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USE OF THE TEXAS A & M DEEP TOWED PUMPING SYSTEM IN THE GULF OF MEXICO ABOARD THE RESEARCH VESSEL GYRE DURING CRUISE 77-G-14, 3-7 DECEMBER 1977

TECHNICAL REPORT

BY

DENIS A. WIESENBURG and DAVID R. SCHINK

REFERENCE 78-4-T

APRIL 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Texas A&M University deep towed pumping system is an apparatus designed to tow a fish-like body containing a pump and a CSTD (conductivity, salinity, temperature and depth) probe at depths down to 150 meters, while the towing vessel is underway at full speed. This survey unit has the capability of pumping eight liters per minute of sea water to analytical

(continued)

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equipment on deck while simultaneously measuring the salinity, temperature and depth at which the towed body is deployed. An on-deck data acquisition system and controlling computer automatically record the CSTD data and provide real-time results that can be used in determining the cruise track or the specific area to be surveyed.

This system was deployed on R/V GYRE Cruise 77-G-14 (3-7 December 1977) to test recent modifications, as well as to determine the reliability and usefulness of a towed pumping system for oceanographic research in surface waters. The mechanical system operated reliably and the towed CSTD data was recorded automatically. Sample water pumped from depths down to 108 meters in the Gulf of Mexico was analyzed for salinity, dissolved oxygen, phosphate, silicate and nitrate. The towed pumping system results compared favorably with the data from hydrocasts taken before and after the towed samples were taken. Temperature profiles taken with the towed CSTD were instrumental in pointing out a malfunction in the shipboard XBT recorder system.

The towed pumping system not only has the potential to survey a large area in some detail within a relatively short period of time; but it can deliver the data almost immediately when the sea water stream is fed directly to automated analytical equipment. This ability to gather real-time data makes the Texas A&M towed pumping system a valuable scientific instrument for oceanographic investigations in surface waters.

Texas A&M University
Department of Oceanography
College Station, Texas

Research conducted through the

Texas A & M Research Foundation

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ABSTRACT

The Texas A&M University deep towed pumping system is an apparatus designed to tow a fish-like body containing a pump and a CSTD (conductivity, salinity, temperature and depth) probe at depths down to 150 meters, while the towing vessel is underway at full speed. This survey unit has the capability of pumping eight liters per minute of sea water to analytical equipment on deck while simultaneously measuring the salinity, temperature and depth at which the towed body is deployed. An on-deck data acquisition system and controlling computer automatically record the CSTD data and provide real-time results that can be used in determining the cruise track or the specific area to be surveyed.

This system was deployed on R/V GYRE Cruise 77-G-14 (3-7 December 1977) to test recent modifications, as well as to determine the reliability and usefulness of a towed pumping system for oceanographic research in surface waters. The mechanical system operated reliably and the towed CSTD data was recorded automatically. Sample water pumped from depths down to 108 meters in the Gulf of Mexico was analyzed for salinity, dissolved oxygen, phosphate, silicate and nitrate. The towed pumping system results compared favorably with the data from hydrocasts taken before and after the towed samples were taken. Temperature profiles taken with the towed CSTD were instrumental in pointing out a malfunction in the shipboard XBT recorder system.

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ACKNOWLEDGEMENTS

The restoration and testing of the Texas A&M University deep towed pumping system has been aided by National Science Foundation Grant OCE-7600065 to the Department of Oceanography. Support for this work has also been received from the Office of Naval Research through Contract N00014-75-C-0537 and additional support was provided through Institutional Grant 04-7-158-44105 to Texas A&M University by the National Oceanic and Atmospheric Administration's Office of Sea Grants, Department of Commerce.

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INTRODUCTION

The Texas A&M deep towed pumping system has undergone many changes and modifications since it was donated to the Oceanography Department in 1974. A major electrical reconfiguration had just been completed when an opportunity came to trouble-shoot the new work on R/V GYRE Cruise 77-G-14. The cruise was an ideal one for deployment of the pumping system. It was a short cruise with emphasis on the physical and chemical oceanography of the Texas shelf waters. The cruise was dubbed a TRANSECT cruise, since its main purpose was to establish a set of baseline values along a transect perpendicular to the Texas coast for a data bank to be established at Texas A&M detailing the oceanogrphic characteristics of the Texas shelf waters. This cruise, scheduled for 3-7 December 1977, gave us a chance to test our equipment, and it also provided us with the opportunity to demonstrate how valuable a towed pumping system can be in studying surface waters of the ocean. The system worked well on this cruise, and we are encouraged about prospects for its future use.

BACKGROUND

In 1974, Texaco Oil Company donated a Model 5-600 deep towed pumping system to Texas A&M University. This system was received in a sea-worn condition, since it had been used for several years in the Gulf of Alaska. Our object since receiving this equipment has been to restore it to working condition and evaluate its performance as an ocean-going research tool. NSF provided the initial funding for this effort through an equipment grant to the Texas A&M Oceanography Department. Additional funding was later provided by the Office of Naval Research and the pumping system is presently being used in conjunction with a Sea Grant project to develop new techniques for measuring chemical variability in surface waters.

The deep towed pumping system (Figure 1) comprises a hydraulic power unit, a seven-meter diameter winch equipped with low-drag, faired towing cable, and a hydrodynamically designed towed body. The hydraulically driven winch mechanism is installed on the stern of the ship. The winch drum accommodates 200 meters of faired cable, the outboard end of which is attached through a tow point assembly and a water-tight electrical connector to the towed body. The towed body (Figure 2) is hydrodynamically designed for balanced and stable operation with a low drag coefficient. The "fish" contains mountings for a submersible pump, a CSTD (conductivity, salinity, temperature and depth) probe, and a transducer and amplifier for use with a bottom sounding fathometer. The pump has a capacity of eight liters per minute, thus the fish can pump water to the deck for analysis while giving a continuous readout of the water salinity and temperature as well as report the sample depth below the surface and above the bottom.

The cable (Figure 3) serves a threefold purpose. The tubular center section functions as a hose for conveying sampled sea water from the submersible pump within the towed body to the shipboard analytical equipment. Electrical conductors provide connections to the electrical package in the towed body housing the CSTD circuitry, and the electrical supply to the water pump. The cable is armor-coated and has the necessary strength capability to function as a towing cable. The addition of Flexnose fairing (Figure 4) to the towing cable gives the cable a low drag coefficient through the water and allows the towed body to reach a depth equivalent to ninety percent of the cable length extended, as opposed to twenty percent for the same diameter bare cable.

Electrical power is provided to the "fish" from a rack mounted deck unit (Figure 5) which contains the pump control and the CSTD monitoring

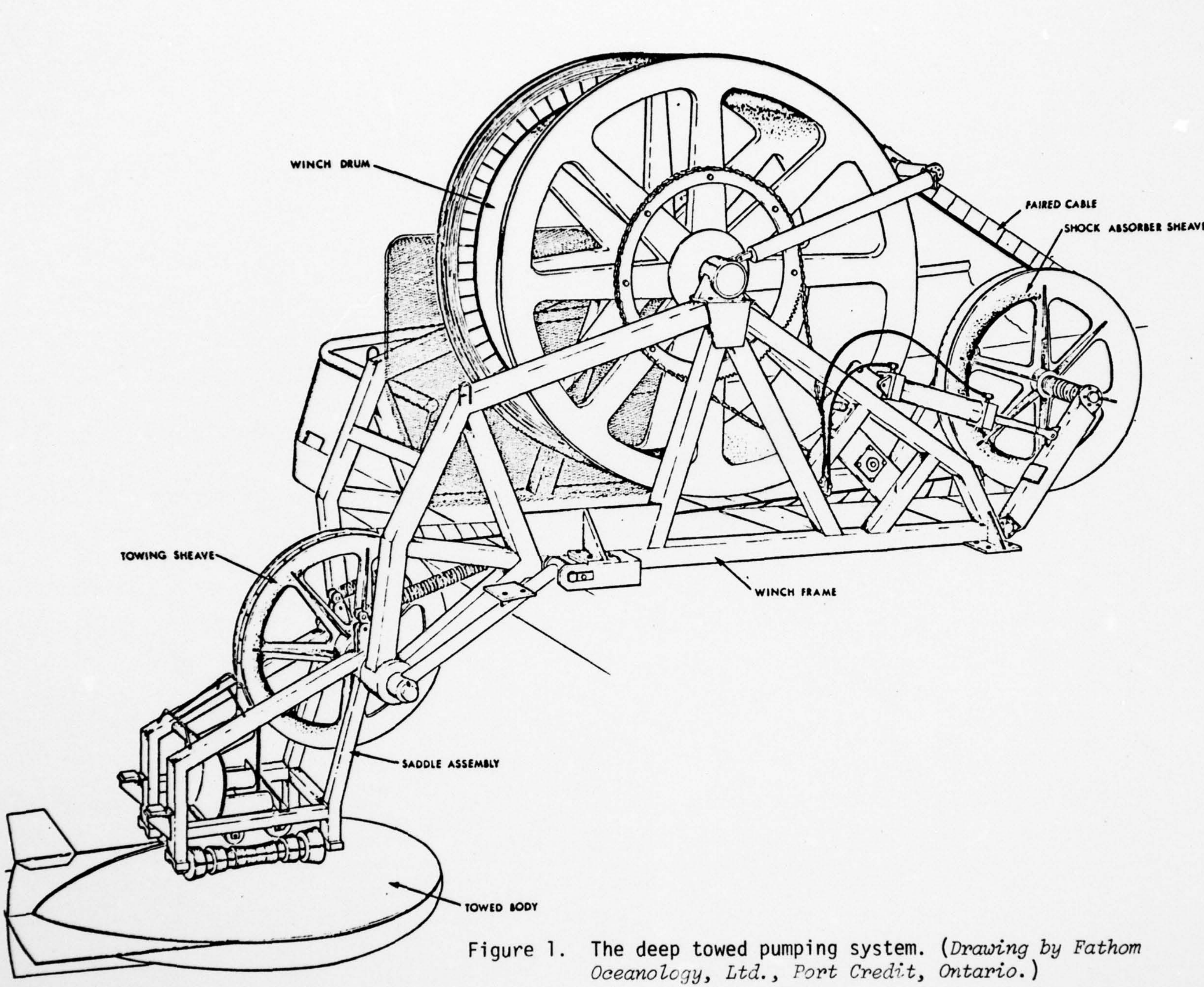


Figure 1. The deep towed pumping system. (*Drawing by Fathom Oceanology, Ltd., Port Credit, Ontario.*)

