meters Speed Knots	Time GMT	52 Meters Dir °T	52 Meters Speed Knots
1	0227	232	0.4	0235	237	0.4	0240	240	0.5	0243	250	0.5	0250	259	0.3
2	0313	226	0.5	0315	262	0.4	0320	241	0.4	0325	253	0.3	0334	275	0.2
3	0407	207	0.4	0413	224	0.4	0419	224	0.3	0425	259	0.4	0430	254	0.3
4	0454	228	0.5	0459	230	0.4	0509	234	0.4	0514	220	0.3	0520	236	0.2
5	0546	250	0.3	0602	205	0.2	0614	253	0.2	0620	310	0.2	0626	258	0.2
6	0651	240	0.3	0658	246	0.3	0705	239	0.2	0711	241	0.2	0717	256	0.4
7	0739	244	0.5	0744	245	0.3	0751	068	0.2	0759	321	0.1	0808	316	0.2
8	0839	164	0.4	0844	155	0.4	0851	206	0.3	0859	030	0.2	0907	075	0.2
9	0927	180	0.5	0931	170	0.5	0937	197	0.4	0943	160	0.3	0950	205	0.2
10	1014	140	0.7	1020	138	0.6	1027	178	0.3	1030	095	0.3	1047	295	0.2
11	1111	146	0.6	1115	131	0.7	1121	160	0.4	1126	162	0.3	1140	206	0.2
12	1200	165	0.7	1205	167	0.5	1210	148	0.2	1220	178	0.5	1226	158	0.5
13	1440	174	0.7	1444	197	0.7	1450	193	0.9	1500	191	0.7	1508	220	0.7
14	1527	175	0.8	1532	217	0.6	1537	209	0.9	1547	208	0.9	1557	222	0.7
15															
16	1920	179	0.8	1924	168	0.4	1929	166	0.4	1935	138	0.4	2000	283	0.2
17	2029	183	0.7	2034	185	0.8	2039	167	0.4	2046	163	0.4	2052	051	0.3
18	2115	179	0.7	2124	192	0.7	2128	167	0.4	2131	111	0.4	2138	156	0.2
19	2213	180	0.8	2217	184	0.6	2220	149	0.5	2228	148	0.5	2233	136	0.3
20	2258	179	0.7	2303	192	0.5	2308	168	0.6	2312	185	0.6	2320	172	0.2
21	2340	179	0.8	2345	178	0.5	2349	184	0.8	2355	154	0.5	2359	120	0.4
22	0020	153	0.8	0025	155	0.6	0029	136	1.0	0034	175	0.5	0041	150	0.4
23	0107	162	0.9	0112	154	0.8	0117	156	0.9	0122	175	0.6	0127	170	0.6
24	0205	187	0.8	0211	159	0.6	0215	178	0.9	0220	196	0.6	0224	175	0.6
25	0250	154	0.8	0253	174	0.6	0256	174	0.7	0258	199	0.7	0302	160	0.8
26	0327	161	0.8	0331	122	0.6	0335	152	0.7	0338	208	0.6	0344	183	0.9

APPENDIX A

Station C, (31°58'40"N, 65°10'15"W) 14-15 August 1961

Series	WIND			4 Meters			10 Meters			16 Meters			22 Meters		
	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots
1	0620	250	10.0	0620	167	0.9	0627	164	0.8	0630	171	0.8	0635	195	0.6
2	0657	250	11.0	0657	191	0.9	0700	177	0.8	0703	215	0.8	0705	177	0.5
3	0735	250	14.0	0735	162	0.7	0740	216	0.7	0745	206	0.7	0747	230	0.5
4	0830	255	14.0	0830	159	0.7	0838	163	0.8	0845	163	0.5	0850	137	0.5
5	0920	260	14.0	0920	184	0.6	0924	156	0.7	0928	186	0.7	0932	166	0.5
6	1016	270	14.0	1016	164	0.8	1022	158	0.7	1033	135	0.7	1040	152	0.7
7	1121	275	14.0	1121	101	0.9	1125	178	0.8	1129	164	0.9	1152	146	0.9
8	1226	285	14.0	1226	126	1.0	1233	157	1.0	1239	160	1.0	1243	167	0.9
9	1325	280	13.0	1325	173	1.0	1330	166	1.0	1335	136	1.0	1340	146	1.0
10	1407	275	12.0	1407	192	1.1	1412	120	0.9	1416	140	0.9	1420	170	0.9
11	1547	275	13.0	1547	197	1.0	1506	164	0.9	1500	170	0.8	1519	172	0.8
12	1613	285	12.0	1613	132	0.9	1621	142	0.8	1624	151	0.6	1629	179	0.7
13	1704	310	12.0	1704	172	0.9	1711	154	0.7	1717	167	0.6	1726	165	0.5
14	1801	290	11.0	1801	123	0.9	1813	164	0.6	1817	147	0.5	1823	157	0.4
15	1858	280	16.0	1858	148	0.7	1906	134	0.5	1912	151	0.3	1918	154	0.4
16	2001	320	22.0	2001	139	0.8	2010	126	0.7	2017	155	0.2	2031	169	0.2
17	2113	225	10.0	2113	148	0.3	2119	150	0.2	2126	137	0.3	2133	200	0.3
18	2200	150	4.0	2200	168	0.6	2203	036	0.3	2210	077	0.2	2220	094	0.2
19	2251		calm	2251	135	0.4	2304	139	0.2	2325	144	0.3	2337	117	0.4
20	0013	240	5.0	0013	176	0.4	0020	095	0.2	0026	089	0.3	0030	088	0.4
21	0102	225	4.0	0102	169	0.4	0106	101	0.4	0110	101	0.4	0115	076	0.4
22	0140		calm	0140	154	0.4	0145	153	0.4	0150	144	0.4	0155	139	0.4
23	0228		calm	0228	139	0.5									

APPENDIX A

Station C (con.)

Series	28 Meters			34 Meters			40 Meters			46 Meters			52 Meters		
	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots	Time GMT	Dir °T	Speed Knots
1	0637	180	0.6	0640	187	0.5	0645	207	0.4	0648	107	0.2	0651	226	0.3
2	0710	167	0.7	0715	189	0.6	0722	176	0.9	0727	137	0.2	0730	266	0.4
3	0750	166	0.6	0755	136	0.7	0800	233	0.6	0811	166	0.3			
4	0857	181	0.4	0904	179	0.5	0909	172	0.5	0914	109	0.5			
5	0936	172	0.6	0941	184	0.6	0955	177	0.4	0959	197	0.4			
6	1045	124	0.8	1051	142	0.7	1101	198	0.5	1110	151	0.4			
7	1158	141	0.8	1201	144	0.6	1207	146	0.5	1215	140	0.5			
8	1250	158	1.0	1300	195	0.6	1310	156	0.8	1315	159	0.8			
9	1345	153	0.8	1340	160	0.6	1356	151	0.6	1358	141	1.0			
10	1425	146	0.7	1431	182	0.7	1444	162	0.8	1449	172	0.5			
11	1530	198	0.6	1532	146	0.6	1540	137	0.7	1549	167	0.5			
12	1635	163	0.5	1641	189	0.4	1642	147	0.6	1651	148	0.5			
13	1734	187	0.4	1742	132	0.4	1750	191	0.3	1755	246	0.3			
14	1830	197	0.3	1838	123	0.3	1845	061	0.2	1851	166	0.3			
15	1926	178	0.3	1932	180	0.3	1946	170	0.3	1954	148	0.3			
16	2039	215	0.4	2045	192	0.2	2050	157	0.3	2058	149	0.3			
17	2138	016	0.2	2145	228	0.2	2147	042	0.2	2152	079	0.3			
18	2227	026	0.2	2232	061	0.3	2237	090	0.5	2240	060	0.4			
19	2347	135	0.4	2352	099	0.5	2358	137	0.5	0005	178	0.2			
20	0035	071	0.4	0038	101	0.6	0043	091	0.5	0055	047	0.3			
21	0118	111	0.4	0124	083	0.5	0129	089	0.6	0133	076	0.5			
22	0200	115	0.4	0205	139	0.4	0210	120	0.5	0215	099	0.5			

APPENDIX B

JAPANESE CURRENT METER DATA
18 METERS

APPENDIX B

CURRENT DATA

BUOYED JAPANESE CURRENT METER (31°56'35"N, 65°10'23"W)

DEPTH: 18 METERS

DATE 1961	TIME GMT	DIR °T	SPEED Knots	DATE 1961	TIME GMT	DIR °T	SPEED Knots
1 Aug	1112	110	—	2 Aug	0751	092	0.2
	1142	050	—		0825	091	0.4
	1212	040	0.2		0858	100	0.2
	1243	040	—		0931	140	0.6
	1315	060	0.1		1005	140	0.6
	1345	055	0.1		1037	145	0.4
	1417	065	0.2		1110	150	0.4
	1449	050	0.3		1144	165	0.3
	1520	085	0.3		1218	225	0.1
	1552	060	0.1		1252	245	—
	1625	040	0.1		1325	—	0.1
	1658	050	0.1		1357	030	0.3
	1732	050	0.3		1430	016	0.1
	1804	035	0.1		1503	020	0.3
	1841	055	0.5		1541	040	0.3
	1908	060	0.7		1610	030	0.8
	1940	060	1.0		1642	045	0.4
	2012	065	0.8		1715	050	0.6
	2045	060	0.9		1747	055	0.5
	2117	—	1.0		1820	065	0.2
	2150	065	0.5		1854	080	0.6
	2223	070	0.7		1927	085	1.0
	2256	075	0.7		1959	087	0.9
	2329	065	1.0		2032	087	0.5
					2105	087	0.5
2 Aug	0002	075	0.9		2138	073	1.2
	0110	080	0.4		2211	080	0.9
	0142	080	0.7		2245	083	1.0
	0216	085	1.1		2317	080	0.6
	0250	090	0.4		2350	080	1.0
	0323	090	0.3				
	0357	090	1.1	3 Aug	0024	085	1.0
	0430	100	0.5		0057	087	1.2
	0504	097	0.8		0130	087	1.1
	0542	—	0.7		0202	087	1.1
	0611	092	0.5		0235	087	0.8
	0644	—	0.4		0308	087	0.8
	0718	090	0.4		0341	090	1.0

DATE 1961	TIME GMT	DIR °T	SPEED Knots
3 Aug	0415	090	1.0
	0448	090	0.8
	0521	092	1.2
	0554	095	0.8
	0627	095	0.7
	0700	—	0.8
	0732	100	0.9
	0805	105	0.6
	0839	110	0.9
	0912	117	0.5
	0946	120	0.4
	1020	130	0.6
	1052	—	0.1
	1126	020	0.1
	1200	—	0.1
	1233	330	0.1
	1307	080	0.5
	1340	110	0.1
	1413	125	0.1
	1446	100	0.1
	1520	090	0.1
	1554	115	—
	1628	075	0.1
	1702	093	—
	1735	095	—
	1810	095	—
	1844	105	0.4
	1918	—	0.4
	1953	030	0.7
	2028	060	0.6
	2102	055	0.8
	2137	055	—
	2212	050	0.5
	2247	055	0.5
	2322	070	1.0
	2358	080	0.6
4 Aug	0033	085	—
	0108	090	—
	0143	090	0.7
	0219	100	—
	0255	092	1.1

DATE 1961	TIME GMT	DIR °T	SPEED Knots
4 Aug	0330	095	1.5
	0407	075	1.2
	0442	080	1.3
	0518	100	—
	0554	100	—
	0629	105	—
	0705	100	—
	0741	100	—
	0817	100	0.9
	0858	090	1.0
	0929	120	—
	1005	120	—
	1041	005	—
	1118	070	—
	1154	140	—
	1230	155	—
	1306	—	—
	1342	240	—
9 Aug	2241	—	0.0
	2311	—	0.0
	2343	—	0.0
10 Aug	0015	030	0.2
	0046	120	0.1
	0119	—	—
	0150	—	0.0
	0223	—	0.0
	0255	—	0.0
	0329	—	0.0
	0401	—	0.0
	0435	—	0.2
	0507	170	0.2
	0540	225	0.1
	0612	250	0.0
	0644	310	0.3
	0717	—	—
	0751	060	0.3
	0825	045	0.3
	0858	070	0.2
	0931	088	0.2
	1005	105	0.3

