HYDRAULICS DIVISION

TECHNICAL NOTE

DATE: January 1984 **REPORT NO.** 84-04

TITLE: Calibration of Thermarine Recorders

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REASON FOR REPORT: In response to a request from the Ontario Ministry of Natural Resources, Fishery Research Station, Wheatly, Ontario.

CORRESPONDENCE FILE NO: 4885-3/83-318

1.0 INTRODUCTION

Two Thermarine Recorders or mechanical bathythermographs were received by the Hydraulics Division for repair and calibration. BT #WP64911 is about 30 years old and is an English unit recorder. BT #DD11503 is about 10 years old and is a metric unit recorder. Both BT's were checked over and lubricated where it was thought necessary. BT #DD11503 had its stylus lifting spring repositioned to the proper place. This was the only repair necessary.

2.0 TEMPERATURE CALIBRATION

A temperature bath was filled with tap water. The temperature coils of BT #WP64911 were immersed in the water. A slide was placed in the BT and the cover was moved to the rear of the BT to lower the stylus onto the slide.

The temperature of the bath was lowered to 0.4°C. At this temperature the cover was opened, the stylus lowering lever was activated and a screwdriver was used to jiggle the slide carrier which is attached to the pressure sensing bellows. This produced a vertical line on the slide at the measured temperature. The heater in the temperature bath was turned on and at selected bath temperatures the above slide marking technique was repeated. Since this BT is an English unit recorder the readings from the celsius thermometer were converted to fahrenheit degrees for the linear regression calculation. The 0.4°C (32.7°F) was lined up with 32.7°F on the grid in the viewer and the other temperatures were read.

BT #DD11505 was placed in the bath with the temperature above 22°C and the refrigeration unit switched on. It was proven that the above technique for marking the slide would not work with this BT because of the position of the slide carrier.

The cover was left open to keep the stylus raised while the temperature decreased. When a selected temperature was reached, the

stylus lowering lever was pressed, allowing the stylus to make a dot on the slide. This was done until a temperature of 0.5°C was reached. The slide was placed in the viewer and the 0.5°C mark aligned with 0.5°C on the grid and the other temperatures were read.

The linear regression calculations produced the following equations:

BT #WP64911 (Figure 1)

$$\text{Actual T (°F)} = 1.016 \times (\text{T read from BT slide}) - 0.548$$
$$r^2 = 0.99994$$

BT #DD11505 (Figure 2)

$$\text{Actual T (°C)} = 0.991 \times (\text{T read from BT slide}) - 0.037$$
$$r^2 = 0.99985$$

The results were plotted and the best fit line was drawn through the point.

3.0 DEPTH CALIBRATION

Both BT's were calibrated for depth at the same time in the pressure test vessel belonging to the Manufacturing and Technical Development Section of the Hydraulics Division. The pressure in the vessel was measured with a pressure gauge graduated in 1 psi increments. The BT's were mounted vertically in a frame which was lowered into the pressure vessel. A slide was placed into each BT and the covers were closed. The pressure was raised to simulate a depth. The pressure was then released and the slides were removed from the BT's. This procedure was repeated five more times, each time with a

higher pressure being applied. When this was completed, slides were placed in the BT's and they were lowered into the pressure vessel until the holding frame hit bottom. The water depth was measured to the pressure element in the BT. This depth was added to the depth calculated from the pressure in the vessel.

The slides were placed in their respective viewers and the depths were recorded. The calculated and corrected depths were plotted vs the depths read from the BT slides. The linear regression calculations produced the following equations:

BT #WP64911 (Figure 3)

$$\text{Actual Depth (FEET)} = 0.96 \times (\text{Depth read from BT slide}) - 4.00$$

$$r^2 = 0.9969$$

BT #DD11505 (Figure 4)

$$\text{Actual Depth (METERS)} = 0.96 \times (\text{Depth read from BT slide}) - 1.49$$

