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Scientific Cruise Report - RRS Frederick Russell, FR6/85

Cruise Objectives

The objectives of the cruise were to establish detailed physico-chemical and flow relationships in a restricted area of the continental slope and adjacent shelf environs to the north and west of Scotland in order to assess the possible importance of slope-shelf exchanges of water during the summer hydrographic regime.

Scientific Personnel

The following scientific personnel were engaged for the whole cruise period.

Dr. G. Savidge	(Queen's University of Belfast)
Miss L.M.L. Hubbard	(" " " ")
Mr. P.W. Boyd	(" " " ")
Dr. P. Foster	(University College of North Wales)
Mr. N. Mathers	(" " " " ")
Mr. A. Nield	(" " " " ")
Mrs. S. East	(" " " " ")
Mr. P. Taylor	(NERC, RVS, Barry)

Narrative of Operations

Location of stations shown in Figure 1.

7.8.85	1630	Depart Plymouth, Millbay Docks. On passage to survey area.
8.8.85		On passage St. Georges Channel and Irish Sea.
	1830-2120	On station north Irish Sea. CTD-Rosette sampler system trials.
9.8.85		On passage Irish Sea and North Channel.
	1030	Running for shelter, SE gale forecast. Heavy seas.
	1300-1345	On station. CTD system trials.
	1620	At anchor, Loch na Laithaich, Mull.
10.8.85	1940	Depart Loch na Laithaich. Set course for current meter station BA1.
11.8.85		Reduced speed overnight. Heavy swell.
	1400-1750	Arrive current meter station BA 1. Test acoustic command modules for current meter (CM) rigs. Lay CM rig on slope in 700 m. Four Aanderaa RCMs deployed at 50, 300, 650 and 680 m, attached to sub-surface buoy.
	1900-2105	Arrive CM station BA 2 (depth 180 m). Deploy combined CM and thermistor chain rig. Three Aanderaa RCMs located at 5, 69 and 160 m with 11 thermistors set between 0-80 m attached to Aanderaa data-logger. Rig marked with spar buoy. Set course for CM station SK 1.

12.8.85	0050-0248	Arrive CM station SK 1 (depth 708 m). Calibrate RCMs. Lay CM rig on slope in 700 m with Aanderaa RCMs set at 50, 300, 650, 680 m attached to sub-surface buoy.
	0330-0435	Arrive CM station SK 2 (depth 180 m). Deploy combined CM and thermistor chain rig. Three Aanderaa RCMs located at 5, 69 and 160 m with 11 thermistors set between 0-80 m attached to Aanderaa data-logger. Rig marked with spar buoy. Set course for hydrographic station I 1020.
	0855	Commence CTD-Rosette sampling at I 1020. Continue hydrographic station sampling eastwards along I-line (56° 45' N).
13.8.85		Continue hydro-sampling I-line.
	1345	Complete I-line at 7° 40' W.
	1900	Commence hydro-sampling westwards along G-line (57° 00' N) from 8° 30' W.
14.8.85	0830	Complete sampling on G-line at 9° 16' W.
	1040	Commence hydro-casting on E-line (57° 15' N) eastwards from 9° 32' W.
	2000	Cease sampling on E-line owing to easterly gale. Unable to keep station sufficiently accurately over slope gradients. Riding out gale.
15.8.85	1115	Re-commence hydro-casting on E-line at 9° 12' W.
	1805	Complete sampling on E-line at 8° 30' W.
	2205	Commence hydro-casting on H-line (56° 45' N) westwards from 9° 00' W.
16.8.85	0700	Complete sampling on H-line at 9° 15' W.
	0850	Commence hydro-casting on K-line (56° 30' N) eastwards from 9° 26' W.
	1530	Complete sampling on K-line at 8° 55' W.
	1705	Commence hydro-casting on M-line (56° 15' N) westwards from 9° 00' W, then eastwards from 9° 12' W.
	2300	Complete sampling on M-line at 8° 42' W.
17.8.85	0020	Commence hydro-casting on N-line (8° 42' W) northwards from 56° 24' N.
	0350	Complete sampling on N-line at 56° 45' N. Proceed to CM mooring BA 1.
	0605-0635	Close and recover CM rig at station BA 1. Weather conditions excellent. All gear recovered successfully and undamaged.
	0715-0745	Close and recover CM thermistor chain rig at station BA 2. All gear recovered successfully and undamaged.
	1130-1200	Close and recover CM rig at station SK 1. All gear recovered successfully and undamaged.
	1240-1310	Close and recover CM/thermistor chain rig at station SK 2. All gear recovered successfully and undamaged. Calibrate RCMs.
	2235	Hydro-cast station N560 (56° 00' N 8° 45' W).
18.8.85	0046	Hydro-cast station N559 (55° 45' N 8° 45' W). Set course for Birkenhead.
19.8.85	1430	Arrive Birkenhead.