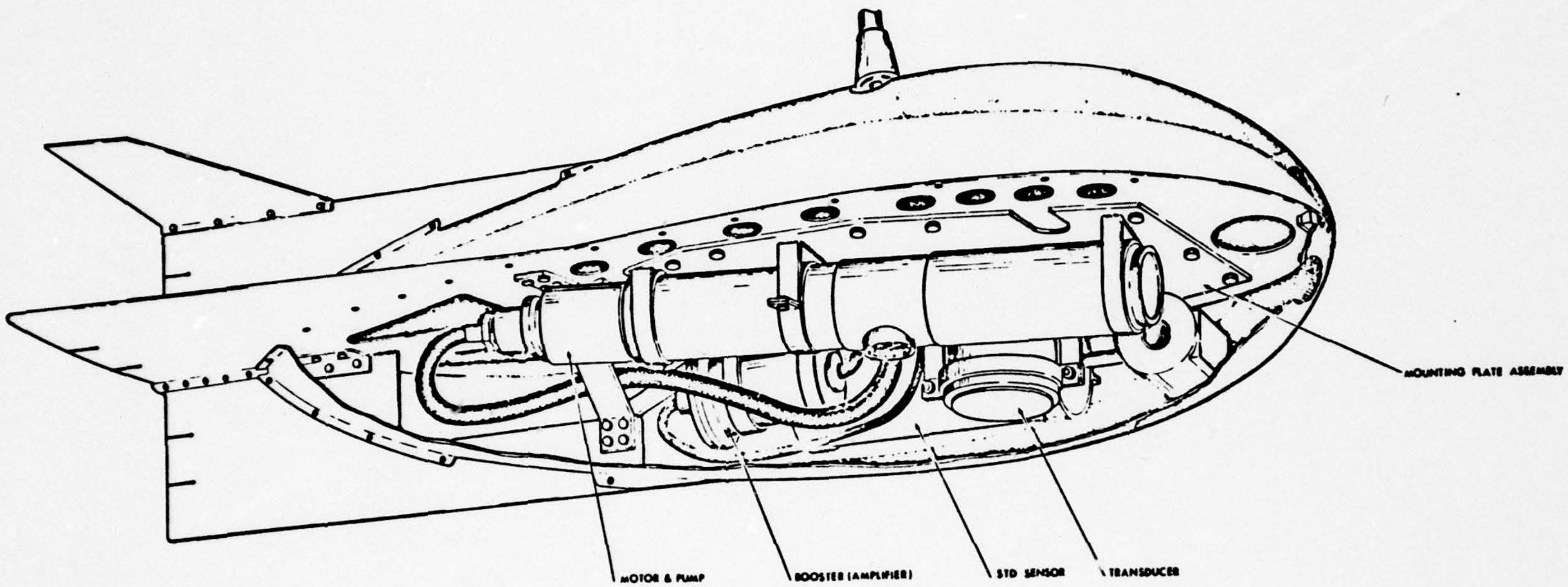


Figure 2. The towed body with part of the casing cut away to show the pump and the CSTD. (*Drawing by Fathom Oceanology, Ltd., Port Credit, Ontario.*)

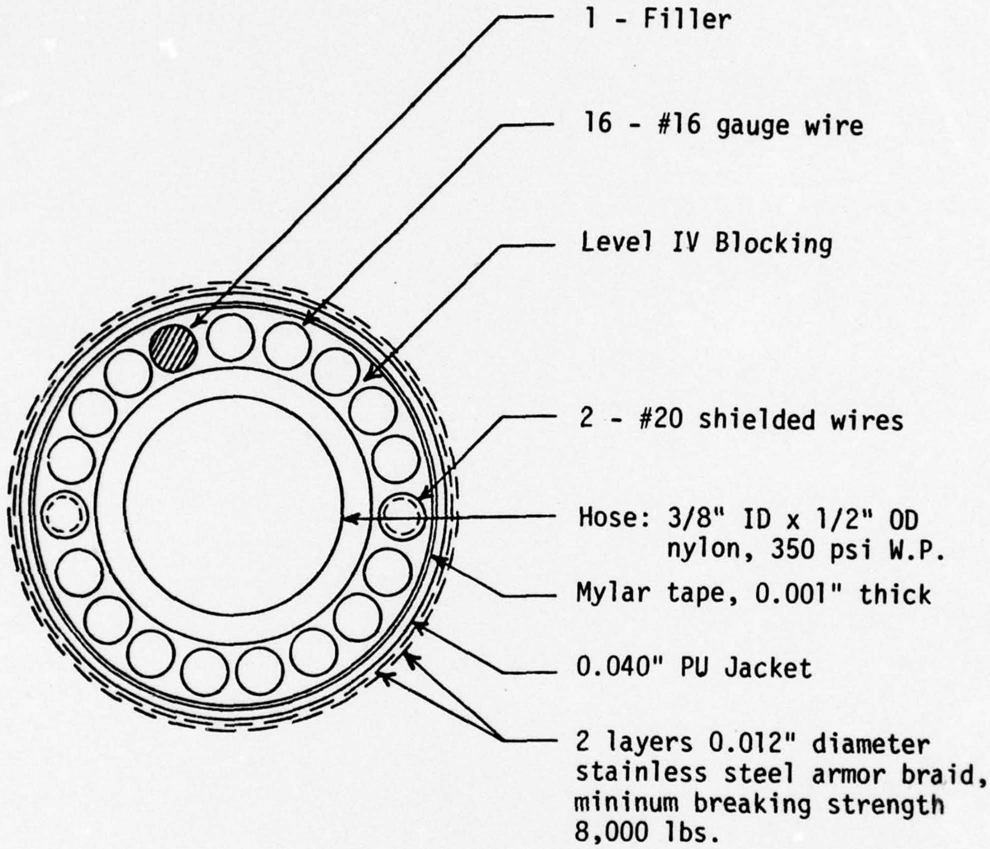
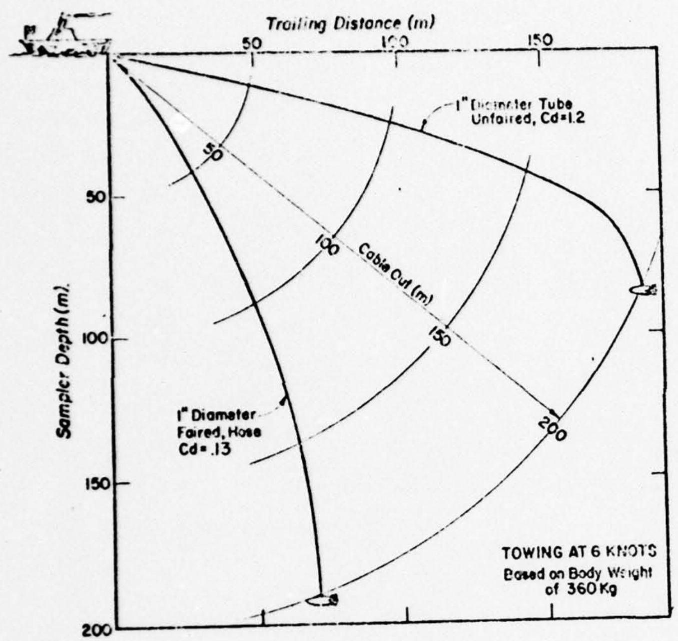
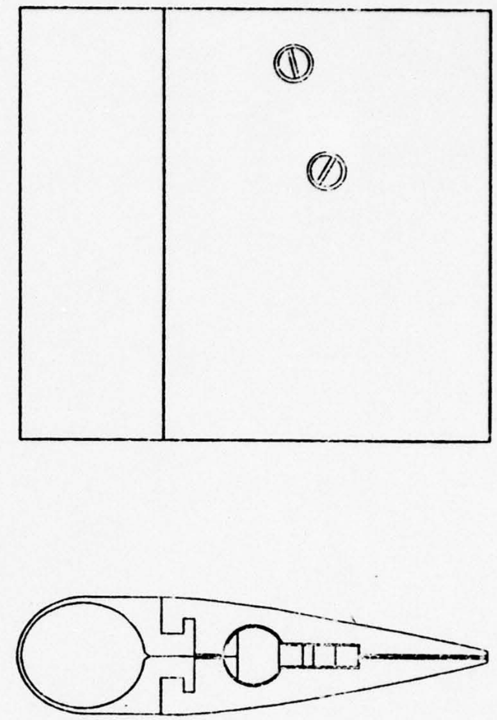


Figure 3. Schematic diagram of the towing cable, cross-sectional view.



CABLE TOWING CHARACTERISTICS



FLEXNOSE FAIRING

Figure 4. Schematic diagram of the Flexnose® fairing used on the cable (right) and plot of towing characteristics of faired and unfaired cable.