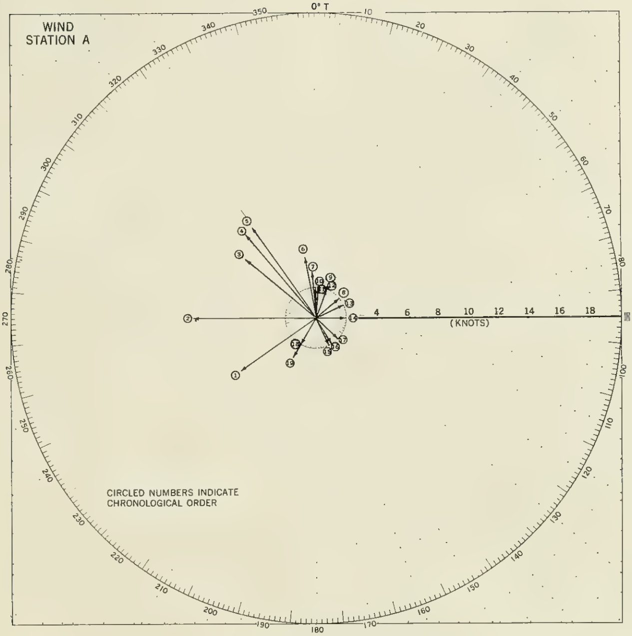
DATE 1961	TIME GMT	DIR °T	SPEED Knots
10 Aug	1038	—	0.0
	1111	100	0.4
	1144	090	0.1
	1218	060	0.3
	1250	070	0.1
	1324	060	0.2
	1357	070	0.1
	1431	070	0.2
	1505	060	0.4
	1538	080	0.4
	1611	075	0.5
	1645	075	0.4
	1718	080	0.5
	1752	095	0.2
	1825	100	0.4
	1858	115	0.2
	1932	120	0.8
	2006	130	0.7
	2039	120	0.1
	2114	120	0.4
	2147	115	0.2
	2222	—	0.7
	2256	120	0.8
	2330	130	0.5
11 Aug	0003	125	0.5
	0037	140	0.5
	0112	140	0.3
	0146	—	0.3
	0220	155	0.3
	0254	—	0.2
	0329	—	0.0
	0403	165	0.1
	0437	—	0.0
	0512	175	0.2
	0545	230	0.1
	0620	270	0.4
	0654	—	0.4
	0727	—	0.0
	0803	—	0.0
	0837	010	0.1
	0913	035	0.1
11 Aug	0948	060	0.1
	1022	080	0.1
	1057	—	0.0
	1131	060	0.3
	1205	080	0.8
	1239	080	0.3
	1314	085	0.3
	1348	088	0.7
	1423	095	0.6
	1457	092	0.2
	1531	095	0.3
	1606	115	0.2
	1642	120	0.2
	1717	122	0.2
	1752	—	0.1
	1827	005	0.2
	1901	125	0.4
	1936	125	0.3
	2012	122	0.5
	2047	—	0.1
	2122	135	0.3
	2157	135	0.1
	2232	135	0.2
	2307	120	0.2
	2342	005	0.4
12 Aug	0016	130	0.4
	0052	130	0.4
	0127	130	0.4
	0201	145	0.1
	0235	135	0.1
	0310	080	0.3
	0345	—	0.0
	0422	130	0.2
	0457	090	0.3
	0531	085	0.1
	0607	080	0.4
	0642	090	0.2
	0717	088	0.1
	0751	080	0.4
	0827	—	0.3
	0903	100	0.4

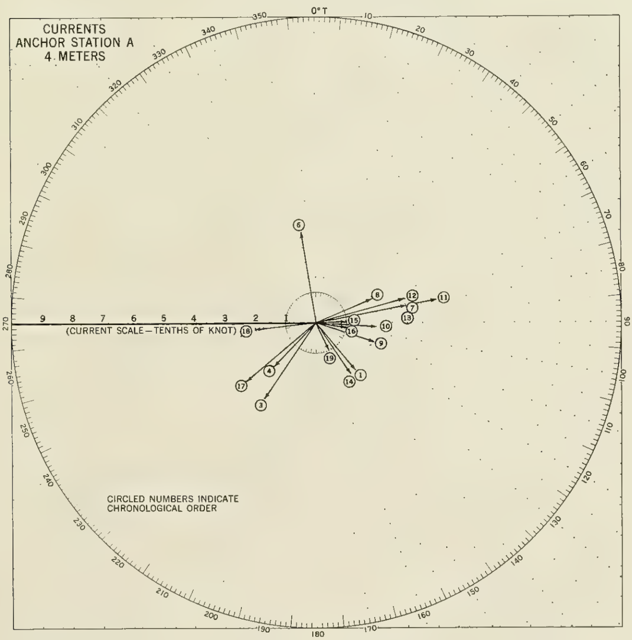
DATE 1961	TIME GMT	DIR °T	SPEED Knots	DATE 1961	TIME GMT	DIR °T	SPEED Knots
12 Aug	0943	105	0.6	13 Aug	1008	220	0.5
	1014	120	0.6		1045	215	0.8
	1050	110	0.4		1121	205	0.7
	1125	095	0.5		1157	200	0.7
	1200	115	0.5		1232	200	0.8
	1236	125	0.4		1308	200	0.9
	1312	140	0.1		1343	200	0.7
	1347	115	0.4		1418	—	0.6
	1422	118	0.5		1454	200	0.8
	1458	—	0.1		1529	200	0.7
	1535	120	0.3		1605	200	0.7
	1611	120	0.3		1641	195	0.7
	1648	120	0.3		1718	190	0.6
	1724	130	0.4		1753	185	0.4
	1800	135	0.4		1828	190	0.5
	1836	120	0.4		1903	190	0.7
	1912	130	0.3		1939	190	0.8
	1948	—	0.8		2015	190	0.8
	2020	145	0.5		2050	190	0.8
	2102	152	0.3		2126	175	0.8
	2137	155	0.5		2201	175	0.8
	2213	160	0.3		2236	175	1.1
	2248	—	0.2		2312	170	1.0
	2324	165	0.3		2347	175	0.5
13 Aug	0000	160	0.6	14 Aug	0022	170	0.7
	0036	160	0.5		0057	160	1.0
	0112	160	0.6		0132	160	0.9
	0147	160	0.6		0207	160	1.2
	0223	170	0.8		0241	—	0.9
	0300	—	0.9		0316	165	1.1
	0335	175	0.7		0351	160	1.1
	0411	185	0.5		0427	170	0.9
	0445	205	0.7		0503	—	1.0
	0521	220	0.5		0537	170	0.8
	0547	230	0.5		0613	165	0.8
	0632	235	0.4		0648	165	1.1
	0708	235	0.4		0722	170	1.0
	0743	235	0.4		0751	175	0.9
	0820	235	0.4		0830	178	0.8
	0856	225	0.4		0905	175	0.7
	0932	220	0.7		0939	175	1.0

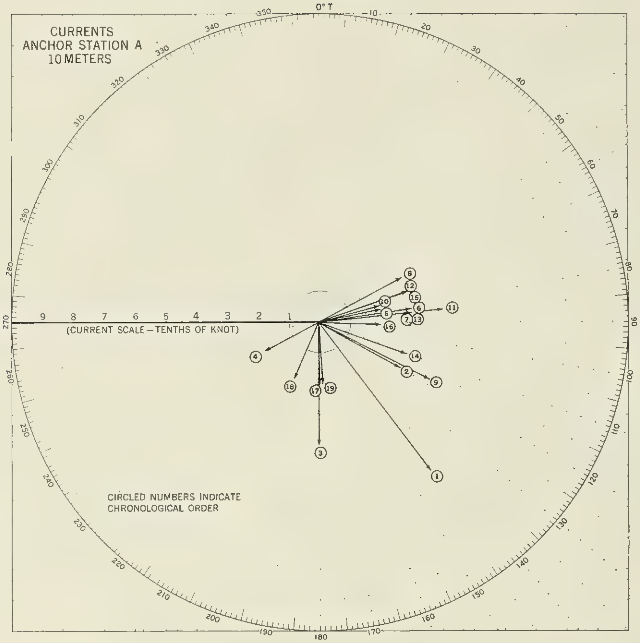
DATE 1961	TIME GMT	DIR °T	SPEED Knots
14 Aug	1014	170	0.9
	1049	170	1.0
	1124	165	1.0
	1200	162	1.1
	1235	160	1.4
	1311	160	1.3
	1346	160	1.4
	1423	—	1.4
	1500	—	1.4
	1536	—	1.2
	1841	145	0.7
	1918	140	0.8
	1955	145	0.4
	2031	145	0.6
	2108	125	0.2
	2144	115	0.4
	2222	110	0.2
	2258	110	0.8
	2335	115	0.7
15 Aug	0012	122	0.2
	0048	120	0.9
	0125	—	0.8
	0201	120	0.7
	0237	118	0.5
	0314	115	0.7
	0350	112	0.4
	0426	110	0.3
	0502	—	0.8
	0538	105	0.6
	0614	110	0.7
	0650	115	1.1
	0725	118	0.9
	0802	112	0.6
	0838	110	0.8
	0915	112	0.8
	0950	110	0.8
	1027	110	0.9

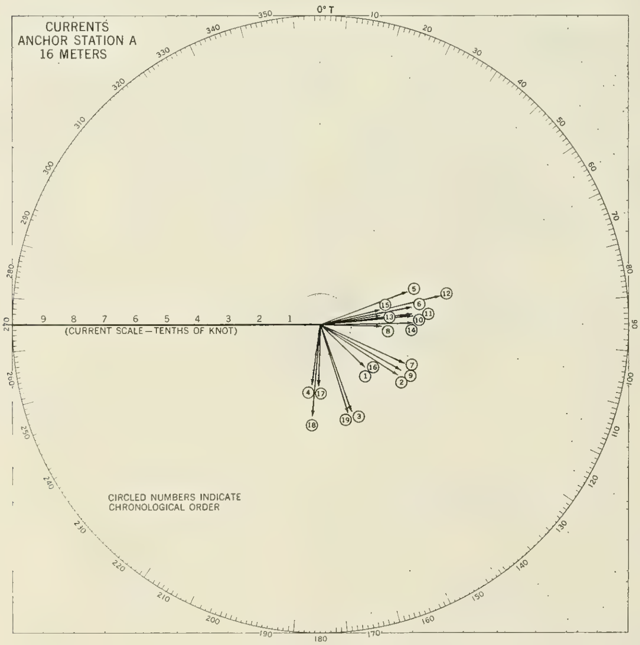
APPENDIX C

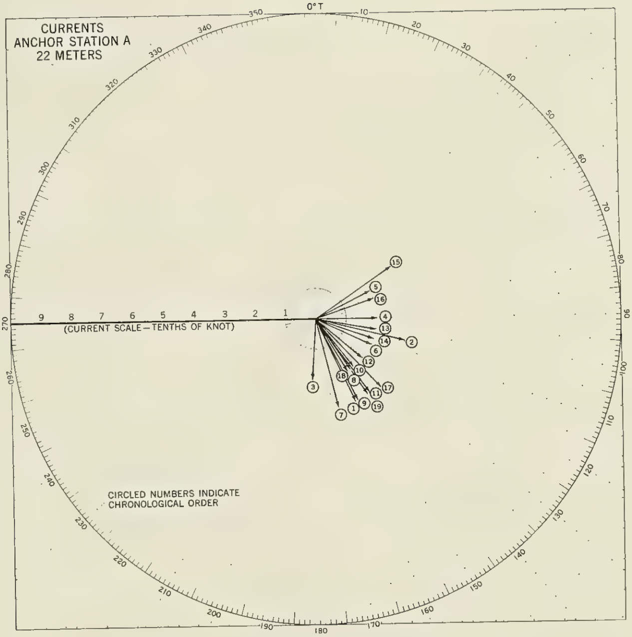
CENTRAL VECTOR DIAGRAMS

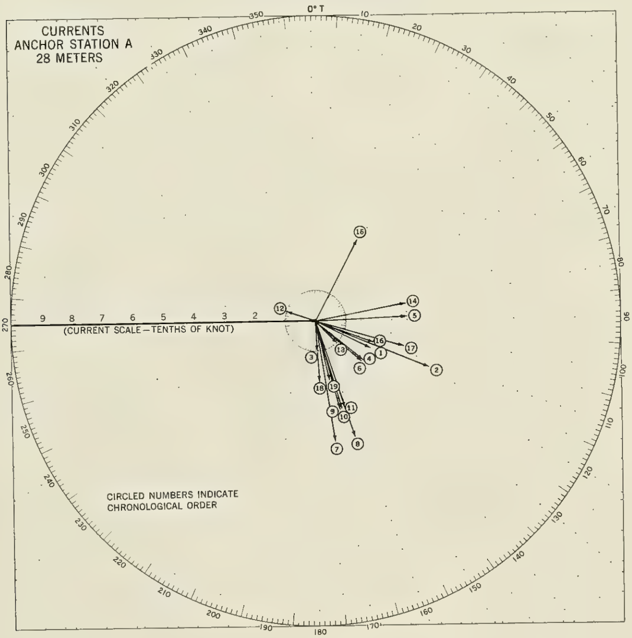

WIND
STATION A
0° T
(KNOTS)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

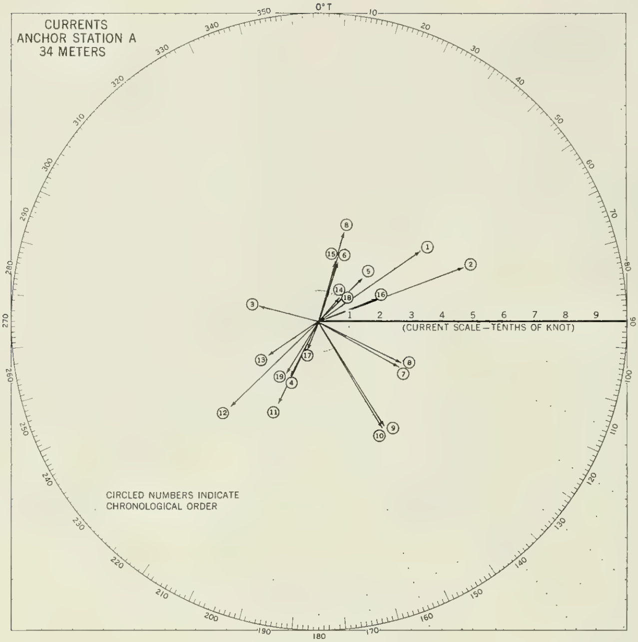

CURRENTS
ANCHOR STATION A
4 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