Data obtained

A total of 85 stations were sampled for hydrographic properties whilst continuous current data was recorded from four depths each at two stations over the slope and from three depths each at two adjacent shelf stations. Thermistor chain data from the upper 80 m was also obtained from the two shelf stations. The duration of the continuous data was of the order of 6 days.

Owing to the reduction in the sea-time allocated from that requested and also to loss of time resulting from weather, it was not appropriate to obtain full suites of water samples for nutrient analyses from all hydro-stations. Continuous high-resolution profiles of temperature-conductivity-depth were obtained from all hydro-stations except those on the I-line; these data were later corrected for calibration error and used to derive salinity and density data. On the early I-line stations a major drift error developed on the normal response thermistor on the RVS CTD sea-unit preventing derivation of salinity and density data. Owing to the incompatibility of the data-logging system for the back-up CTD unit, the rapid response thermistor on the RVS CTD was used to obtain temperature data only on the remaining I-line stations. It was not possible to derive salinity and density data for these remaining I-line stations. By the commencement of the next (G-) transect line, modifications to the data logging system had been carried out allowing use of the back-up CTD sea unit. This system was employed for the remainder of the cruise although unfortunately it did not allow use of the profiling fluorometer, as would have the RVS CTD unit.

Samples for analysis of ammonium-nitrogen (NH_4), nitrate + nitrate-nitrogen (NO_3), silicate (Si) and dissolved oxygen (O_2) were collected from up to ten depths at all stations on the I-, E- and M-lines. All samples were analysed shipboard using auto-analytical techniques for the nutrient analyses and manual methods for the oxygen determinations.

The RCM data was decoded, calibrated and processed and records from all sites were complete. The thermistor chain records from station SK 2 have likewise been processed and were found in order. However, the thermistor chain data from station BA 2 was found to be impossible to decode, apparently resulting from a fault in the logger.

A chart showing the cruise track and location of stations is appended in Figure 1.

General Conclusions

Despite the foreshortening of time available during the cruise, nevertheless it is considered that the principal objectives of the cruise were achieved. Four detailed latitudinal sections of the continental slope in the survey area were carried out with station spacing dictated by 100 m depth increments. Detailed physical measurements were made on each of these transects and were backed up by nutrient sampling on the northernmost transect. These four 'core' transects were complemented by an extended shelf-deep water transect and a further less detailed slope section, both involving nutrient sampling. These hydrographic data were supplemented by a spatially comprehensive, albeit temporally limited, suite of current data together with a restricted amount of thermistor chain data.

Considering results derived from the E-line section for which the most comprehensive data suite exists, the distribution of temperature (Figure 2) comfirmed the presence of a layer of cool bottom water confined to the shelf and separated from slope water of similar temperature by a layer of warm water of maximum vertical extent 200 m associated with the slope current. Towards the shelf edge, temperature inversions were observed suggesting mixing between the slope current water and the sub-thermocline shelf water of similar temperature. No major structure was associated with the distribution of salinity (Figure 3) other than an expected offshore increase in salinity values. In contrast to previous work the slope current water was not defined by a local salinity maximum. These physical features were in general repeated on the other slope transects.

Nitrate and silicate distributions (Figures 4 and 5) exhibited certain similarities. High nutrient concentrations characterised the cold bottom water of the shelf whilst nutrient minima were associated with the warm slope current water. Immediately offshore of the slope current water localised increases in nutrients were observed, these being particularly marked in the case of NO_3 and resulting in a doming of the isolines apparently unrelated to physical structure.

A clear oxygen deficit was associated with the bottom shelf water (Figure 6) suggesting a degree of physical stability over the summer season. This deficit was more pronounced in the more southerly sections. There was also evidence that low oxygen concentrations were characteristic of the slope current water and that these low oxygen concentrations were continuous with the bottom shelf water. The evidence on this point is however not unequivocal and further observations are required to confirm the relationship. Interestingly on the I-line it was observed that the reduced oxygen values associated with the slope water extended to 550 m.

Evidence for an exchange of bottom shelf and slope waters was provided by the distributions of data points on temperature:nitrate plots for the E-line (Figure 7). Three groupings of data points were evident. The two flank groupings were focussed on data from slope stations 2 and 4: however, both groupings encompassed data points referring to the bottom shelf water. The central grouping of points also contained data from both shelf and slope stations. The lack of spatial resolution of the shelf and slope waters, especially the bottom layers, thus suggests an intermixing of these apparently discrete water bodies as defined by their physical definition.

Current data from the two slope stations showed several similarities, although considerably greater residuals were recorded from the deeper layers at the more northerly station SK 1. In all instances except in the surface layers at station BA 1 the residual drift was in a direction to the west of north; at BA 1 at 50 m the residual was slightly to the east of north. All current records demonstrated a strong semi-diurnal component; a component of similar period was also apparent in the temperature record of the RCMs located at 50 m above the bottom at both stations, but was not apparent in any other of the records from any depth.