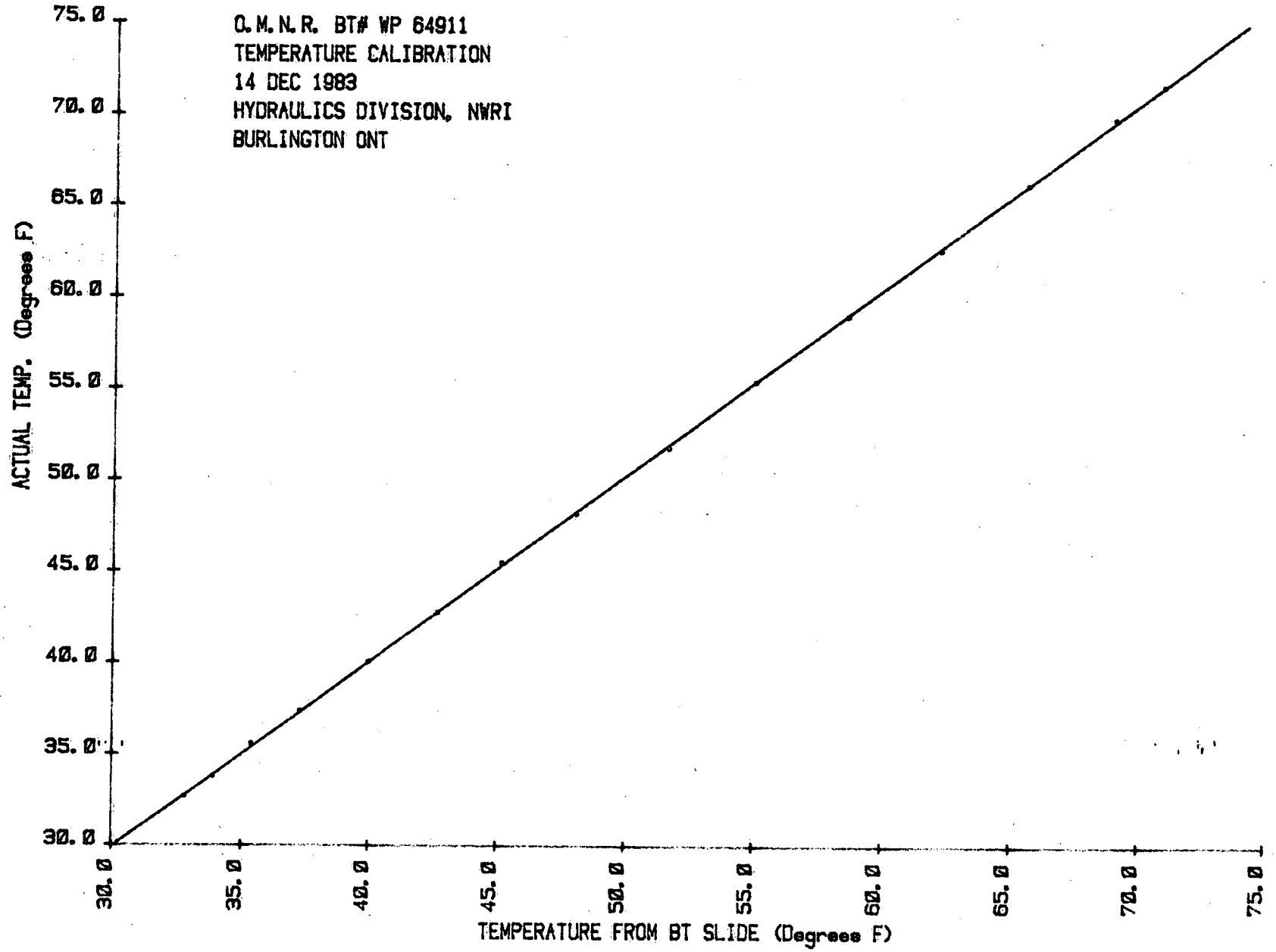

O.M.N.R. BT# WP 64911
TEMPERATURE CALIBRATION
14 DEC 1983
HYDRAULICS DIVISION, NWRI
BURLINGTON ONT
ACTUAL TEMP. (Degrees F)
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
TEMPERATURE FROM BT SLIDE (Degrees F)

Figure 1.