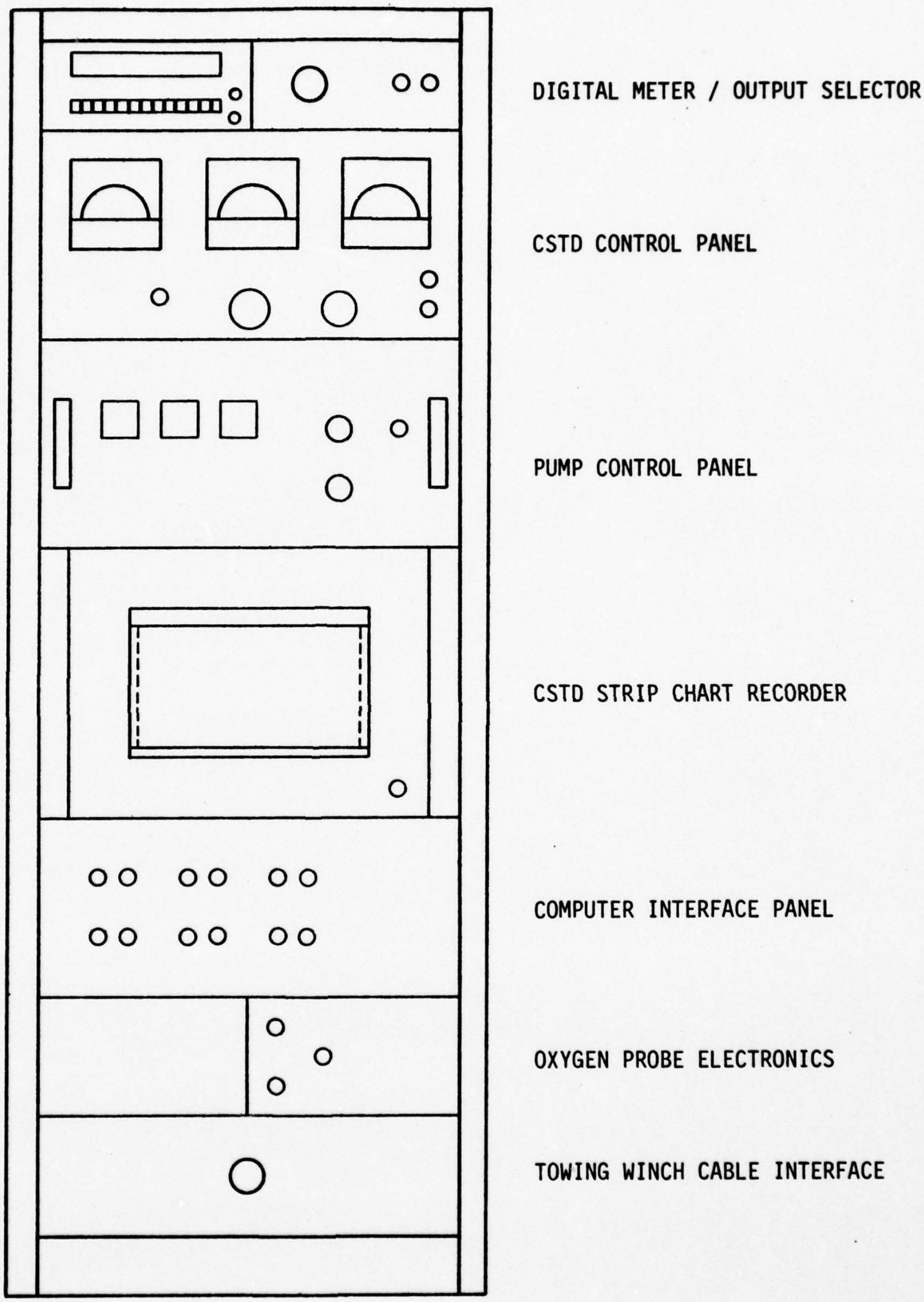


Figure 5. Rack mounted deck instrumentation for pump and CSTD control.

equipment. The deck instrumentation unit is connected to the "fish" via a twenty-conductor cable and a slip-ring assembly on the winch mechanism. This unit sends 220 VAC to the pump and $\pm$ 15 VDC to the CSTD and receives the CSTD return signals from the probe in the "fish". The CSTD data is continuously recorded on a strip chart recorder and can be monitored either by using the analog meters on the CSTD control panel, or with the digital readout system that we have constructed. In addition, the rack instrumentation has a computer interface panel which can be used to send the CSTD data to a data logger or computer system for recording and data reduction. The towed CSTD data is normally fed directly to the GYRE's shipboard Hewlett-Packard 2100 computer where the data is automatically recorded and used to calculate salinity, potential temperature, and sigma-θ in real time using programs we have written to process the data. The same programming automatically logs the day, time, wind speed, wind direction and the ship position (if requested). The system has the capability of plotting the data in several formats after it has been recorded.

An auxillary computer terminal is located with the deck readout unit. This terminal allows one person to monitor both the analytical equipment and the data output from the towed CSTD. If the rate of data collection from the CSTD needs to be changed,that rate can be changed from once a second to once every 10^4 seconds. A sample of the towed CSTD data recorded on GYRE Cruise 77-G-3 is shown in Table 1. During this run, the "fish" is being lowered from 47 to 107 meters, the data rate is once per minute, and ship position is not being recorded.

Since the launching and recovery of the towed body is a remoted operation with no manhandling involved, the towed pumping operation can be initiated by one person in almost any kind of weather. Initially, the

Table 1

Sample of towed CTD data from Cruise 77-G-3. Fish is being lowered from 47 meters to 107 meters (column 1). Sample rate 60 sec.

DAY HR MN SC / DEPTH	SAL	LATITUDE / COND	TEMP	LONGITUDE / SIGMA THETA	POT TEMP	TOT HC	WIND SPD	WIND DIR
114 21 14 50								
47	34.799	54.55	26.65	22.699	26.649		5.8	262
114 21 15 50								
59	34.261	53.65	26.50	22.342	26.498		5.8	262
114 21 16 50								
74	34.858	53.70	25.75	23.086	25.748		5.8	262
114 21 17 50								
83	34.944	53.35	25.30	23.230	25.298		5.8	262
114 21 18 50								
98	34.916	52.90	24.90	23.330	24.897		5.8	262
114 21 19 50								
105	35.337	53.10	24.55	23.753	24.547		5.8	262
114 21 21 28								
107	34.976	53.35	25.25	23.269	25.247		5.8	262
114 21 21 50								
107	34.976	53.35	25.25	23.269	25.247		5.7	261
114 21 22 50								
109	35.166	53.45	25.10	23.458	25.097		5.7	261
114 21 23 50								
107	35.013	53.40	25.25	23.297	25.247		5.7	261
114 21 24 50								
105	35.573	54.05	25.15	23.750	25.147		5.7	261
114 21 25 50								
107	35.094	53.30	25.05	23.419	25.047		5.7	261
114 21 26 50								
105	34.798	52.90	25.05	23.195	25.047		5.7	261

towed body is launched at a ship's speed of six to nine knots with a following sea, and then the ship's speed can be increased to full ahead. The towed body can be deployed to maximum depth in approximately ten minutes. In essence, the Texas A&M deep towed pumping system incorporates all the inherent characteristics of the conventional static sampling system (e.g. an STD/rossette combination) plus a built-in towing capability which allows continuous uninterrupted surveillance over a wide area.

THE CRUISE

GYRE Cruise 77-G-14, under the direction of the Chief Scientist, Capt. T. K. Treadwell, was planned to serve a two-fold purpose. It was primarily a student training cruise designed to acquaint new students with the sea-going aspects of oceanographic research. Secondarily, however, the cruise was a TRANSECT data collection cruise.

The TRANSECT program began at Texas A&M in 1977 with the concept that a data bank at Texas A&M would be valuable in characterizing the changing nature of Texas Gulf waters with respect to various physical and chemical oceanographic parameters. This cruise was the second TRANSECT cruise to gather data for that purpose, and it was well staffed with a five-man group of technicians whose purpose was to collect and process the hydrographic and nutrient data that was to be obtained.

Eighteen stations were occupied between 3 and 7 December 1977 on a transect from Galveston to the shelf break, then traversing westward, and returning to the coast near Matagorda Island (see Figure 6). At each station location (Table 2) a hydrocast was taken and measurements were made of temperature (by reversing thermometer), salinity (by inductive salinometer),

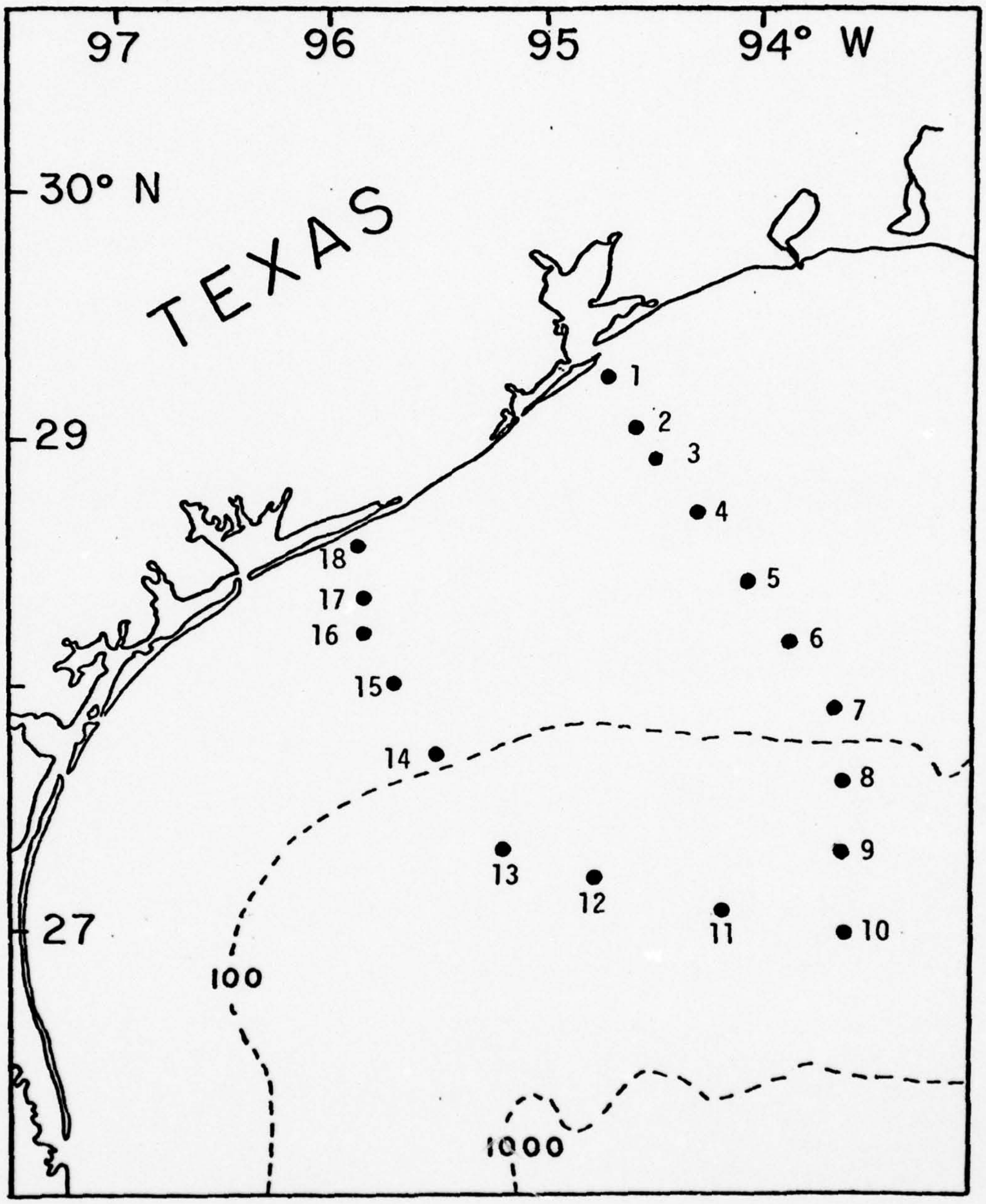


Figure 6. Cruise track for the R/V Gyre on cruise 77-G-14, 3-7 December 1977. Contours are in fathoms.