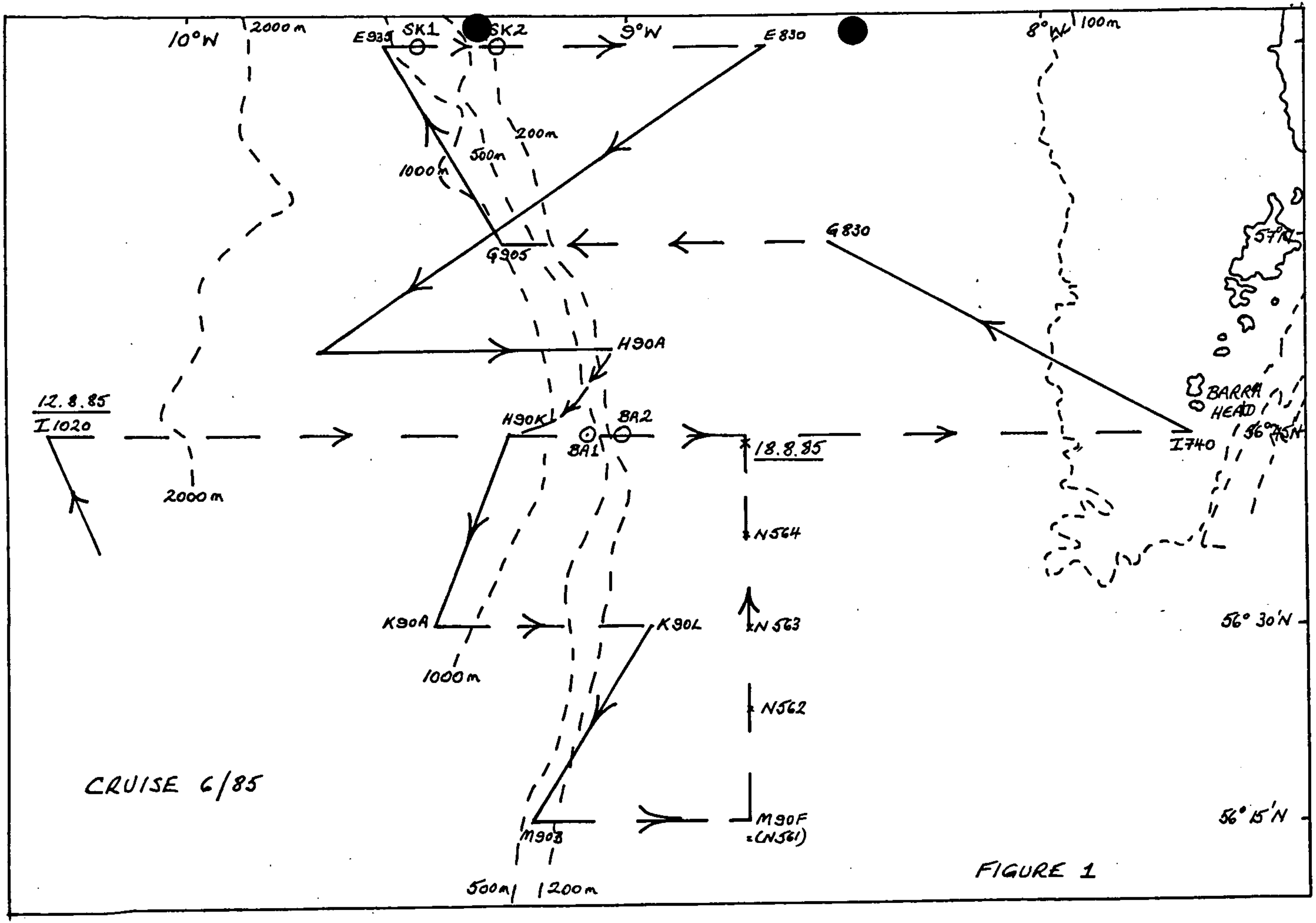
The current data from the two shelf stations again demonstrated a strong northerly component in the residual drift with an offshore component developed in the surface layers. Considerable variation was apparent in the residuals in the middle and bottom layers. In keeping with the dominant tidal period in the north-west Scottish shelf region, a strong diurnal component was evident in the currents at station BA 2; at station SK 2 to the north this component was less well developed and was apparent for only a part of the record. At this latter station a marked instability in the current record at 160 m was evident between August 14-15, although this instability was not reflected in the corresponding temperature record. The comparable thermistor chain data record at SK 2 was again dominated by a semi-diurnal period with vertical isotherm displacement showing a maximum excursion of 40 m again on August 15. This was followed by a period of reduced amplitude wave activity with more irregularity than was evident in the earlier part of the record. The temperature record obtained from the RCM at 20 m above the bottom at station BA 2 showed considerable aperiodic variation possibly associated with excursions of upper slope water onto the outer shelf.