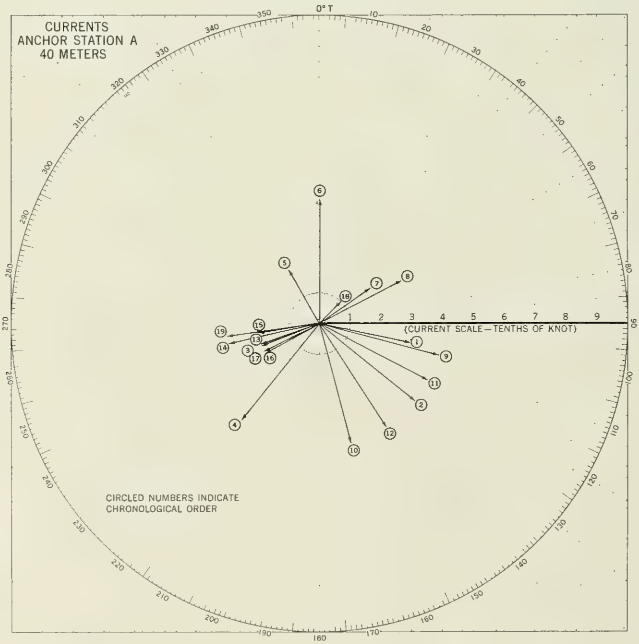

CURRENTS
ANCHOR STATION A
10 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

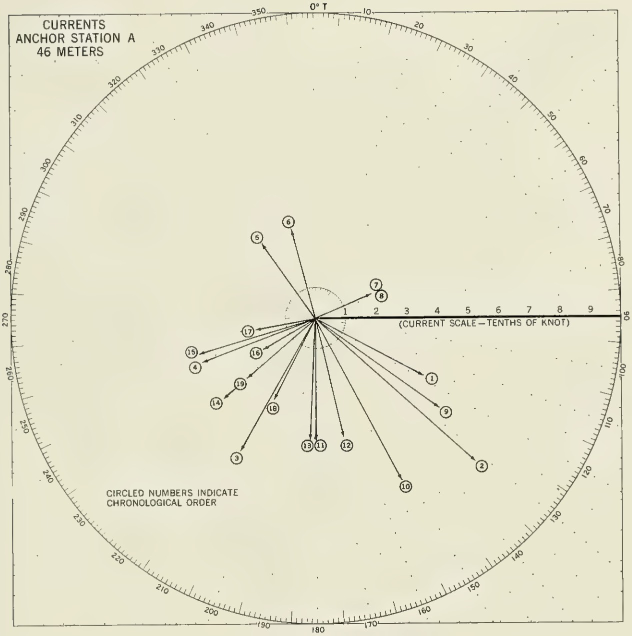

CURRENTS
ANCHOR STATION A
16 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

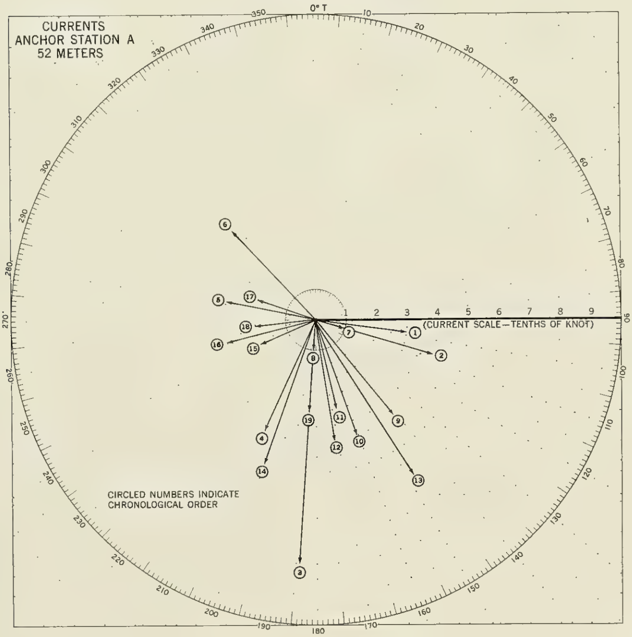

CURRENTS
ANCHOR STATION A
22 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

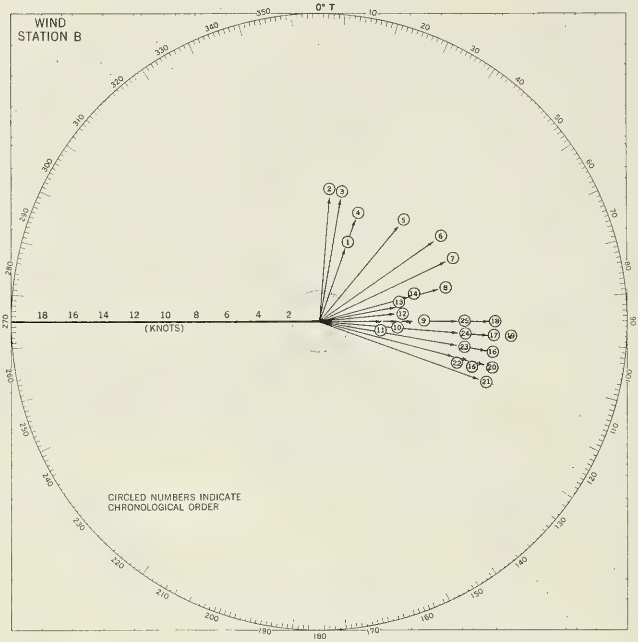

CURRENTS
ANCHOR STATION A
28 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

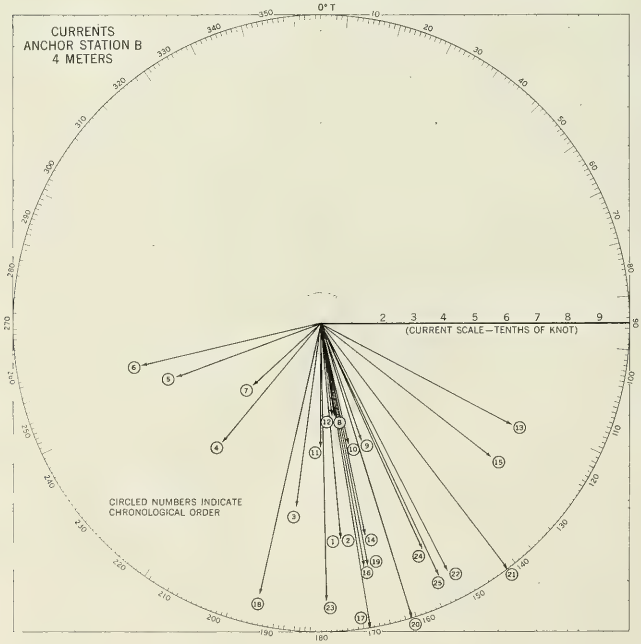

CURRENTS
ANCHOR STATION A
34 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

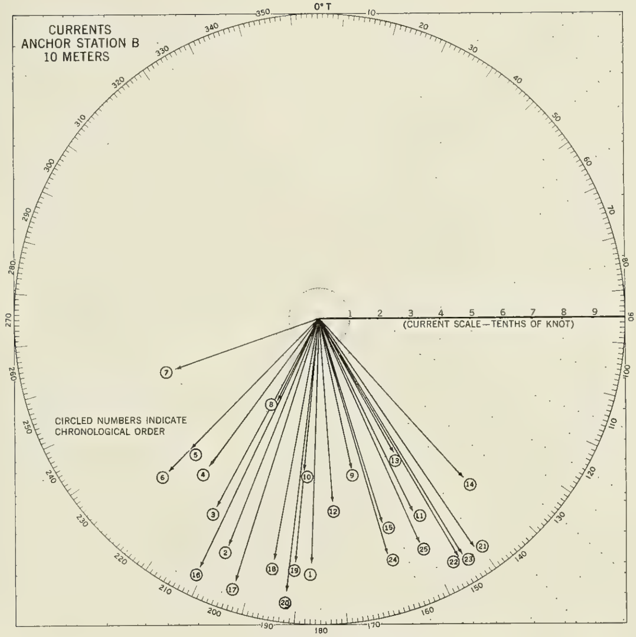

CURRENTS
ANCHOR STATION A
40 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

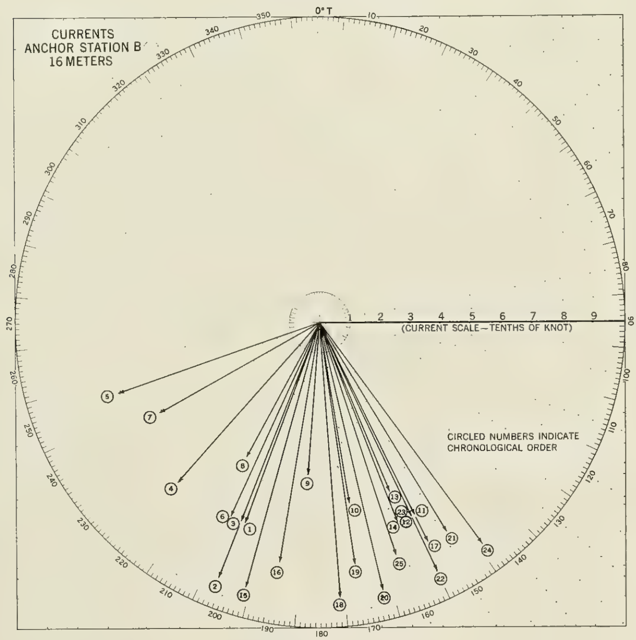

CURRENTS
ANCHOR STATION A
46 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

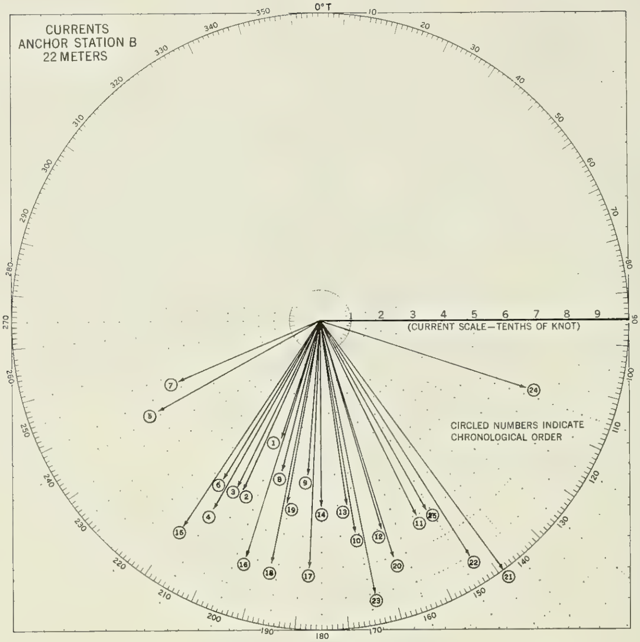

CURRENTS
ANCHOR STATION A
52 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

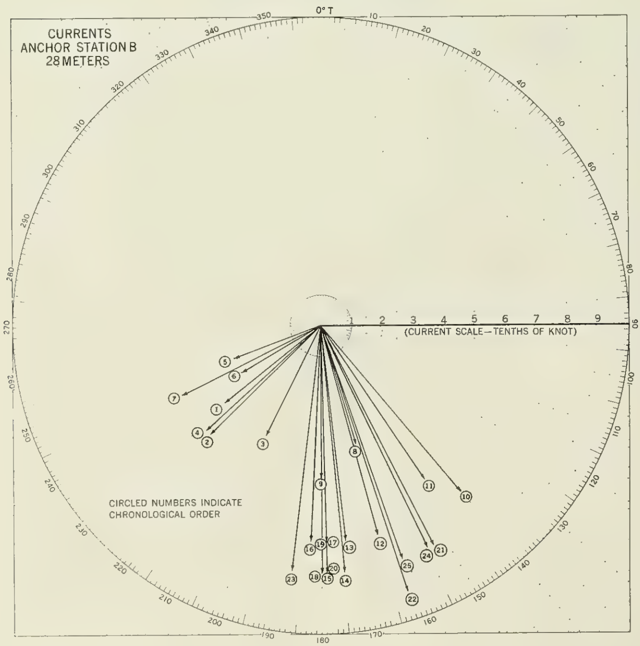

WIND
STATION B
0° T
(KNOTS)
18 16 14 12 10 8 6 4 2
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