Table 2

Hydrographic station locations for GYRE Cruise 77-G-14, 3-7 December 1977.

Station	Latitude °N	Longitude °W	Day	Time CST
1	29 15.2	94 41.0	12/3	1215
2	29 04.6	94 34.2		1347
3	28 56.6	94 26.5		1518
4	28 42.8	94 16.5		1732
5	28 26.0	94 02.1		2026
6	28 10.2	93 50.0		2317
7	27 54.7	93 37.7	12/4	0250
8	27 35.9	93 36.0		0757
9	27 19.6	93 36.9		1053
10	26 58.0	93 36.5		1700
11	27 05.0	94 09.0	12/5	0402
12	27 13.1	94 42.1		1136
13	27 20.3	95 08.8		1954
14	27 43.2	95 27.2	12/6	0135
15	28 01.3	95 41.4		0608
16	28 12.8	95 47.9		0845
17	28 21.0	95 48.0		1003
18	28 35.5	95 49.0		1220

dissolved oxygen (by micro-Winkler methods), and the nutrients silicate, phosphate, and nitrate (by Technicon autoanalyzer). In addition, an STD cast was taken at some stations to make detailed profiles of the salinity and temperature versus depth gradients. XBT's were also dropped at regular intervals between stations, while the ship was underway, in order to supplement the hydrocast and STD station data temperature records. All data was logged into the shipboard computer as soon as it was processed. The TRANSECT plan for the future includes continuing cruises of this type on a semi-annual basis with the ultimate goal of conducting quarterly cruises over the approximate area covered by this cruise (Figure 6).

It was obvious from the beginning that a towed pumping system would be a tremendous aid to the TRANSECT cause, since supplemental water samples and continuous CSTD measurements could be made while the ship was underway between stations. The scope of operation of the towed pumping system on this cruise was limited since our main purpose in going at this time was to test the recent modifications made to the electrical and mechanical systems. Thus, our primary aim was to establish that we had a reliable, working system, determine what problems remained to be solved and evaluate the future potential of the pumping system. Our alternate goal was in gathering supplemental data for the TRANSECT effort.

DEPLOYMENT OF THE TOWED PUMPING SYSTEM

On Cruise 77-G-14 we planned to use the towed pumping system to sample between two deep-water stations and to correlate the towed CSTD data and the water sample measurements from pumped water with the station hydrocast data. During this operation, water from the towed pump would be sampled at several depth intervals and measurements made for salinity, dissolved oxygen, phosphate, silicate, and nitrate. We also planned to compare the towed CSTD temperature data with the temperature record to be obtained from XBT's launched at regular intervals during the cruise.

The towed body was launched on the second day of Cruise 77-G-14 to test the mechanical system. The launch was begun at 1500Z (338J). Both the pump and the CSTD were operational and the fish was moved up and down at shallow depths (to 40 meters) to test the hydraulic chain drive. The chart record of the CSTD signal for this test is shown in Figure 7. It was noted at this juncture that the chain was slipping; thus the fish was retrieved so a link could be removed from the chain. No water samples were taken or analyzed at this time, however an XBT (Figure 8) was launched during the run. Since the towed CSTD had not penetrated the thermocline during this test, little comparison could be made with the XBT record.

The fish was launched again on day 399J while the ship was cruising between stations 12 and 13. After one successful launch and recovery to test the hydraulics, the system was launched for data collection. The fish was successively lowered to depths of 20, 40, 60, 85, and 108 meters. The CSTD data record from the strip chart recorder is shown in Figure 9. After five minutes at each depth, water samples were taken for analysis of salinity, dissolved oxygen, phosphate, silicate and nitrate and then the fish was lowered to the next depth. The digitized CSTD data recorded for each sample is shown in Table 3. An XBT (Figure 10) was launched to provide a temperature record for comparison while the towed pumping system was in operation. Before maximum deployment of the fish, some entanglement occurred between the chain and the chain guard, so the chain guard was removed and the fish was recovered at 0030Z, 340J.

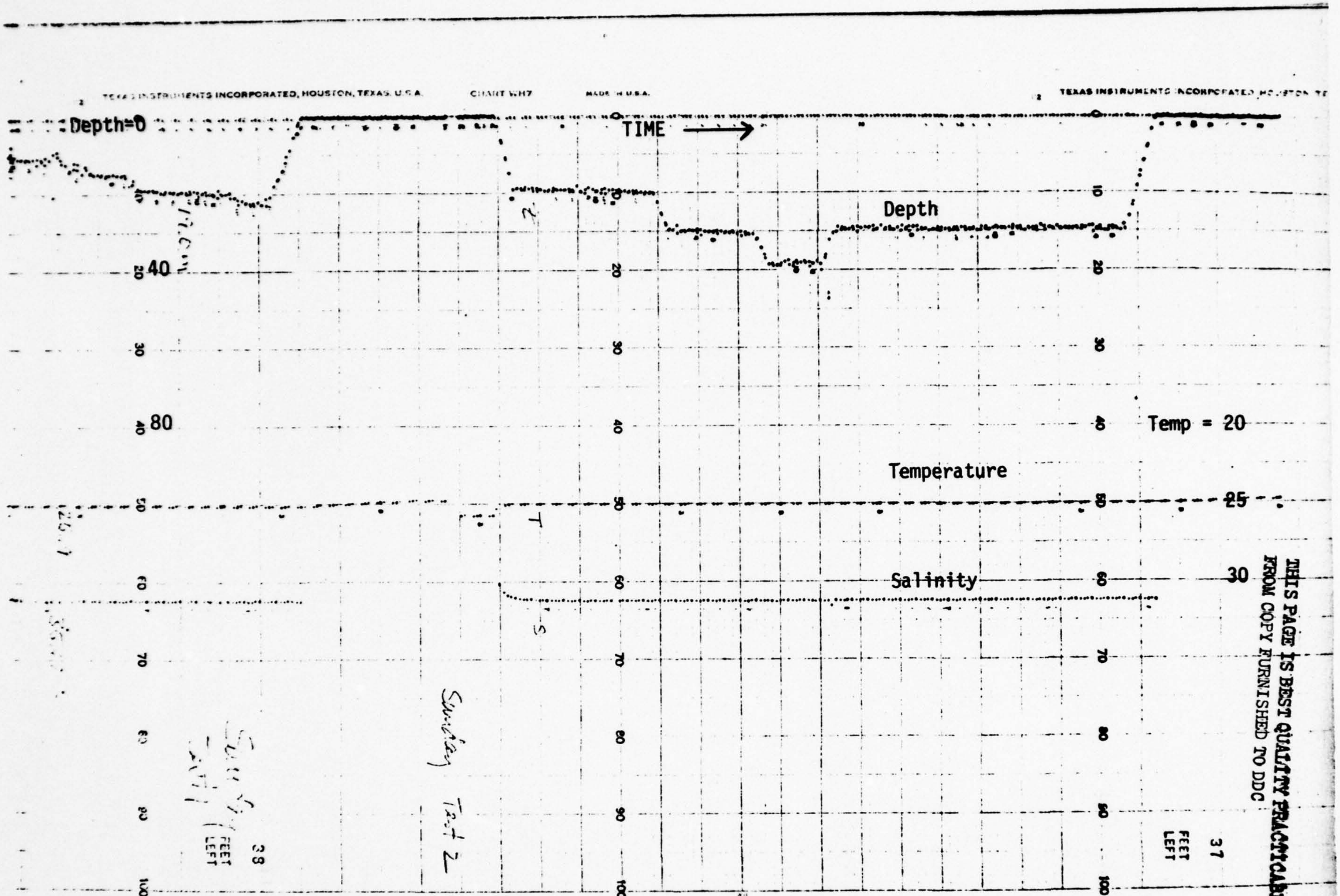


Figure 7. Towed CSTD record from the first test of the towed pumping system on cruise 77-G-14. Maximum depth achieved was 40 meters. Temperature was isothermal at 25.19°C and salinity was isohaline at 35.47 ‰.