Acknowledgements

I wish to acknowledge with grateful thanks the assistance and co-operation of Capt. E. Dowell, the officers and crew of the RRS Frederick Russell. The success of the cruise, at times in the face of indifferent weather, owes much to their navigational and deployment skills.

Particular thanks are due to Mr. P. Taylor of RVS who, in addition to supervising the mooring deployments, made especial and lengthy efforts to link up the RVS CTD data logging system to the back-up CTD unit following failure of the RVS sea unit. In the absence of Mr. Taylor's effort, there is little doubt that the effectiveness of the cruise would have been severely restricted.

LEGENDS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SK1
SK2
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H90A
BARRA HEAD
12.8.85
I1020
H90K
BA2
BA1
18.8.85
I740
56°45'N
2000m
N564
K90A
N563
K90L
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CRUISE 6/85
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(N561)
M90B
56° 15'N
500m
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FIGURE 1

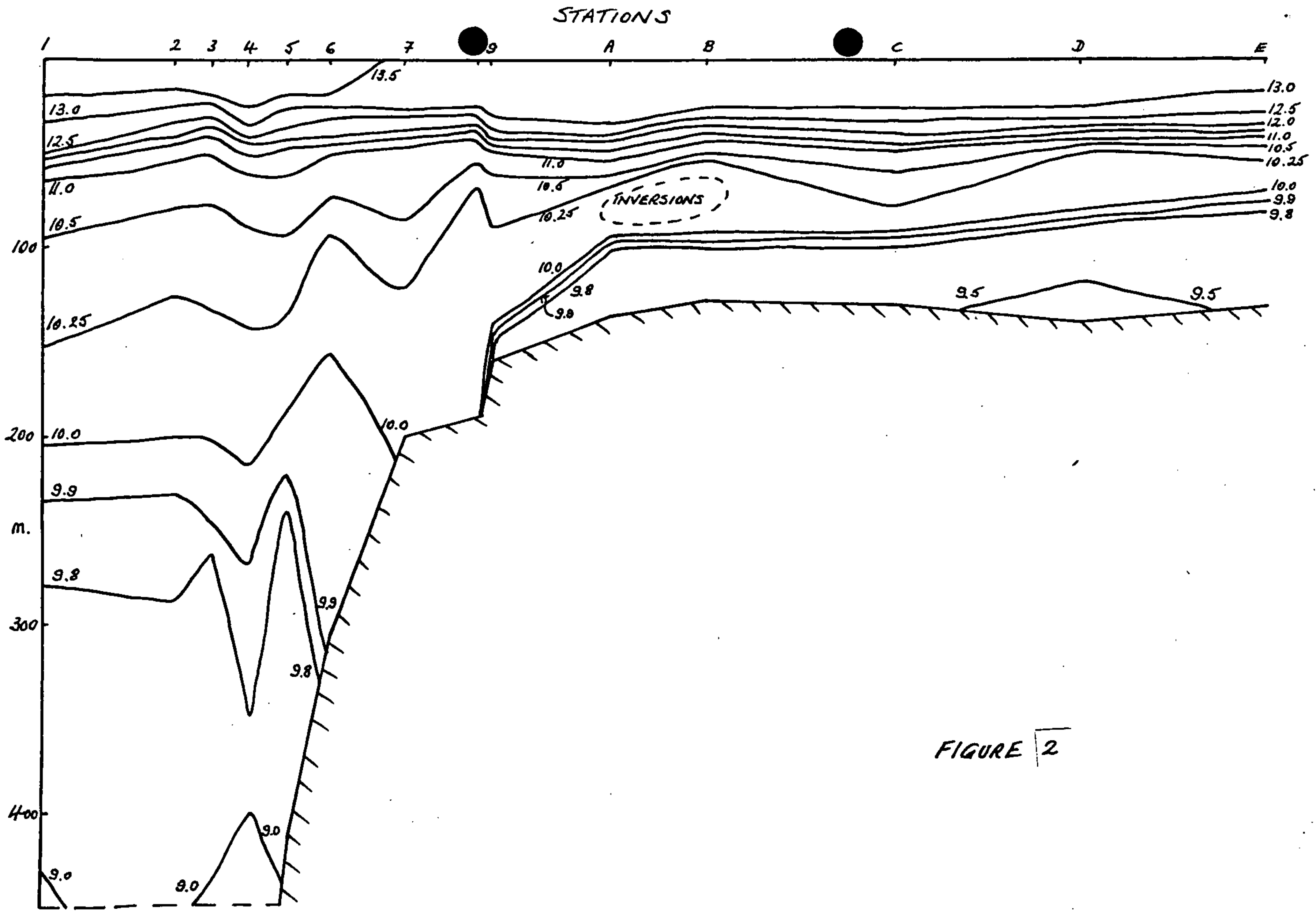
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FIGURE 2