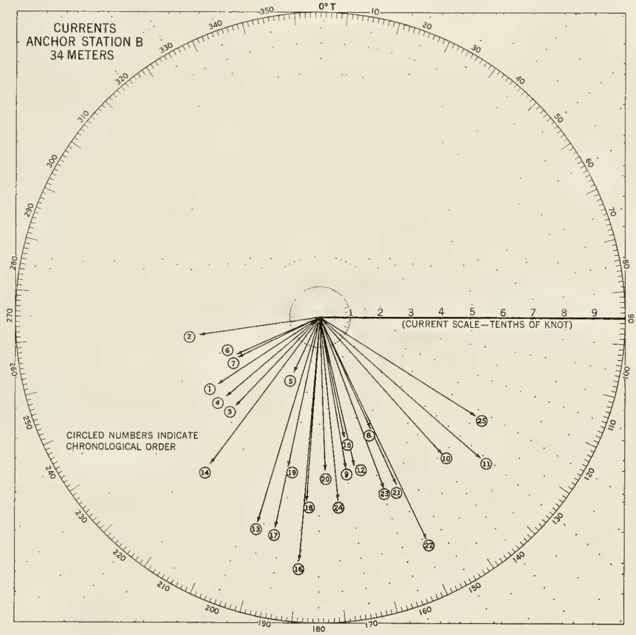

CURRENTS
ANCHOR STATION B
4 METERS
0° T
2 3 4 5 6 7 8 9
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

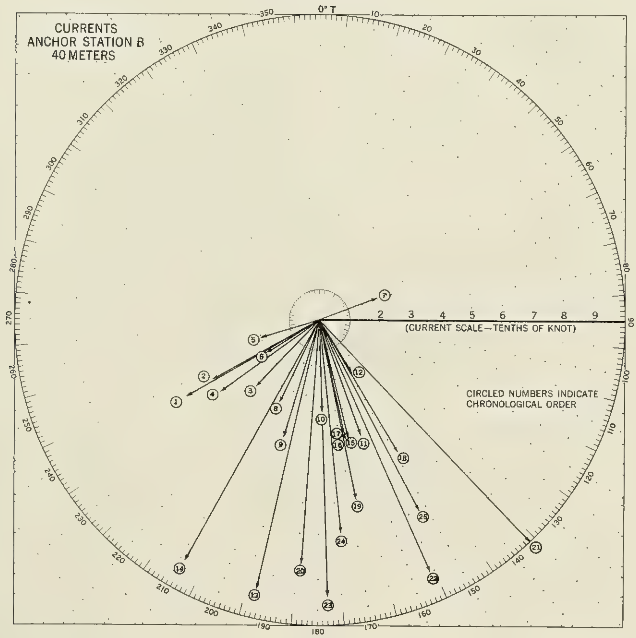

CURRENTS
ANCHOR STATION B
10 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE CHRONOLOGICAL ORDER

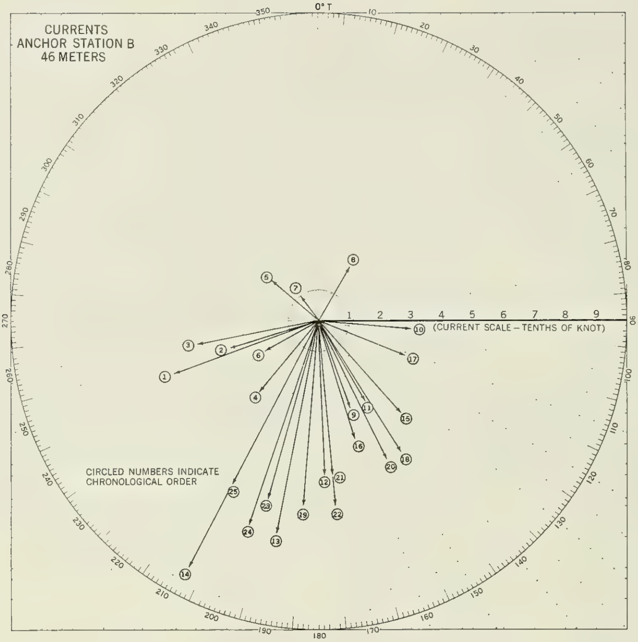

CURRENTS
ANCHOR STATION B
16 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE CHRONOLOGICAL ORDER

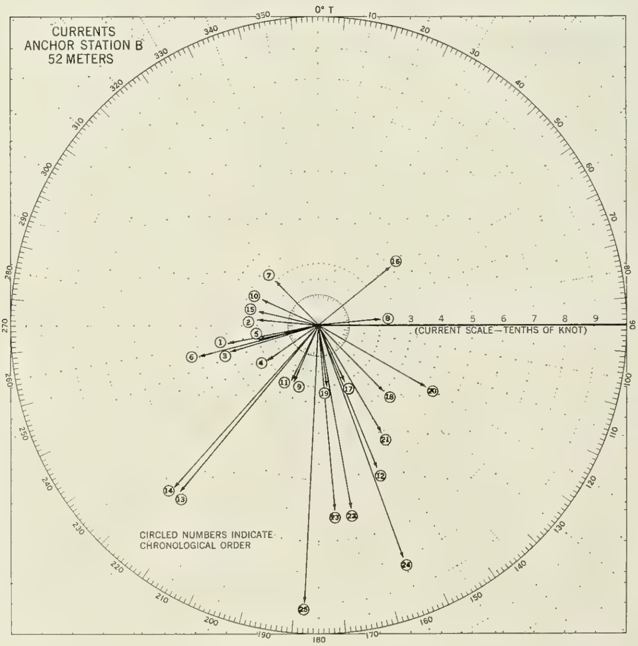

CURRENTS
ANCHOR STATION B
22 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

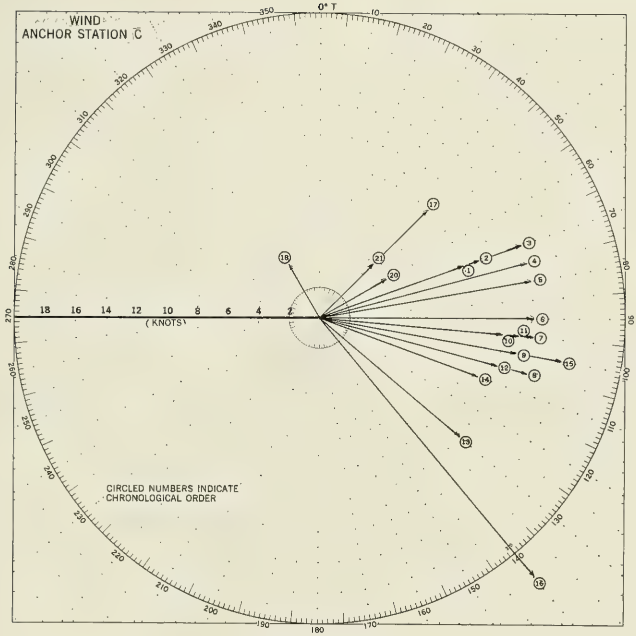

CURRENTS
ANCHOR STATION B
28 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

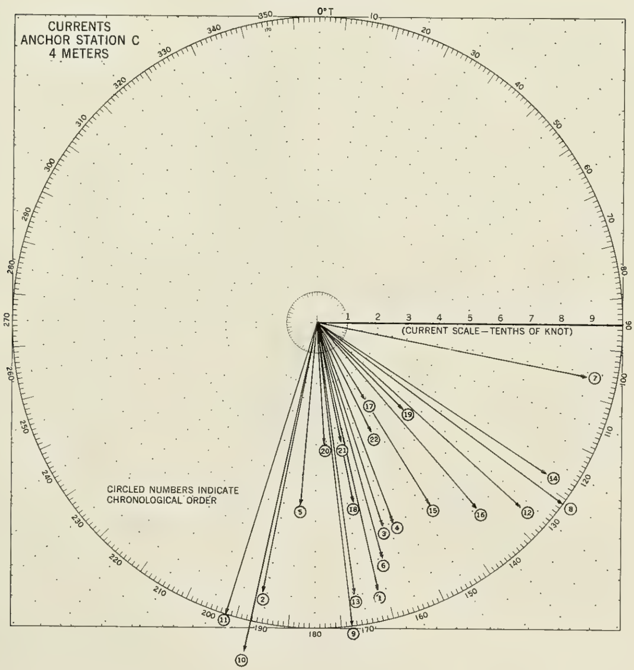

CURRENTS
ANCHOR STATION B
34 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

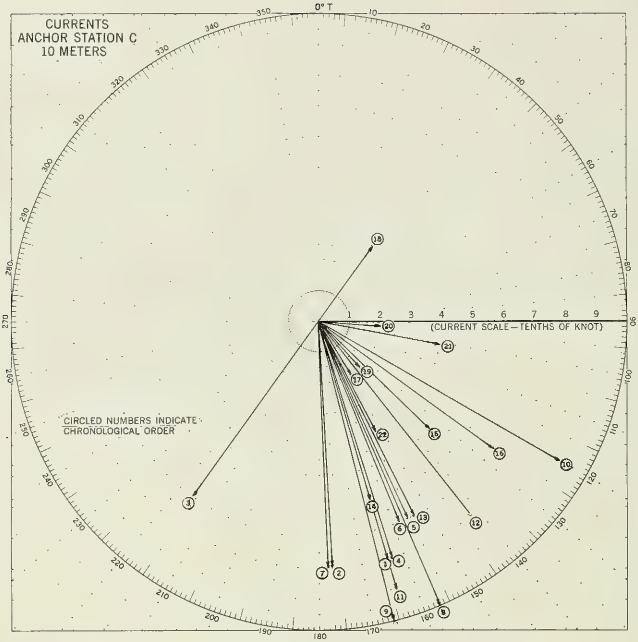

CURRENTS
ANCHOR STATION B
40 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

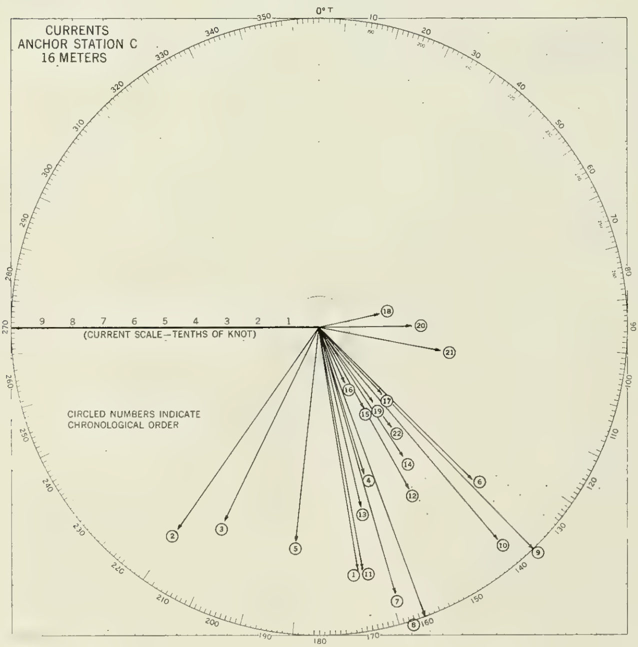

CURRENTS
ANCHOR STATION B
46 METERS
0° T
(CURRENT SCALE – TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

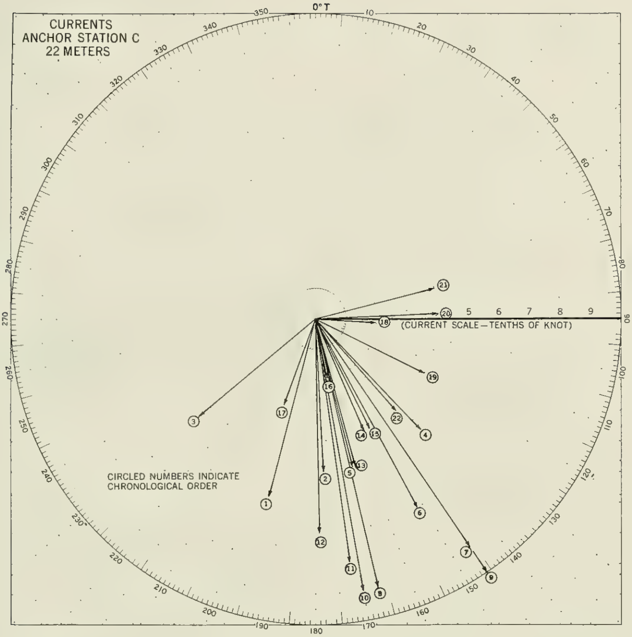

CURRENTS
ANCHOR STATION B
52 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