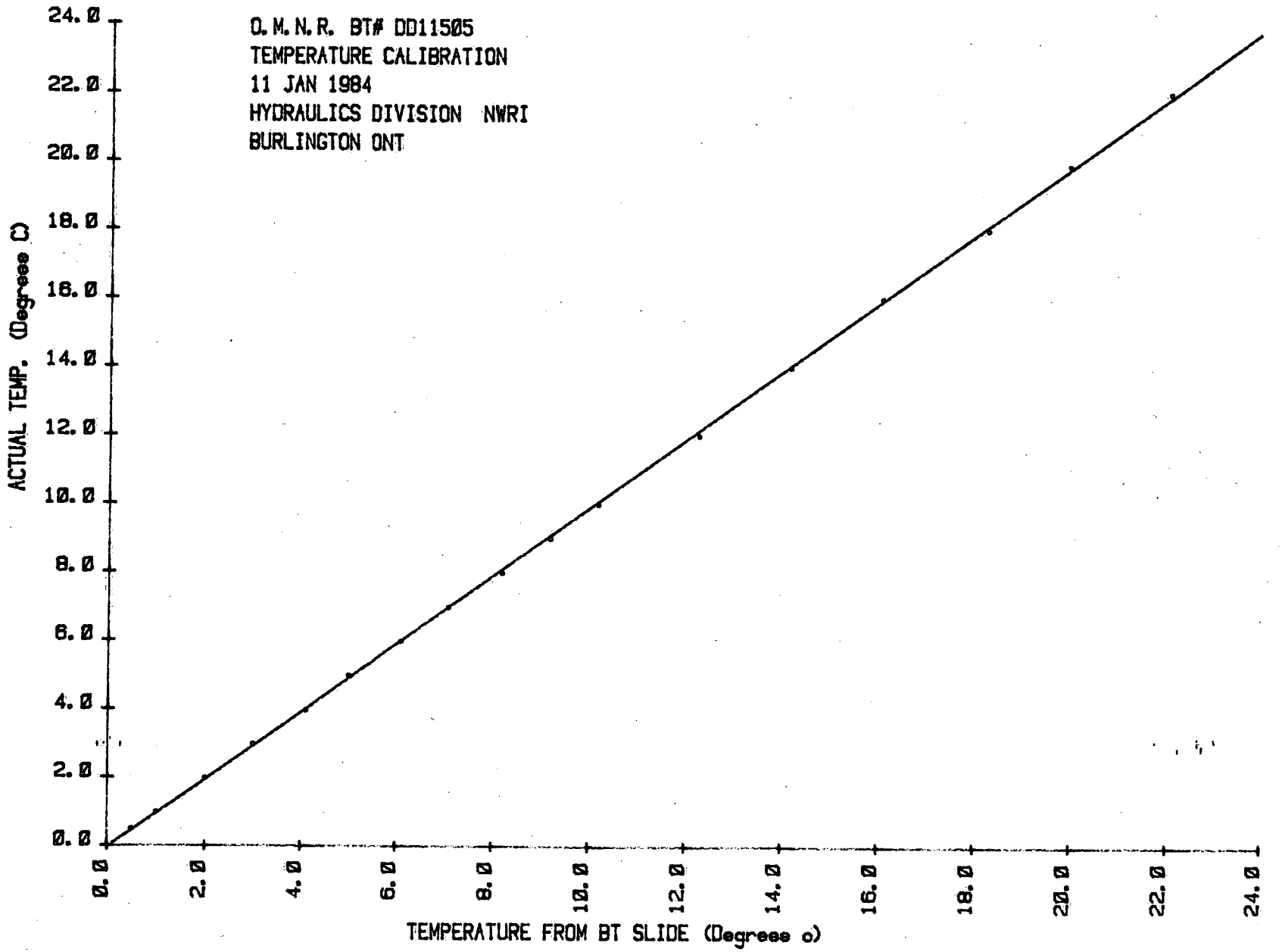

O.M.N.R. BT# DD11505
TEMPERATURE CALIBRATION
11 JAN 1984
HYDRAULICS DIVISION NWRI
BURLINGTON ONT
ACTUAL TEMP. (Degrees C)
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
TEMPERATURE FROM BT SLIDE (Degrees c)

Figure 2.