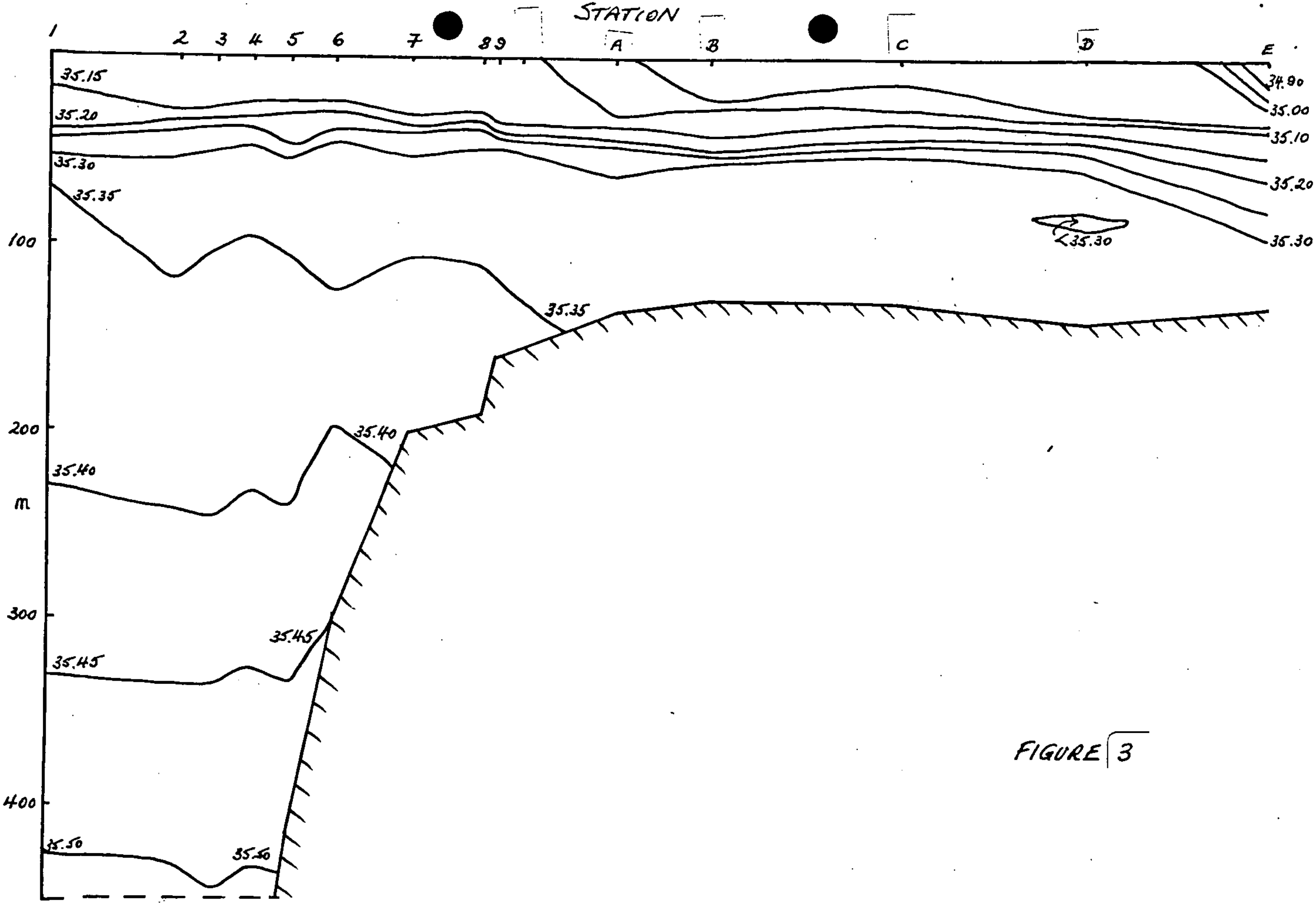

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