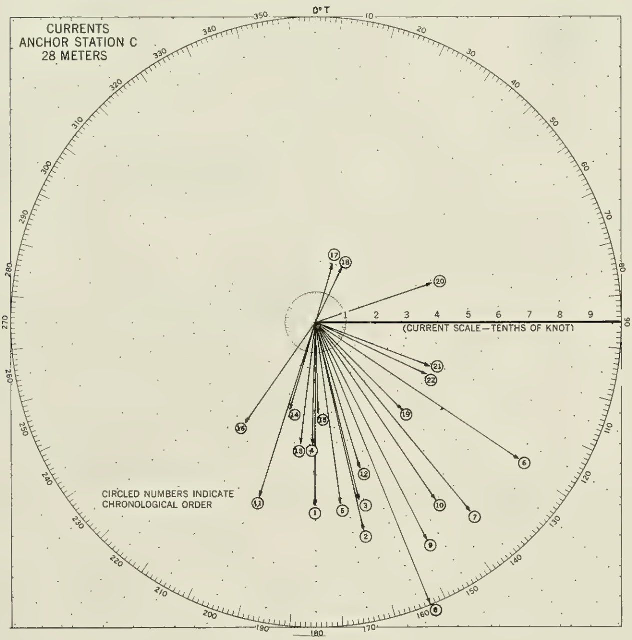

WIND
ANCHOR STATION C
(KNOTS)
CIRCLED NUMBERS INDICATE CHRONOLOGICAL ORDER

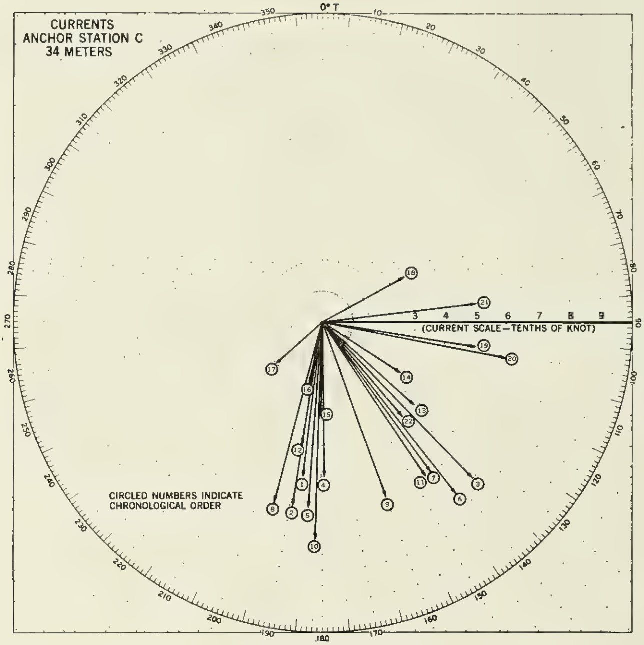

CURRENTS
ANCHOR STATION C
4 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE CHRONOLOGICAL ORDER

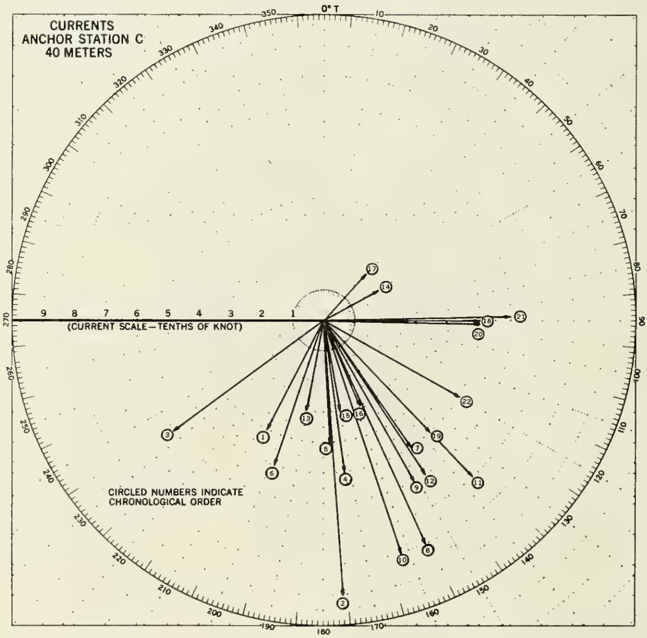

CURRENTS
ANCHOR STATION C
10 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

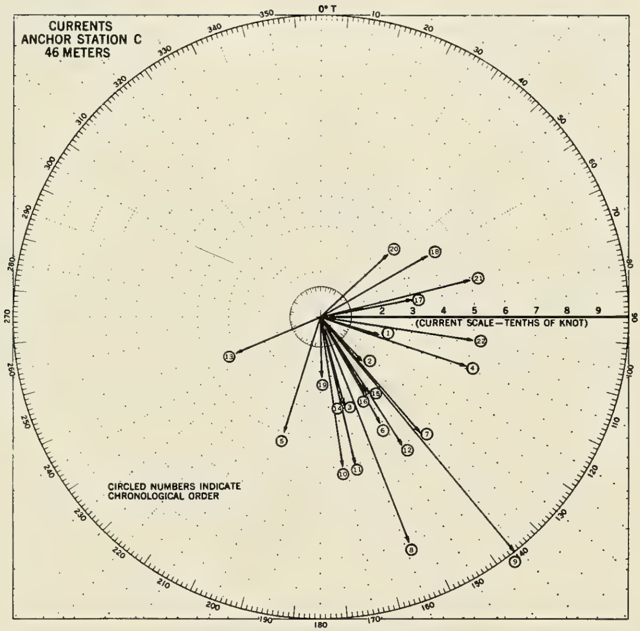

CURRENTS
ANCHOR STATION C
16 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER


CURRENTS
ANCHOR STATION C
22 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER


CURRENTS
ANCHOR STATION C
28 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER


CURRENTS
ANCHOR STATION C
34 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

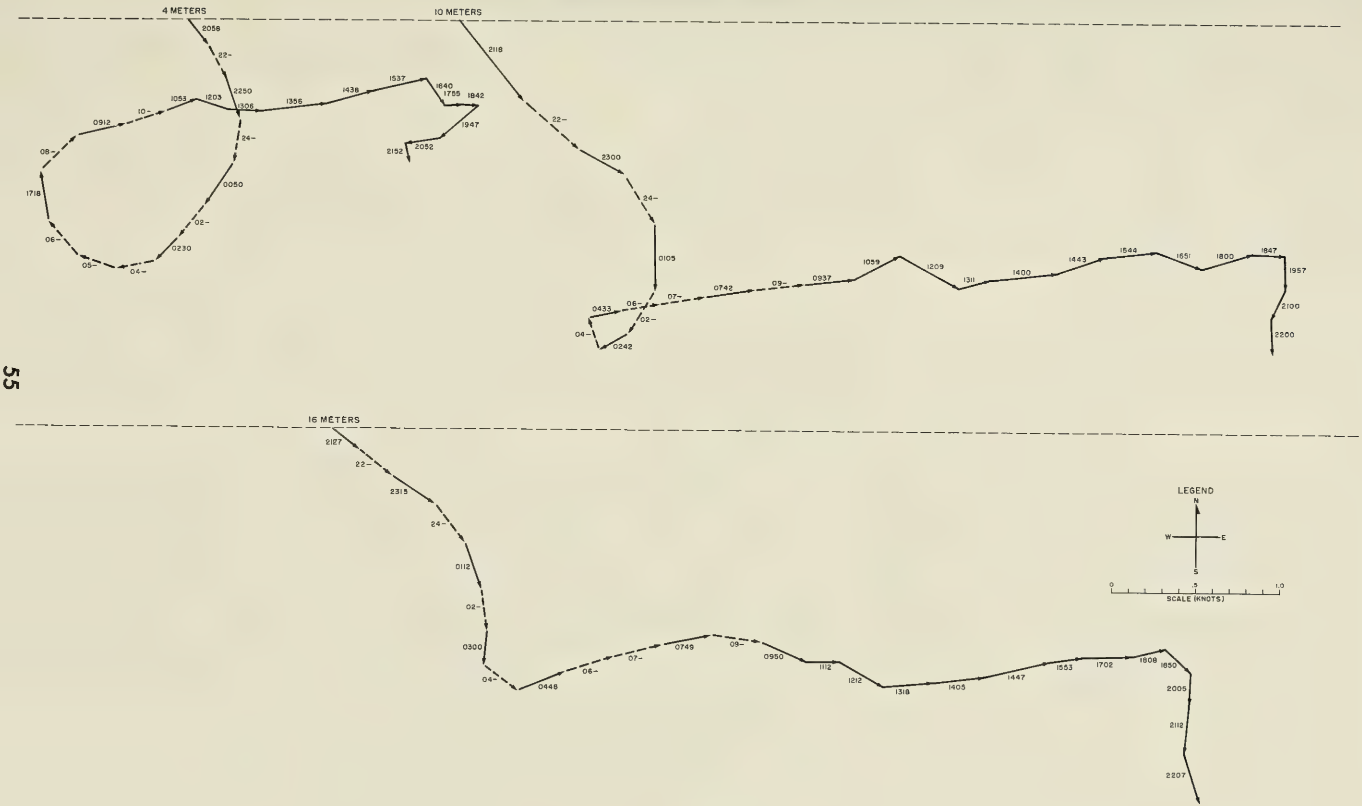

CURRENTS
ANCHOR STATION C
40 METERS
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER