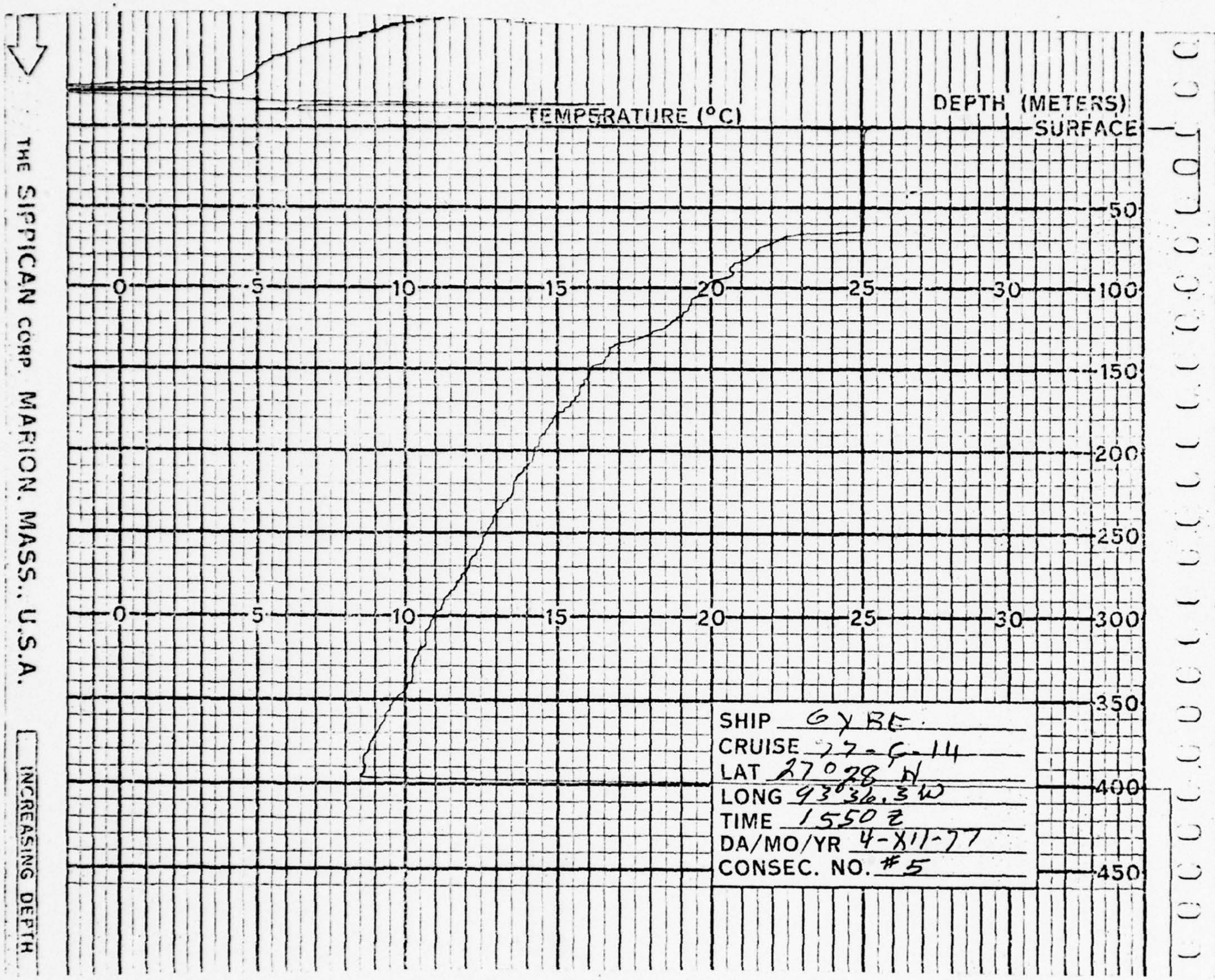


Figure 8. Chart of XBT #5 which was launched during the first test of the of the towed pumping system on cruise 77-G-14.

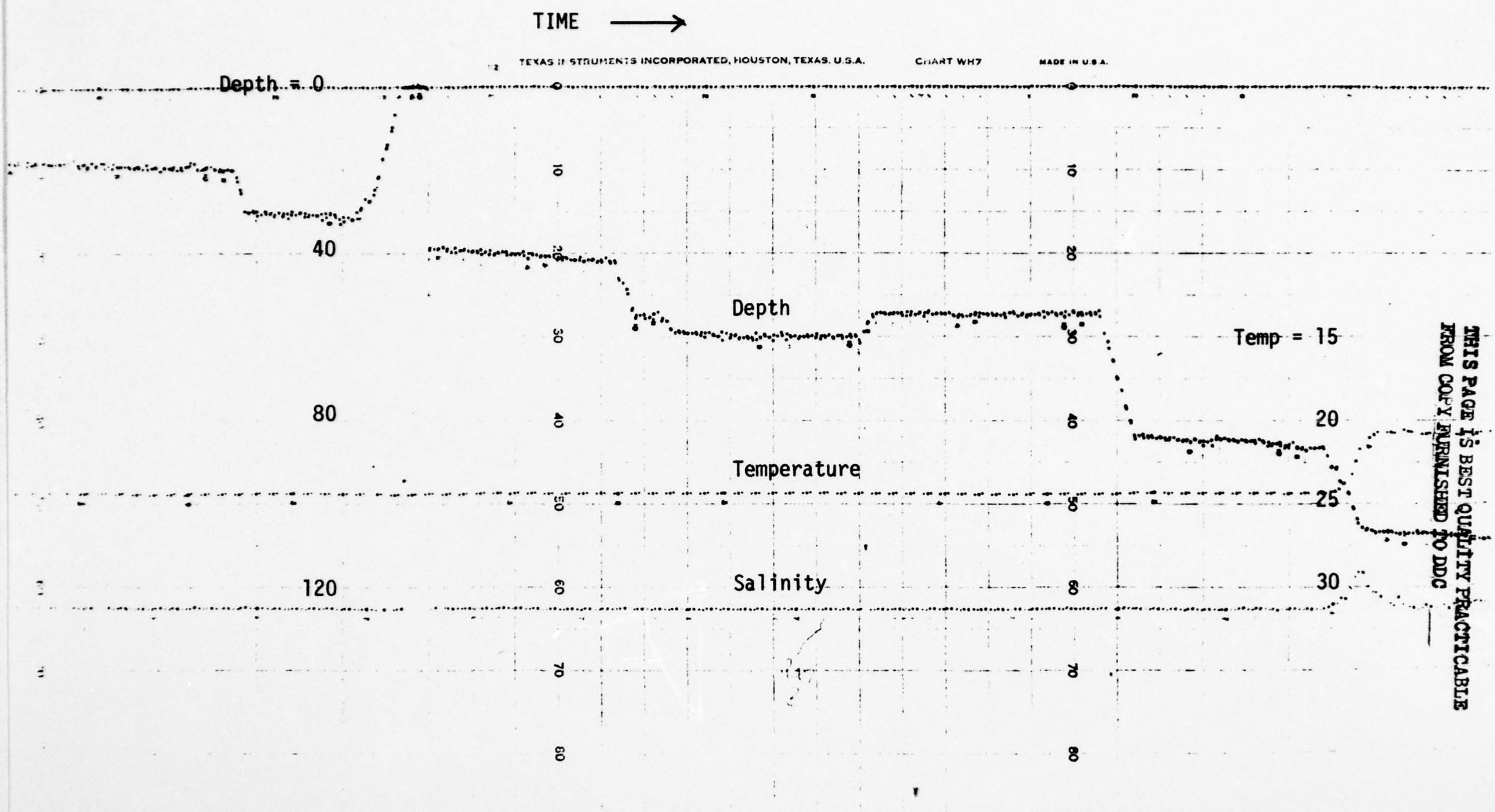


Figure 9. Towed CSTD record from the second test of the towed pumping system on cruise 77-G-14. Maximum depth achieved was 108 meters. Note the thermocline between 85 and 108 meters.

Table 3

CSTD data recorded from the towed pumping system and other values obtained from pumped water samples on Cruise 77-G-14, 5 December 1977.

TIME GMT	DEPTH (m)	TEMP °C	SAL. °/oo	O_2 µM	PO_4 µM	Si µM	NO_3 µM
2231	20	24.54	36.43	108.0	.18	2.2	0
2243	41	24.47	36.43	107.8	.18	2.2	0
2300	60	24.50	36.43	106.2	.18	2.2	0
2313	85	24.49	36.43	116.3	.17	2.1	0
2324	108	20.84	36.43	103.8	.16	2.3	0

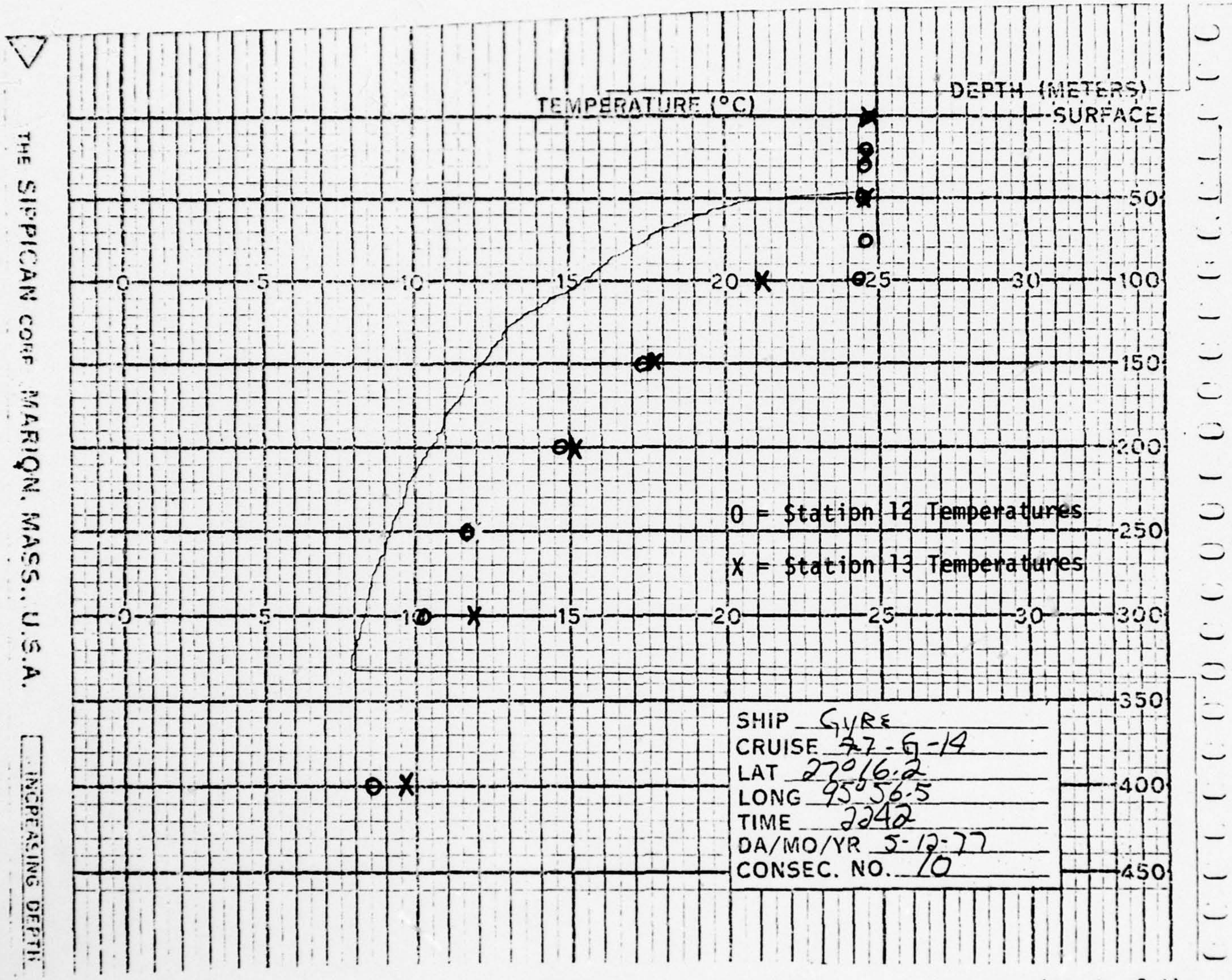


Figure 10. Chart of XBT #10 which was launched during the second test of the towed pumping system on cruise 77-G-14.