FIGURE 3

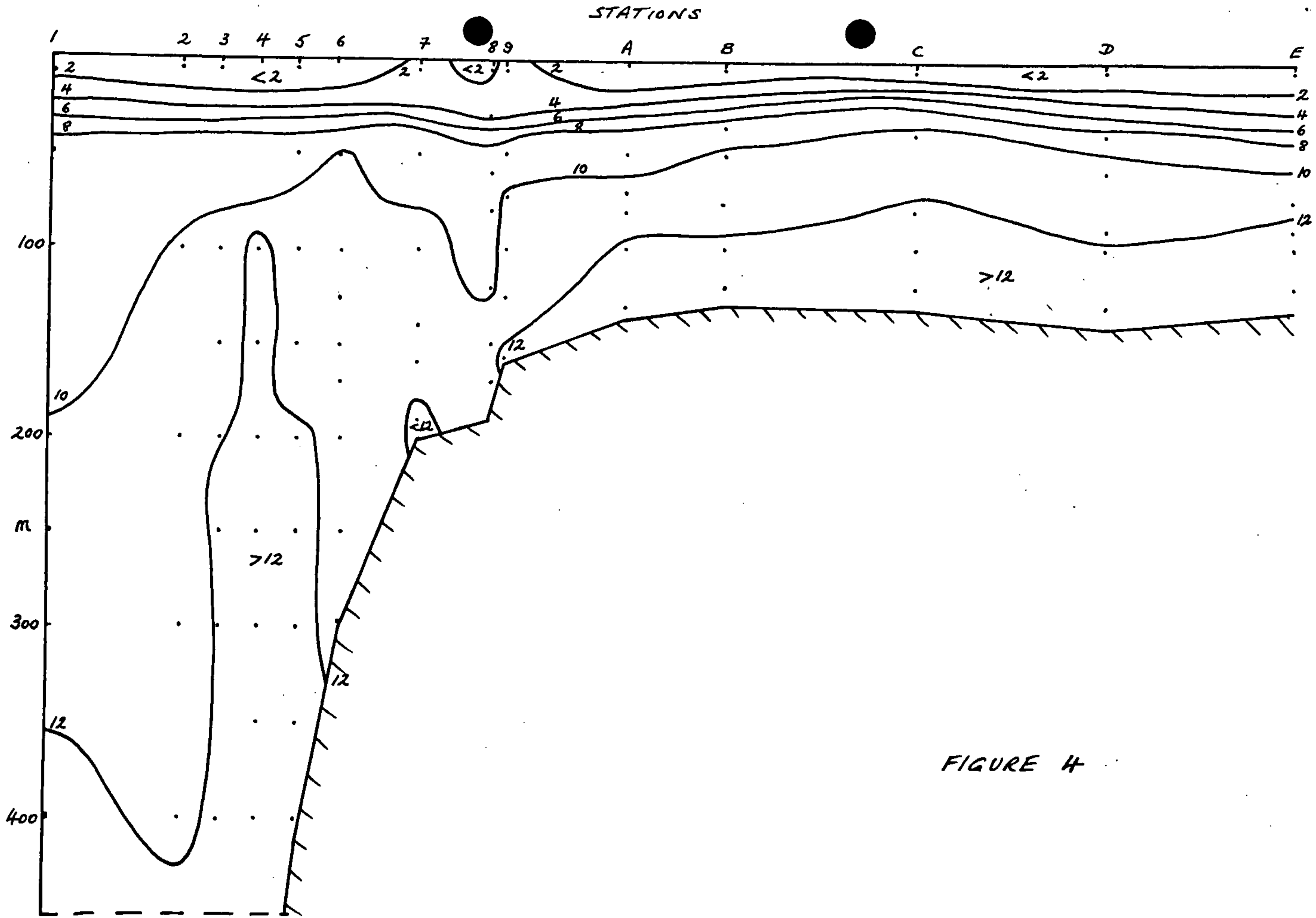


FIGURE 4