CURRENTS
ANCHOR STATION C
46 METERS
0° T
(CURRENT SCALE—TENTHS OF KNOT)
CIRCLED NUMBERS INDICATE
CHRONOLOGICAL ORDER

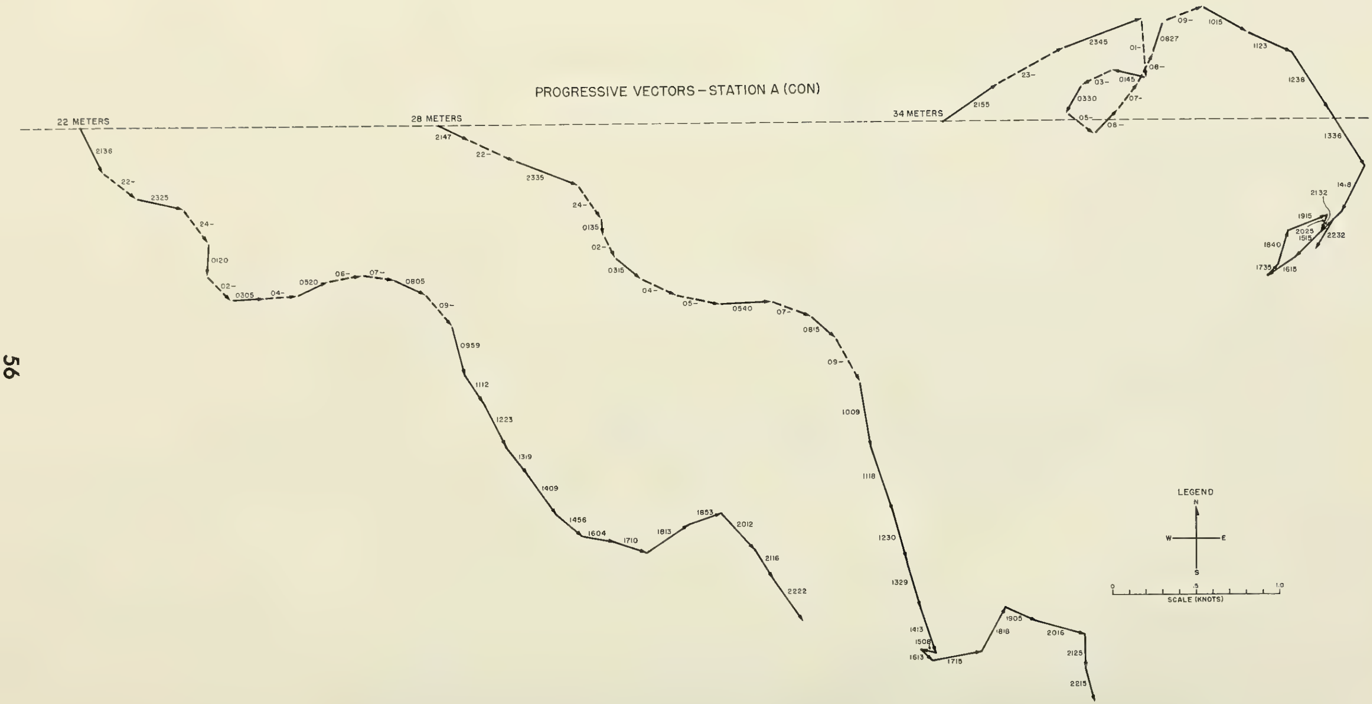
APPENDIX D

PROGRESSIVE VECTOR DIAGRAMS

PROGRESSIVE VECTORS—STATION A

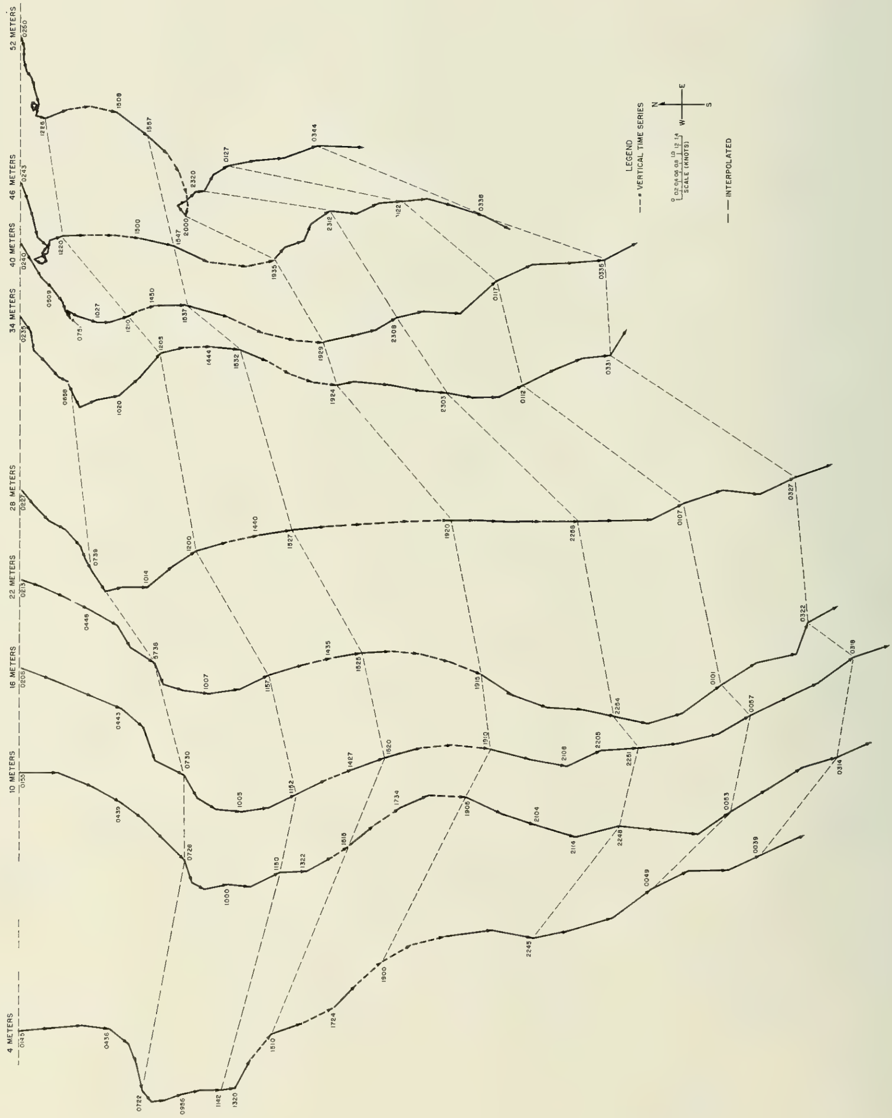


PROGRESSIVE VECTORS – STATION A (CON)

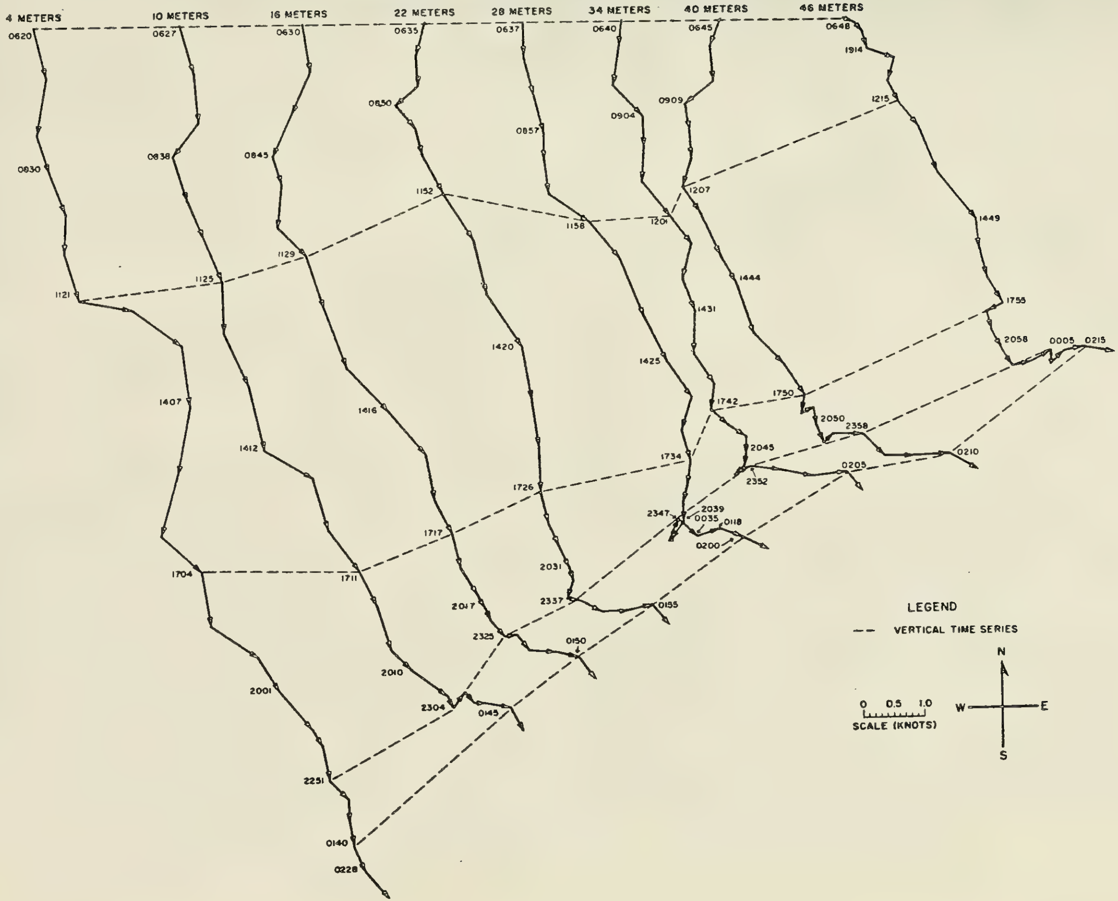


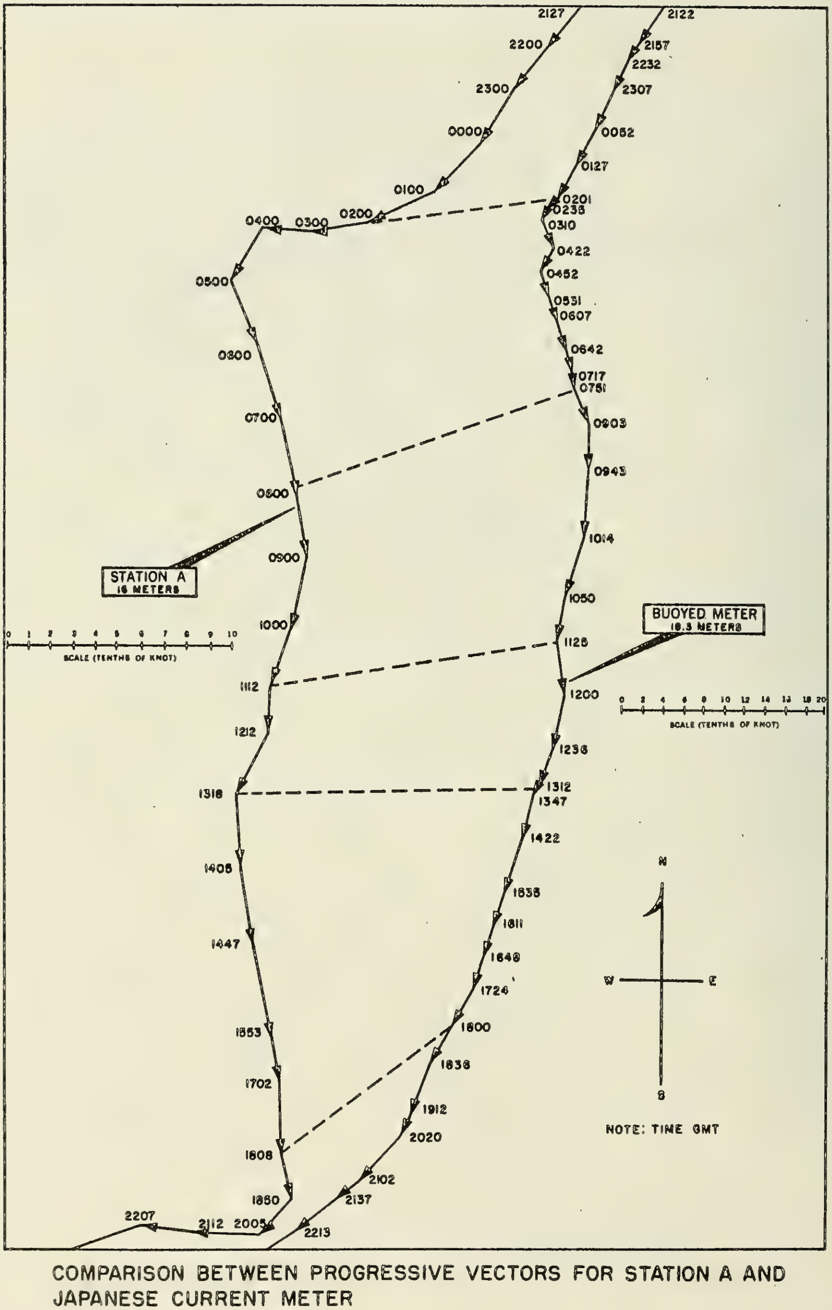
PROGRESSIVE VECTORS—STATION A (CON)