EVALUATION OF EQUIPMENT PERFORMANCE

The system modifications that had been made to the towed pumping system since its last cruise in the summer were both electrical and mechanical. On past cruises, there had been problems with the electrical termination in the "fish". Before this cruise, new connectors for both the pump and the CSTD were installed using a new method of waterproofing the underwater electrical connections. As a result of this improved encapsulation of the connectors, no electrical problems occurred in the fish. There was no water leakage into the wiring, as had occurred in some past cruises, and the pump and CSTD worked, uninterrupted, for the entire cruise.

Data from the CSTD was monitored continuously during the pumping operation; water was sampled periodically for chemical analyses. Salinity, temperature, and depth measurements were transmitted from the fish to the deck instrumentation, recorded on the strip chart recorder and monitored using the digital volt meter. A malfunction of the conductivity circuit board in the fish prevented conductivity data from reaching the computer; thus salinity could not be calculated using the temperature and conductivity, but was available from the strip chart record.

An excessive amount of noise on the signal lines from the fish to the computer prevented accurate logging of any data in the computer. While the fish was actually being towed at a depth of 55 meters, the depths recorded by the computer varied from 53 to 59 meters. The actual water temperature was 24.50 °C, but the computer recordings varied from 24.35 to 25.05 °C (Table 4). The inherent noise in the temperature data can also be seen in the plot for the computer-recorded data (Figure 11). No noise problem was encountered with the strip chart recorder and the digital

Table 4

Sample of computer-recorded towed CSTD data from Cruise 77-G-14.
Fish is being towed at a constant 55 meters. Sample rate is 30 sec.

DAY HR MN SC		LATITUDE		LONGITUDE					
DEPTH	SAL	COND	TEMP	SIGMA THETA	POT TEMP	TOT HC	WIND SPD	WIND DIR	BARO
339 23 02 00		27 16.2 N		094 59.4 W					
54	7.569	13.25	25.05	2.782	25.050				
339 23 02 32		27 16.2 N		094 59.5 W					
54	10.802	18.15	24.45	5.366	24.450				
339 23 03 00		27 16.3 N		094 59.5 W					
54	13.121	21.70	24.50	7.091	24.499				
339 23 03 32		27 16.3 N		094 59.6 W					
55			24.45						
339 23 04 00		27 16.3 N		094 59.7 W					
59			24.45						
339 23 04 32		27 16.4 N		094 59.7 W					
54	10.166	17.10	24.25	4.943	24.250				
339 23 05 00		27 16.4 N		094 59.8 W					
57			24.45						
339 23 05 32		27 16.5 N		094 59.8 W					
53	1.888	3.60	24.50	-1.343	24.500				
339 23 06 00		27 16.5 N		094 59.9 W					
54	2.134	4.05	24.70	-1.209	24.700				
339 23 06 32		27 16.5 N		094 59.9 W					
57	0.016	0.20	24.75	-2.817	24.750				
339 23 07 00		27 16.6 N		094 60.0 W					
54			24.45						
339 23 07 32		27 16.6 N		095 00.1 W					
53	7.624	13.15	24.35	3.008	24.350				
339 23 08 00		27 16.7 N		095 00.1 W					
57	8.657	14.95	24.90	3.638	24.900				

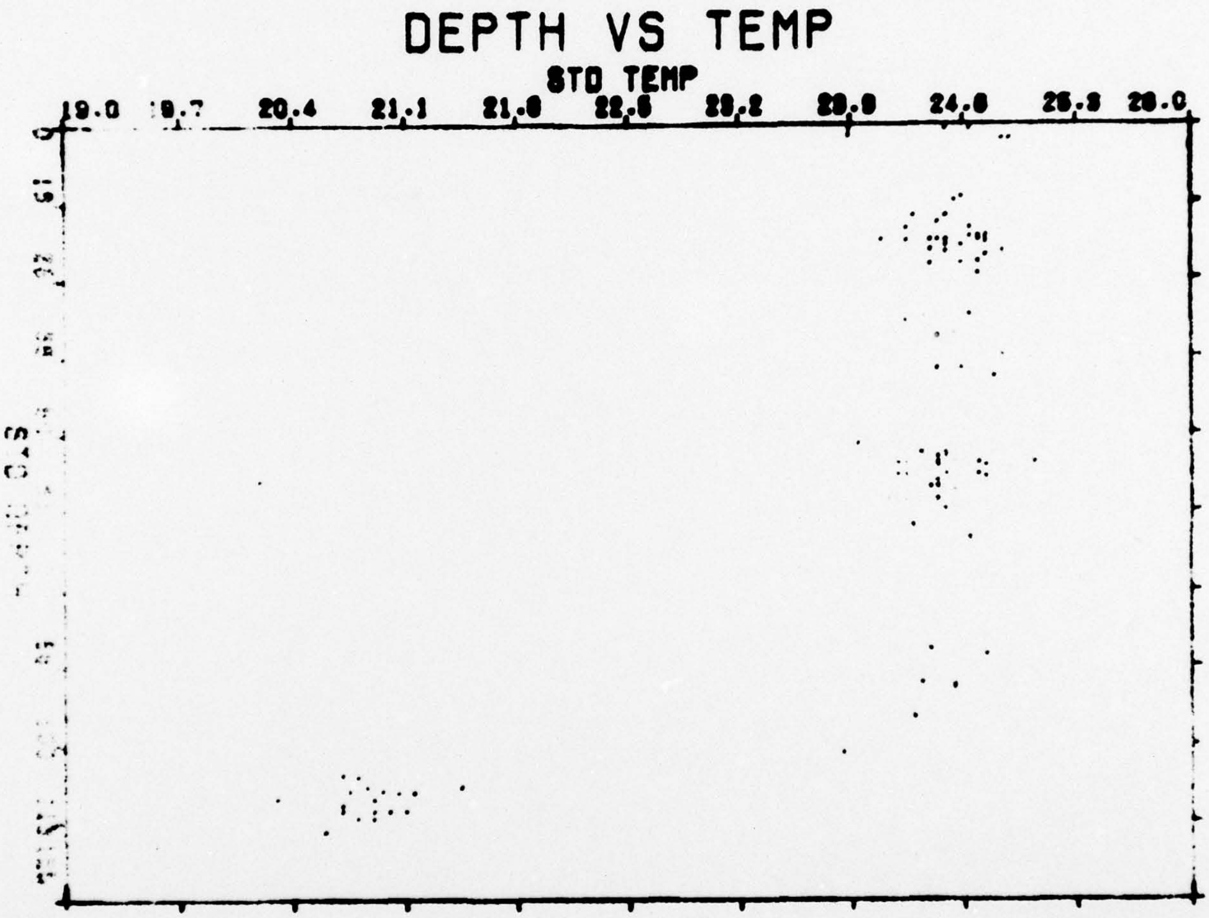


Figure 11. Plot of towed CSTD temperature data versus depth, generated by the Gyre's shipboard computer. Note the scatter in the temperature data.

multimeter since both of these instruments have damping circuits which will filter out high frequency electrical noise before the value is plotted. Thus, we were able to obtain reliable CSTD data readouts using the strip chart recorder and verifying the data using the digital multimeter readout unit (see Figure 5).

Laboratory evaluation of the electrical noise problem after the cruise indicated that the CSTD signal noise could be eliminated by filtering the output DC voltages before they were measured by computer. The proper filters were purchased and have been successfully tested for this purpose. Laboratory testing of the integrated system with the shipboard computer has shown that the use of a low pass filter provides a noise-free signal to the computer. This solution should alleviate our electrical noise problems on future cruises. The laboratory test data for the filtered and unfiltered temperature, conductivity, and depth data is shown in Table 5.

In summary, the equipment testing program designed for this cruise was a complete success. The mechanical systems proved very workable. We were able to launch and recover the fish in relatively rough seas with only one person at the controls. This remoted launch capacity has a distinct advantage in that the towed pumping system can be operated in almost any kind of weather.

The new underwater termination method employed on this cruise seemed to resolve all of the electrical problems that had plagued us on earlier cruises. The CSTD data was collected and the pump operated simultaneously with no electrical interference. The only minor problems that occurred were the malfunction of the conductivity circuit board in the fish, and the inability of the computer to accurately measure the noisy CSTD signal. Both of these problems were quickly resolved when the CSTD and the computer were returned to the laboratory.

Table 5

CSTD voltages for temperature, conductivity, and depth with and without the filtering system that was recently installed. To calculate temperatures and conductivitues, the voltage is multiplied by a factor of ten. For depth, one volt is equal to 100 meters. All values are in volts.