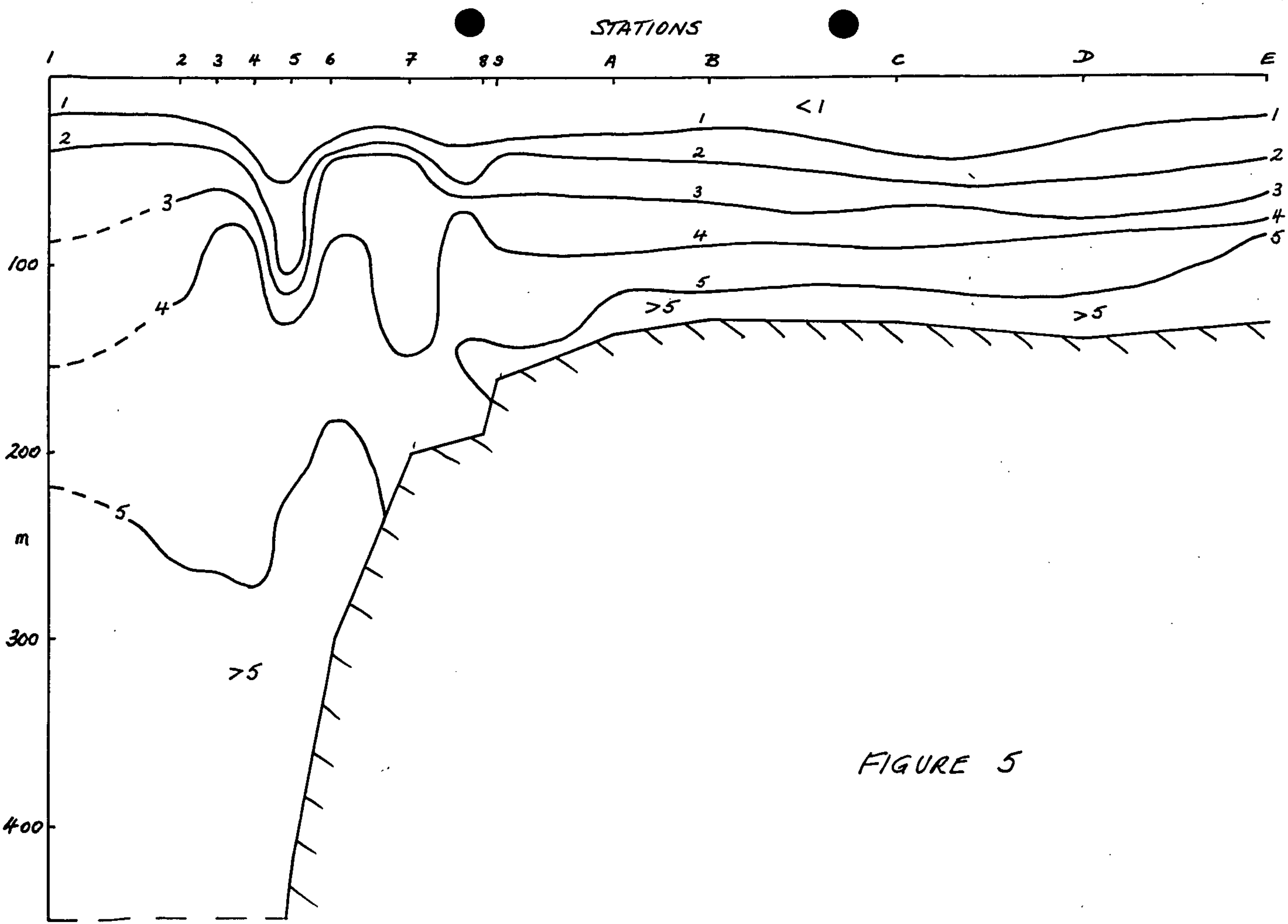
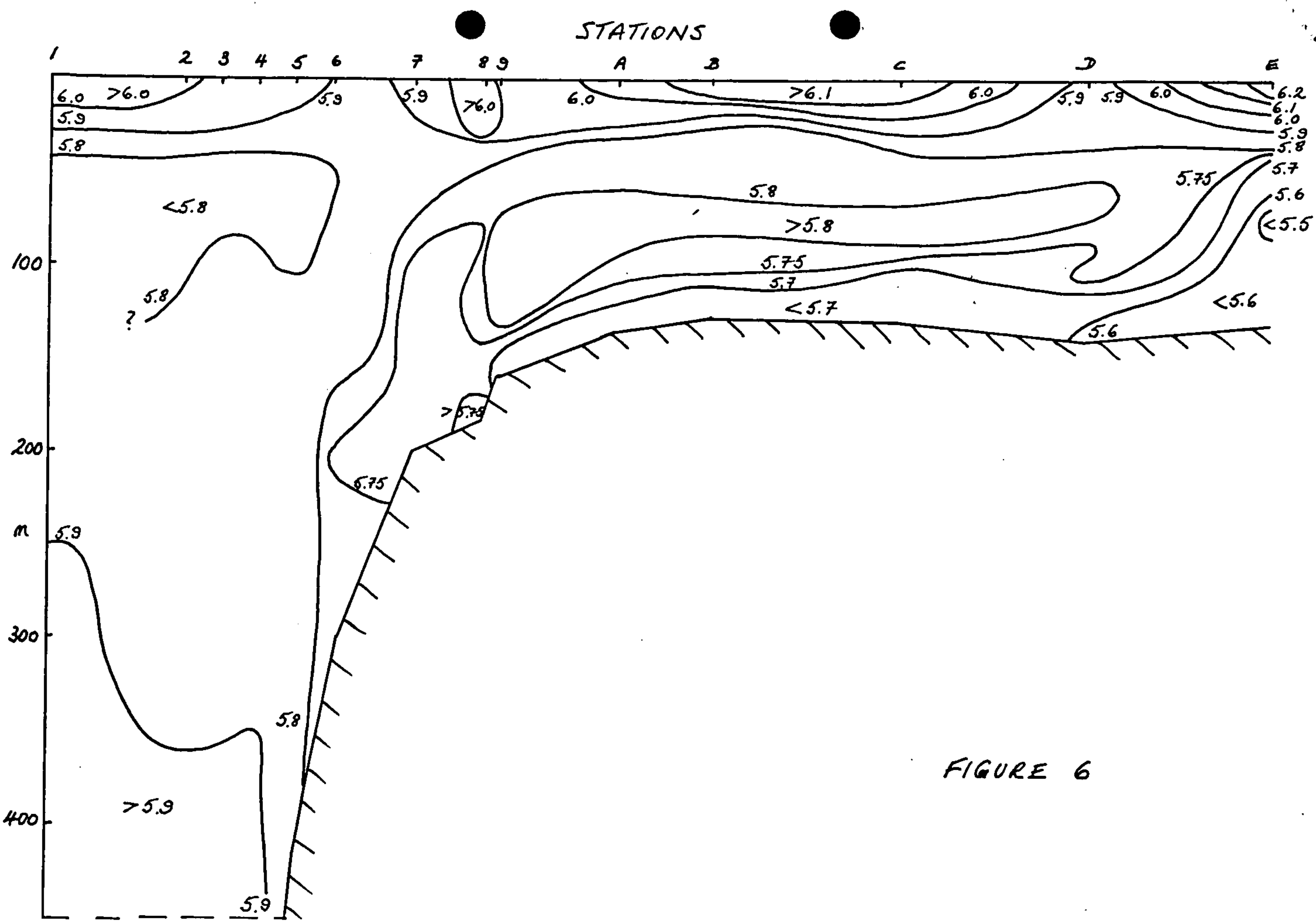