PROGRESSIVE VECTORS — STATION B

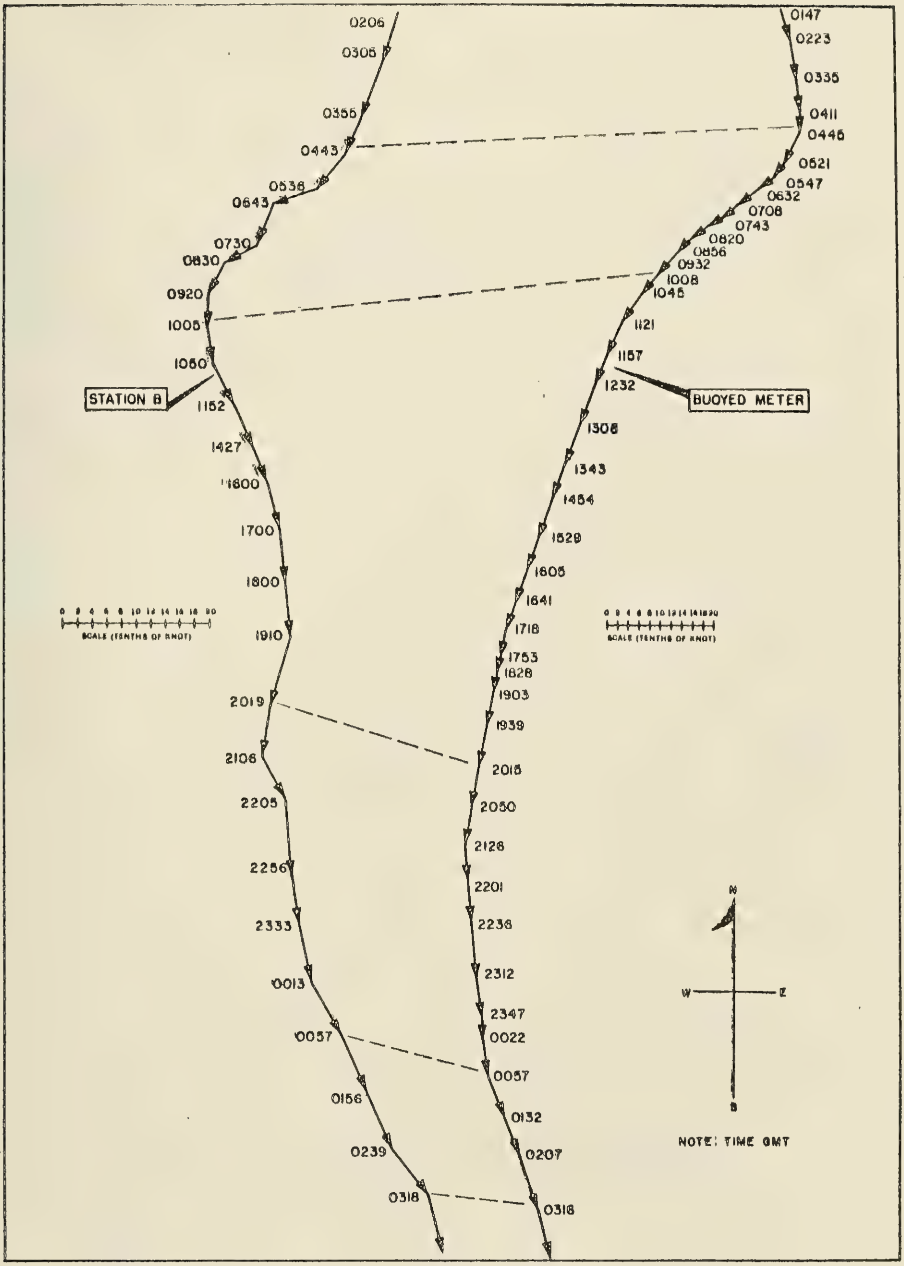


PROGRESSIVE VECTORS — STATION C

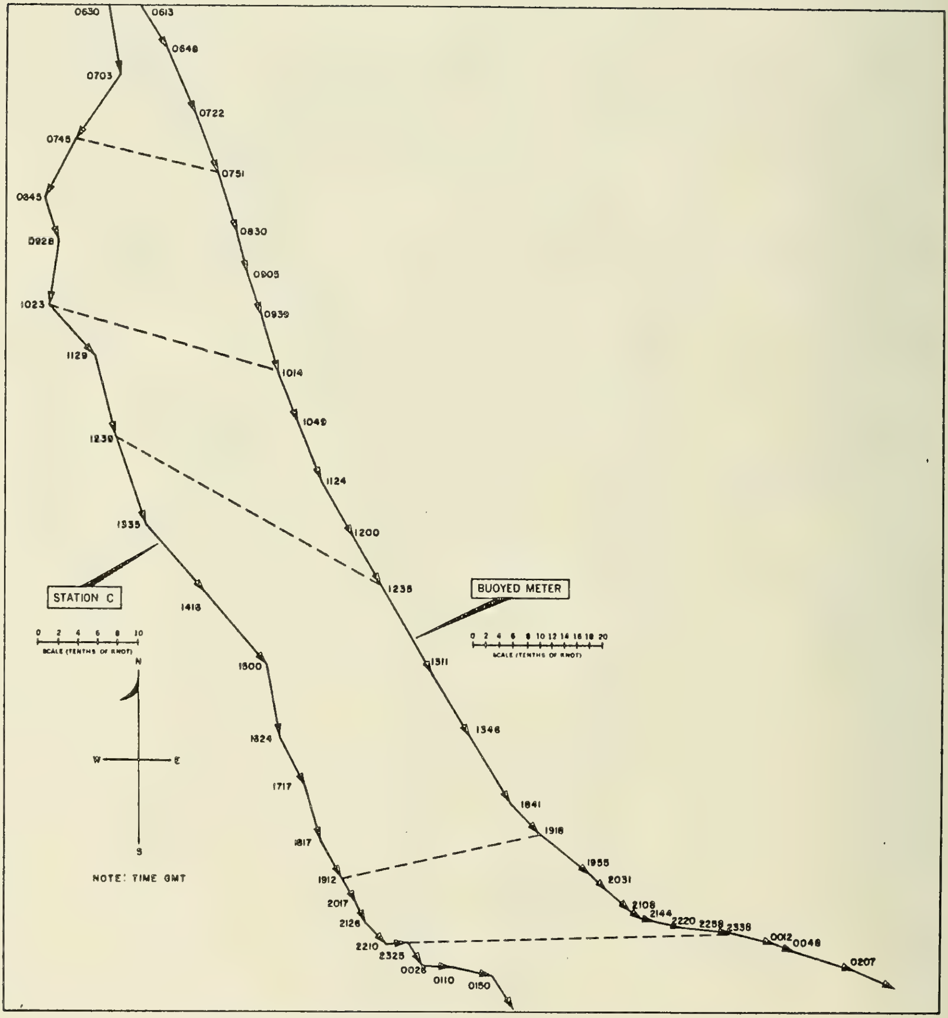




COMPARISON BETWEEN PROGRESSIVE VECTORS FOR STATION A AND JAPANESE CURRENT METER



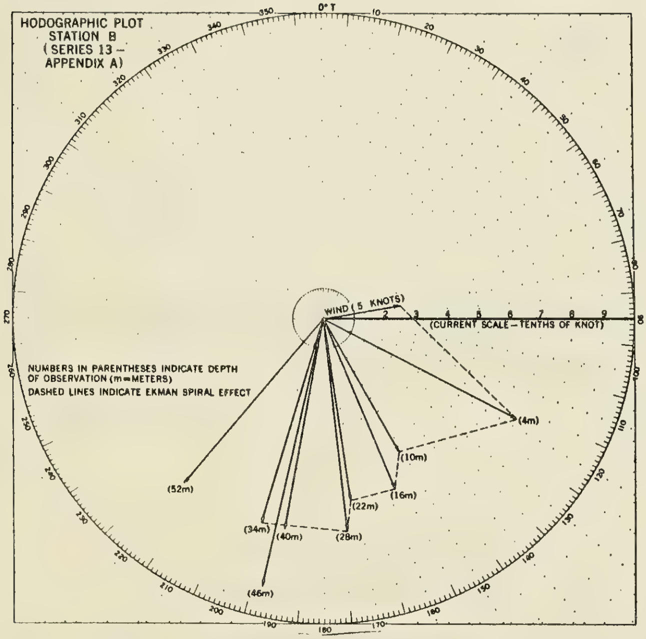
COMPARISON BETWEEN PROGRESSIVE VECTORS FOR STATION B AND JAPANESE CURRENT METER

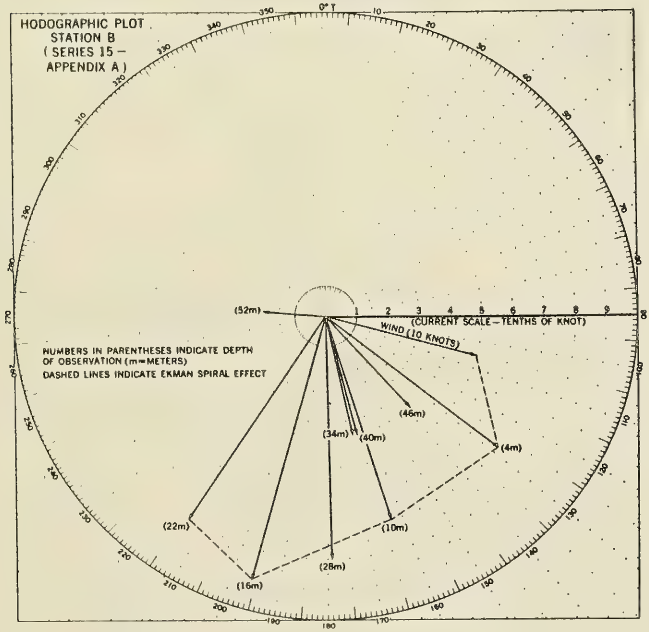


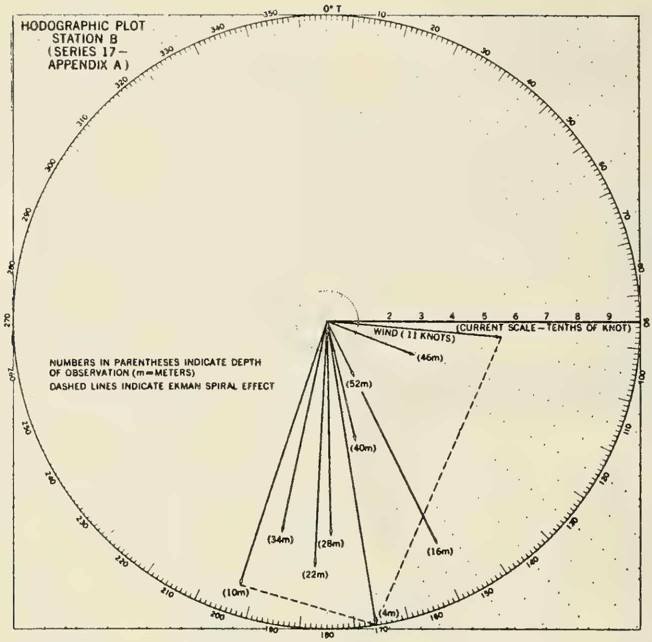
COMPARISON BETWEEN PROGRESSIVE VECTORS FOR STATION C AND JAPANESE CURRENT METER

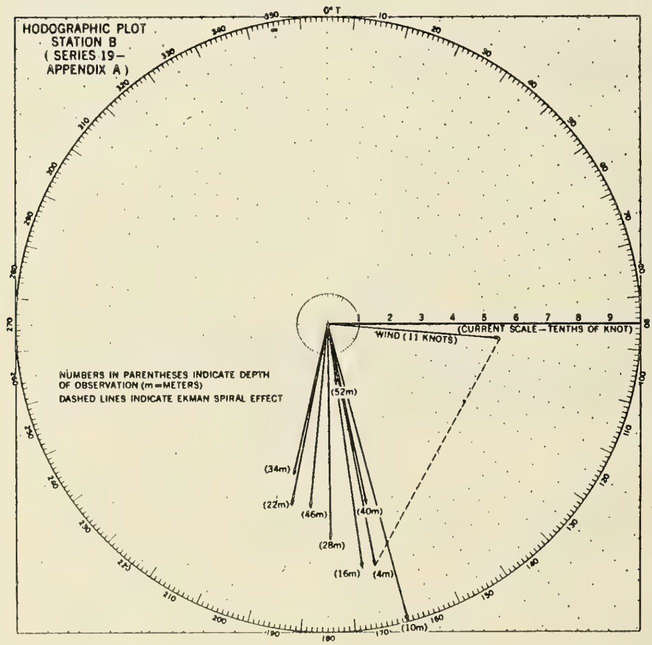
APPENDIX E

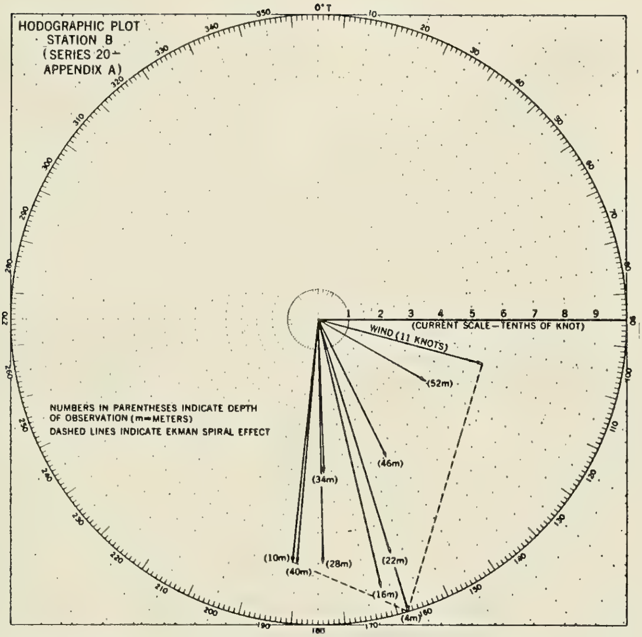
HODOGRAPHS

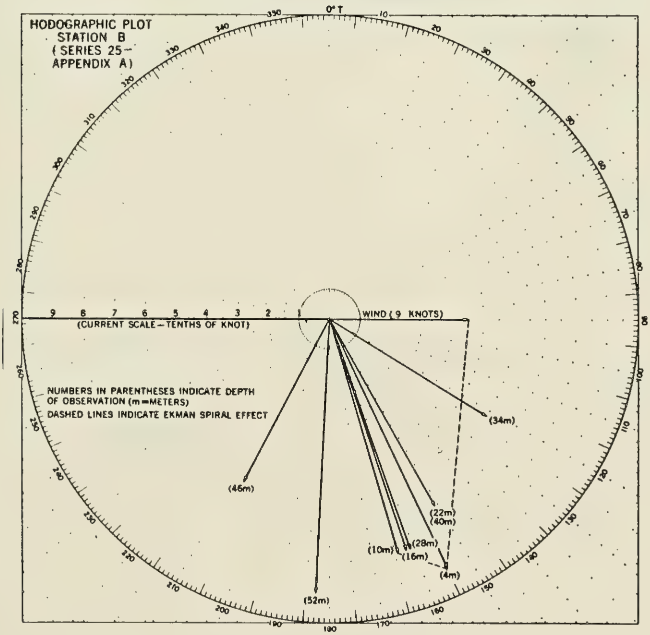

HODOGRAPHIC PLOT
STATION B
(SERIES 13 – APPENDIX A)
WIND (5 KNOTS)
(CURRENT SCALE – TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m = METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(4m)
(10m)
(16m)
(22m)
(28m)
(34m)
(40m)
(46m)
(52m)