Temperature volts		Conductivity volts		Depth volts	
Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
2.325	2.330	2.035	2.045	1.670	1.675
2.325	2.330	2.035	2.045	1.670	1.680
2.325	2.325	2.035	2.045	1.670	1.685
2.325	2.330	2.035	2.035	1.670	1.675
2.325	2.315	2.035	2.030	1.665	1.685
2.325	2.320	2.035	2.025	1.670	1.670
2.325	2.320	2.035	2.040	1.670	1.675
2.330	2.320	2.040	2.045	1.670	1.675
2.330	2.325	2.035	2.045	1.670	1.675
2.330	2.330	2.035	2.035	1.670	1.680
2.330	2.345	2.040	2.035	1.670	1.680
2.330	2.335	2.035	2.030	1.670	1.675
2.330	2.335	2.035	2.035	1.670	1.675
2.330	2.335	2.035	2.045	1.670	1.670
2.330	2.330	2.040	2.045	1.670	1.670
2.330	2.325	2.035	2.035	1.670	1.670
2.330	2.325	2.035	2.030	1.670	1.670
2.330	2.330	2.035	2.025	1.670	1.670
2.325	2.325	2.040	2.035	1.665	1.685
2.330	2.310	2.040	2.045	1.670	1.675

CRUISE RESULTS

The water samples taken with the towed pumping system from five depths between stations 12 and 13 were analyzed for salinity, dissolved oxygen, and nutrients. Since the pumping system sampling was done between these stations (Figure 6), the hydrographic data for stations 12 and 13 were used for correlation with the towed pumping system data. The preliminary hydrographic and nutrient data for stations 12 and 13 are given in Tables 6 and 7. The temperature, salinity, dissolved oxygen (Figure 12) and nutrient (Figure 13) data for these two stations were plotted for depths down to 150 meters, to compare that data with the towed pumping system data. The sample data from the towed pumping system (Table 3) are plotted on the same graphs. The pumped sample values were in close agreement with the hydrocast data for each parameter. The slight discrepancy in the oxygen data at 85 meters might have been caused by the untrained person who was drawing and preserving the samples for micro-Winkler oxygen analysis. The difference in silicate values is still being investigated.

While samples taken from the towed pumping system at five water depths compare favorably with the hydrocast data, the temperature data gives a better indication of the utility of a deep towed pumping system. In comparing the temperature data from the towed pumping system with the XBT temperature profile (Figure 10) taken while the towed pumping system was in operation, an obvious difference is evident. The XBT profile indicates that the depth of the thermocline is 47 meters while the towed CSTD shows the thermocline depth to be 91 meters (Figure 9). This was an immediate indication that the GYRE's XBT system was malfunctioning. Temperature values for stations 12 and 13, between which the XBT was taken, were then

Table 6

Preliminary hydrographic and nutrient data from station 12.

PRELIMINARY DATA REPORT
R/V GYRE GY-77-14 LEG 1 STATION 012 CAST 1
POS 27 12.7 N 094 44.0 W FIRST CAST AT 339 20 35

CAST BOTT		ADOP DEPT	TEMP DEG C	POT TEMP	SALI 0/00	SIGMA THETA	OXY	SIL	DYNAMIC HEIGHT	THERMO ANOMALY	PRES DECI
1	1	0	24.59	24.59	36.435	24.570	4.821	1.50	0.0000	337.6	0
1	2	20	24.51	24.51	36.438	24.597	4.791	1.60	0.0674	335.1	20
1	3	30	24.46	24.46	36.436	24.610	4.793	1.60	0.1009	333.8	30
1	4	50	24.46	24.46	36.435	24.609	4.772	1.60	0.1680	333.9	50
1	5	75	24.47	24.47	36.428	24.601	4.748	1.70	0.2522	334.7	76
1	6	100	24.36	24.36	36.412	24.623	4.701	1.90	0.3365	332.7	101
1	7	150	18.33	18.33	36.296	26.200	3.348	4.20	0.4677	182.7	151
1	8	200	14.61	14.60	35.889	26.761	2.886	8.40	0.5486	129.5	202
1	9	250	11.59	11.58	35.439	27.027	2.494	13.00	0.6102	104.3	252
1	10	300	10.24	10.23	35.243	27.121	2.533	15.60	0.6634	95.4	302
1	11	400	8.49	8.47	35.024	27.241	2.885	19.50	0.7604	84.1	403
1	12	600	6.39	6.36	34.891	27.441	3.221	25.00	0.9264	65.2	605
1	13	750	5.53	5.49	34.899	27.558	3.657	26.20	1.0301	54.3	757

PRELIMINARY DATA REPORT
R/V GYRE GY-77-14 LEG 1 STATION 012 CAST 1
POS 27 12.7 N 094 44.0 W FIRST CAST AT 339 20 35

CM	T-CO2 MM	P UM	SI UM	NO3 UM	NO2 UM	NH3 UM	H2S UM	PH	CH4 NM	N2 UM	O2 UM	SALI 0/00
0		0.16	1.5	0.0							4.8	36.4
20		0.15	1.6	0.0							4.8	36.4
30		0.13	1.6	0.0							4.8	36.4
50		0.13	1.6	0.0							4.8	36.4
75		0.14	1.7	0.0							4.7	36.4
100		0.14	1.9	0.0							4.7	36.4
150		0.58	4.2	10.5							3.3	36.3
200		1.19	8.4	16.9							2.9	35.9
250		1.58	13.0	25.5							2.5	35.4
300		1.74	15.6	28.2							2.5	35.2
400		2.03	19.5	32.5							2.9	35.0
600		2.17	25.0	33.0							3.2	34.9
750		1.98	26.2	28.5							3.7	34.9

Table 7

Preliminary hydrographic and nutrient data from station 13.

PRELIMINARY DATA REPORT
R/V GYRE GY-77-14 LEG 1 STATION 013 CAST 1
POS 27 20.6 N 095 09.0 W FIRST CAST AT 340 01 50

CAST BOTT	ADOP DEPT	TEMP DEG C	POT TEMP	SALI 0/00	SIGMA THETA	OXY	SIL	DYNAMIC HEIGHT	THERMO ANOMALY	PRES DECI
1 1	0	24.55	24.55	36.439	24.584	4.729	2.00	0.0000	336.3	0
1 2	25	24.57	24.57	36.434	24.577	4.773	2.00	0.0843	337.0	25
1 3	50	24.53	24.52	36.432	24.588	4.620	2.00	0.1688	336.0	50
1 4	100	21.15	21.15	36.341	25.491	4.477	1.60	0.3168	250.0	101
1 5	149	17.69	17.69	36.286	26.351	3.059	5.00	0.4215	168.3	150
1 6	198	15.13	15.12	35.978	26.716	2.885	7.20	0.4983	133.8	200
1 7	296	11.92	11.91	35.478	26.996	2.700	12.40	0.6232	107.3	298
1 8	394	9.64	9.62	35.150	27.153	2.640	16.70	0.7290	92.4	397
1 9	492	7.90	7.87	34.958	27.280	2.743	20.90	0.8222	80.5	496
110	590	7.15	7.12	34.908	27.350	2.930	22.60	0.9069	73.9	595
111	688	6.36	6.32	34.883	27.439	3.224	24.10	0.9849	65.5	694
112	837	5.58	5.54	34.904	27.556	3.549	24.90	1.0901	54.5	845

PRELIMINARY DATA REPORT
R/V GYRE GY-77-14 LEG 1 STATION 013 CAST 1
POS 27 20.6 N 095 09.0 W FIRST CAST AT 340 01 50

CM	T-CO2 MM	P UM	SI UM	NO3 UM	NO2 UM	NH3 UM	H2S UM	PH	CH4 NM	N2 UM	O2 UM	SALI 0/00
0		0.24	2.0	0.0							4.7	36.4
25		0.22	2.0	0.0							4.8	36.4
50		0.16	2.0	0.0							4.6	36.4
100		0.19	1.6	0.5							4.5	36.3
149		0.76	5.0	13.5							3.1	36.3
198		1.10	7.2	18.7							2.9	36.0
296		1.57	12.4	21.0							2.7	35.5
394		1.92	16.7	30.0							2.6	35.2
492		2.11	20.9	34.5							2.7	35.0
590		2.15	22.6	37.0							2.9	34.9
688		2.18	24.1	34.5							3.2	34.9
837		2.12	24.9	31.5							3.5	34.9

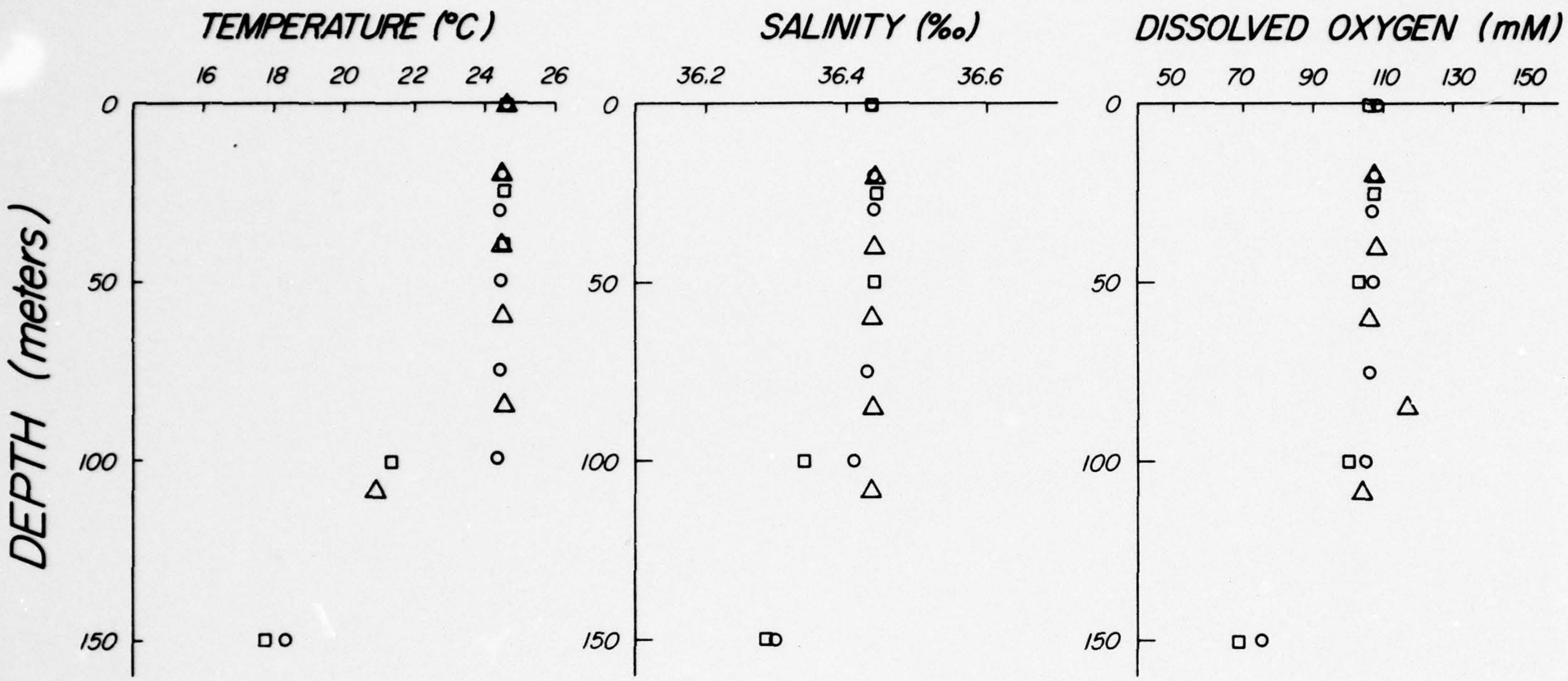


Figure 12. Plots of temperature, salinity, and dissolved oxygen for stations 12 and 13, and from the towed pumping system samples. Station 12 = ○ , Station 13 = □ , and Towed Pumping System = △ .