FIGURE 5



STATIONS
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FIGURE 6

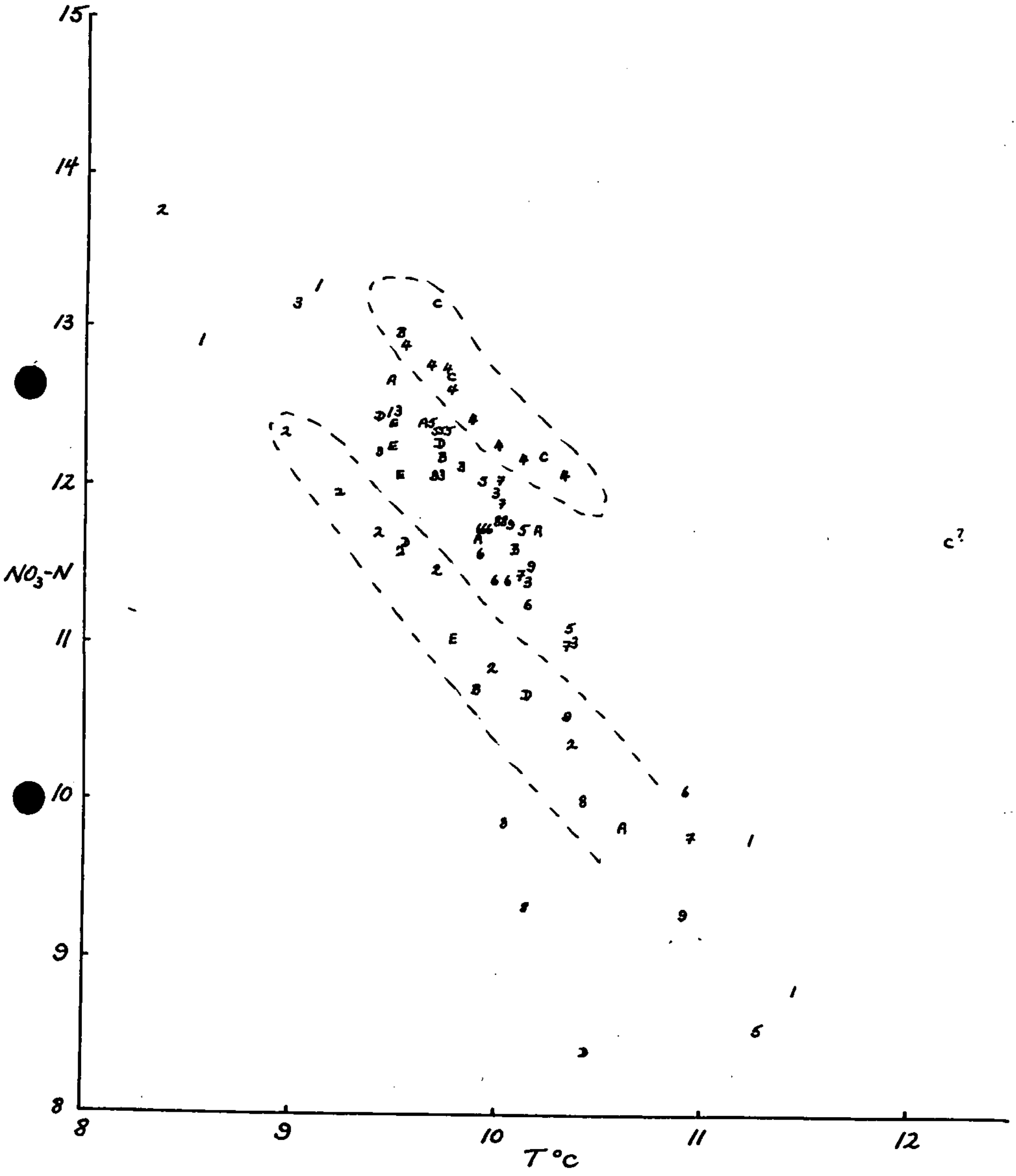

FIGURE 7