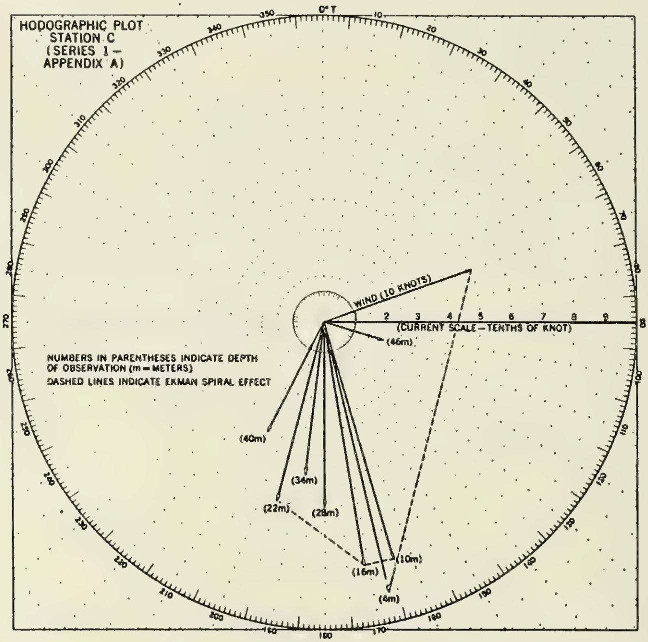

HODOGRAPHIC PLOT
STATION B
(SERIES 15 – APPENDIX A)
WIND (10 KNOTS)
(CURRENT SCALE – TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m = METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(52m)
(46m)
(34m)
(40m)
(4m)
(22m)
(10m)
(28m)
(16m)

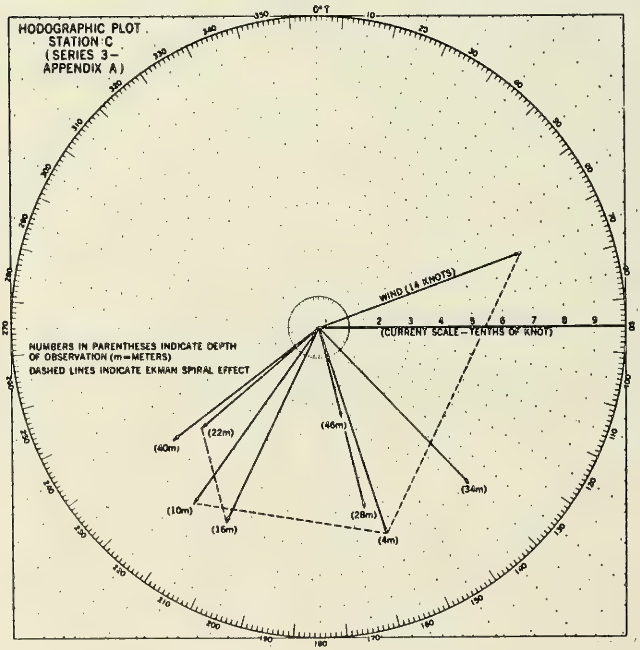

HODOGRAPHIC PLOT
STATION B
(SERIES 17—
APPENDIX A)
0° T
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(CURRENT SCALE—TENTHS OF KNOT)
WIND (11 KNOTS)
(46m)
(52m)
(40m)
(34m)
(28m)
(22m)
(16m)
(10m)
(4m)

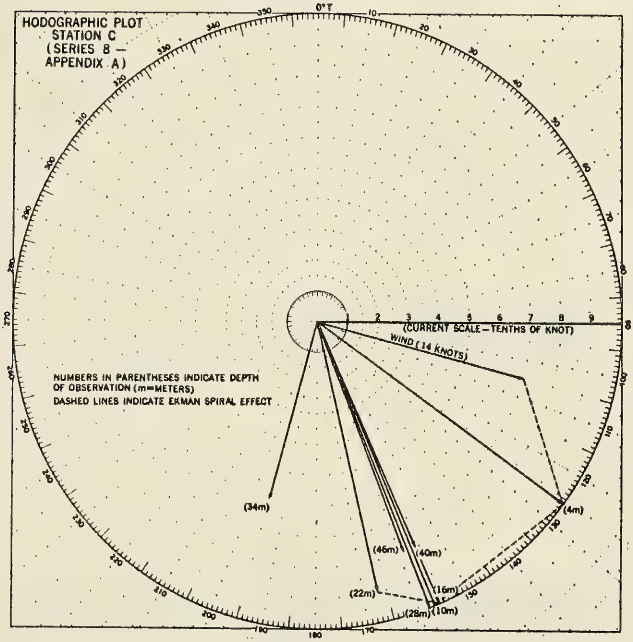

HODOGRAPHIC PLOT
STATION B
(SERIES 19—
APPENDIX A)
0° T
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(CURRENT SCALE—TENTHS OF KNOT)
WIND (11 KNOTS)
(52m)
(34m)
(22m)
(46m)
(40m)
(28m)
(16m)
(4m)
(10m)

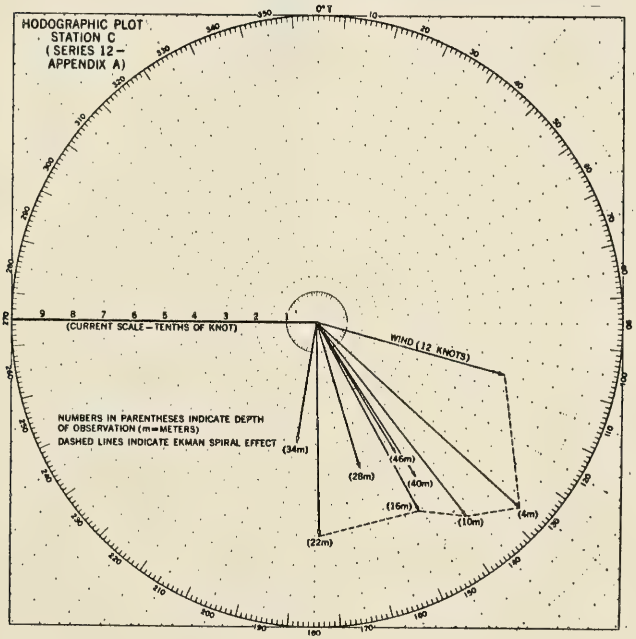

HODOGRAPHIC PLOT
STATION B
(SERIES 20–
APPENDIX A)
0° T
WIND (11 KNOTS)
(CURRENT SCALE—TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(52m)
(46m)
(34m)
(10m)
(40m)
(28m)
(22m)
(16m)
(4m)

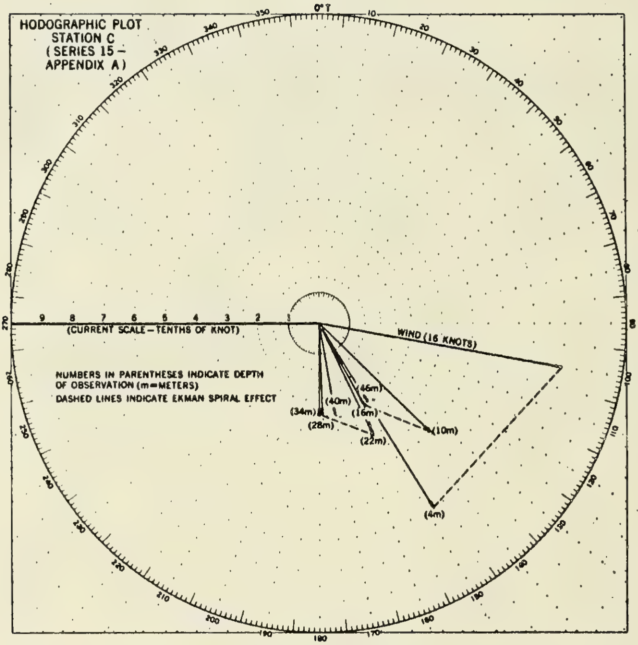

HODOGRAPHIC PLOT
STATION B
(SERIES 25–
APPENDIX A)
0° T
WIND (9 KNOTS)
(CURRENT SCALE—TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(34m)
(46m)
(22m)
(40m)
(28m)
(10m)
(16m)
(4m)
(52m)


HODOGRAPHIC PLOT
STATION C
(SERIES 1 – APPENDIX A)
0° T
WIND (10 KNOTS)
(CURRENT SCALE – TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m = METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(46m)
(40m)
(34m)
(22m)
(28m)
(16m)
(10m)
(4m)


HODOGRAPHIC PLOT
STATION C
(SERIES 3 – APPENDIX A)
0° T
WIND (14 KNOTS)
(CURRENT SCALE – TENTHS OF KNOT)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m = METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(22m)
(40m)
(46m)
(34m)
(10m)
(28m)
(16m)
(4m)


HODOGRAPHIC PLOT
STATION C
(SERIES 8 — APPENDIX A)
(CURRENT SCALE—TENTHS OF KNOT)
WIND (14 KNOTS)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(34m)
(4m)
(46m)
(40m)
(16m)
(22m)
(28m)
(10m)


HODOGRAPHIC PLOT
STATION C
(SERIES 12 — APPENDIX A)
(CURRENT SCALE—TENTHS OF KNOT)
WIND (12 KNOTS)
NUMBERS IN PARENTHESES INDICATE DEPTH OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(34m)
(46m)
(28m)
(40m)
(16m)
(10m)
(4m)
(22m)


HODOGRAPHIC PLOT
STATION C
(SERIES 15 –
APPENDIX A)
0°T
9 8 7 6 5 4 3 2 1
(CURRENT SCALE – TENTHS OF KNOT)
WIND (16 KNOTS)
NUMBERS IN PARENTHESES INDICATE DEPTH
OF OBSERVATION (m=METERS)
DASHED LINES INDICATE EKMAN SPIRAL EFFECT
(46m)
(40m)
(34m)
(16m)
(28m)
(10m)
(22m)
(4m)

APPENDIX F

NET DISPLACEMENTS AND MEAN CURRENTS OVER PLANTAGENET BANK BASED ON OBSERVED VELOCITIES AT STATIONS A, B, AND C

APPENDIX F

NET DISPLACEMENTS AND MEAN CURRENTS OVER PLANTAGENET BANK
BASED ON OBSERVED VELOCITIES AT STATIONS A, B, AND C

Depth (meters)	Net Dir (°T)	Net Hourly Displacement * (nautical miles)	Net Daily Displacement * (nautical miles)	Mean Observed Hourly Velocity Dir (°T)	Mean Observed Hourly Velocity Speed (knots)
			Station A		
4	119	0.1	1.5	**	0.2
10	110	0.2	5.2	**	0.2
16	111	0.2	5.4	136	0.2
22	124	0.2	5.2	144	0.2
28	132	0.2	5.1	160	0.2
34	107	0.1	2.4	**	0.2
40	182	0.1	2.1	**	0.2
46	191	0.2	4.6	**	0.2
52	193	0.2	5.3	**	0.2
			Station B		
4	167	0.6	15.2	176	0.7
10	181	0.7	16.2	183	0.7
16	182	0.7	17.0	181	0.7
22	186	0.7	16.1	184	0.7
28	180	0.7	15.6	187	0.5
34	184	0.5	12.0	187	0.5
40	182	0.5	11.9	183	0.4
46	183	0.4	9.4	**	0.4
52	205	0.3	6.2	**	0.4
			Station C		
4	158	0.8	***	157	0.7
10	155	0.7		146	0.6
16	156	0.6		150	0.6
22	158	0.6		154	0.6
28	156	0.5		145	0.5
34	154	0.4		153	0.5
40	150	0.4		146	0.5
46	142	0.4		138	0.4

* Net displacements have been computed by interpolating hourly values in data gaps.
** Average value meaningless, because current rotated through north (0°).
*** Sufficient data not obtained to determine daily displacements.

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OCEAN CURRENTS OVER PLANTAGENET BANK, BERMUDA, by Robert A. Pedrick, June 1962. 73 p. including 9 figs. (NAVOCEANO TR-131, ASWEPS REPORT No. 6)

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Appendixes

Results of a study of ocean currents over Plantagenet Bank, Bermuda from 1 to 15 August 1961 are presented. A net south-southeasterly flow influenced by wind, thermal stratification, and bottom friction was observed. Currents in the southern region of the Bank were rotary and displayed irregular characteristics apparently associated with eddy turbulence. Current data are depicted as central vector plots, hodographic plots, and progressive vector diagrams in the appendixes.

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3. Oceanography
4. ASWEPS

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