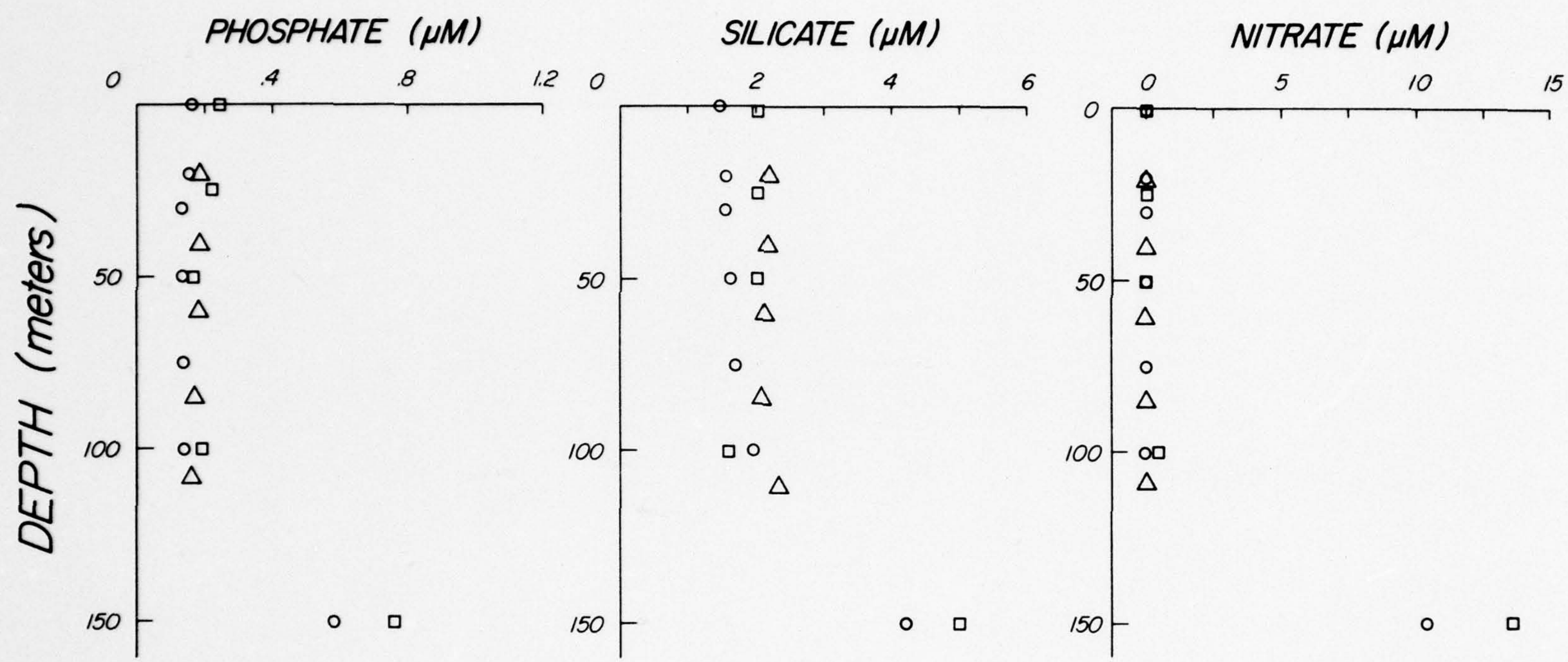


Figure 13. Plots of phosphate, silicate, and nitrate for stations 12 and 13, and from the towed pumping system samples. Station 12 = ○ , Station 13 = □ , and Towed Pumping System = △ .

plotted on the XBT chart (Figure 10). This comparison substantiated the towed pumping system thermocline depth and thus further indicated that the XBT unit had been malfunctioning. Stationary STD data taken at several stations also verified the towed CSTD temperature data. Thus the towed pumping system is able to provide an accurate map of the thermocline in any given area, unless the thermocline is quite deep.

FUTURE PLANS

After the successful testing of the towed pumping system hardware on GYRE Cruise 77-G-14, the next stage of development for this apparatus involves a direct linkage between water sampling and data collection. This step will be taken on a GYRE cruise that is scheduled for March 1978 (78-G-2). The sea water sample stream will be analyzed automatically for several parameters.

1) The pumped water will pass through a chamber containing a dissolved oxygen probe and a pH probe. Oxygen concentrations will be recorded with the shipboard computer and pH measurements will be collected using a strip chart recorder.

2) The sample stream will be directly fed to a two-channel auto-analyzer system that will give a continuous measurement of phosphate and silicate concentrations.

3) A gas stripping system (Figure 14) will use helium to remove dissolved gases from the pumped sea water from the fish. Nitrogen and argon concentrations will be determined by automatic operation using a thermal conductivity gas chromotograph. Carbon monoxide, methane and higher molecular weight, volatile hydrocarbons will be trapped from the stripper gas and analyzed using a gas chromatograph equipped with a flame ionization detector.

4) Samples will also be drawn for manual determination of salinity and dissolved oxygen.

CONCLUDING REMARKS

In these tests only discrete samples were collected and analyzed. When water from this deep towed pumping system is fed directly to various types of analytical equipment, the real potential of mapping various parameters in the surface layer will be realized. This system now is capable of sampling, analyzing, and reducing data in real time. Thus any observed anomalies can be reinvestigated immediately. For example, if an unusual temperature or nutrient structure is noted in a particular area, that region could be surveyed in greater detail using the towed pumping system, or the ship could be positioned to take static STD measurements or hydrocast samples. Thus a towed pumping system not only has the potential to survey a large area, in some detail, within a relatively short period of time; but it can deliver the data immediately and make the survey more effective and more responsive to the conditions encountered. This capability to gather real-time data makes the Texas A&M towed pumping system a valuable scientific instrument for oceanographic investigations in surface waters.

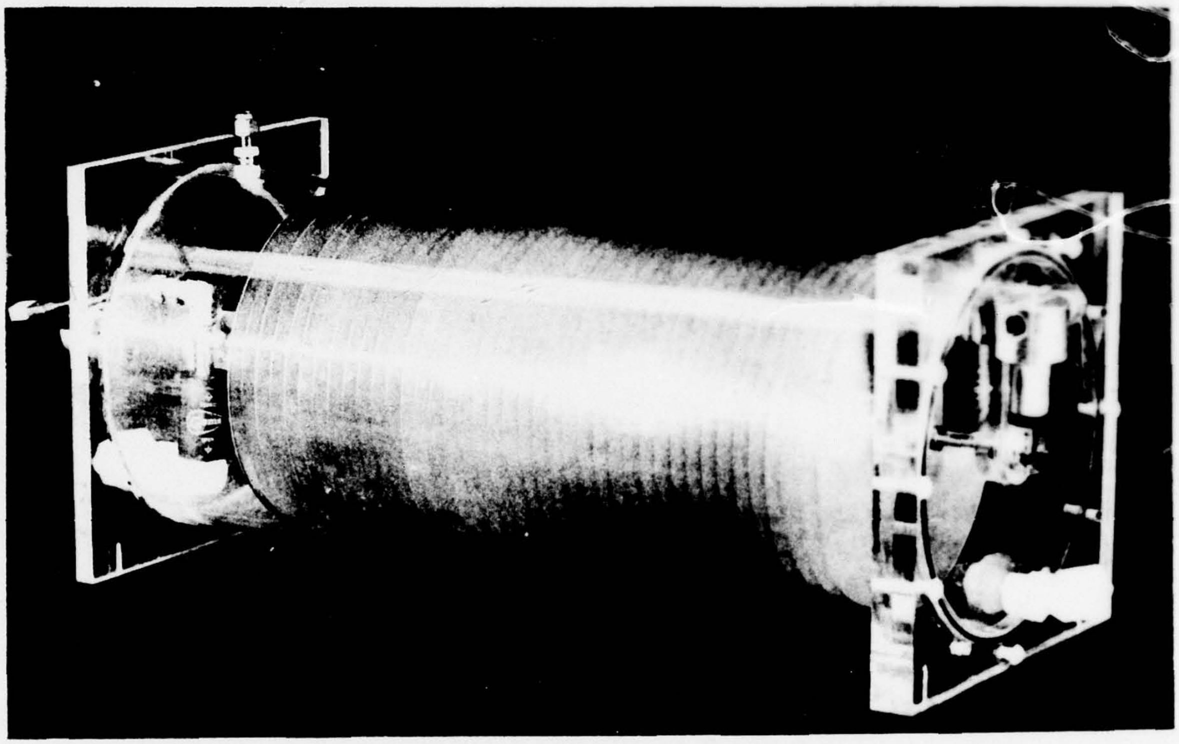


Figure 14. Photograph of gas stripper removed from the system.

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