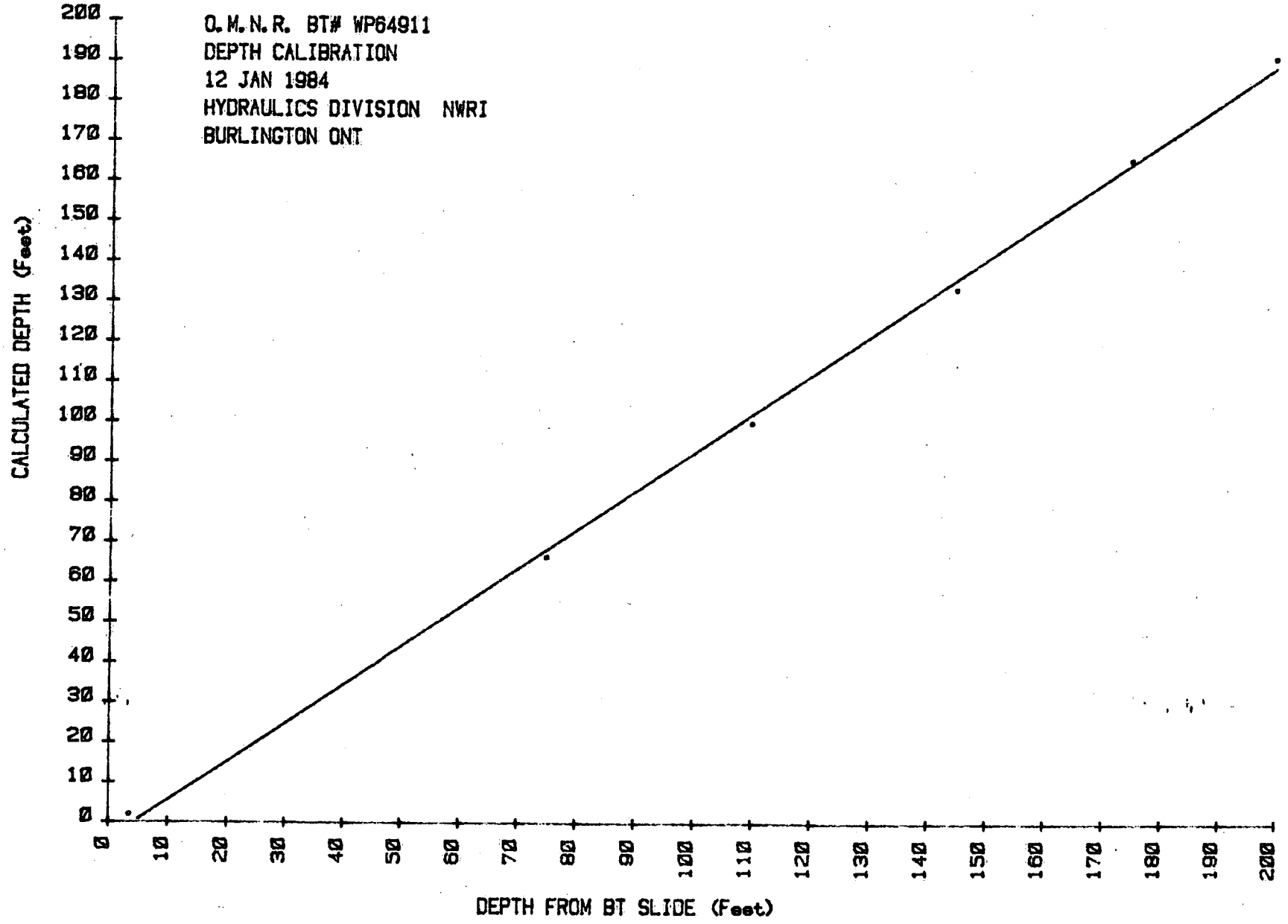

O.M.N.R. BT# WP64911
DEPTH CALIBRATION
12 JAN 1984
HYDRAULICS DIVISION NWRI
BURLINGTON ONT
CALCULATED DEPTH (Feet)
DEPTH FROM BT SLIDE (Feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200

Figure 3.

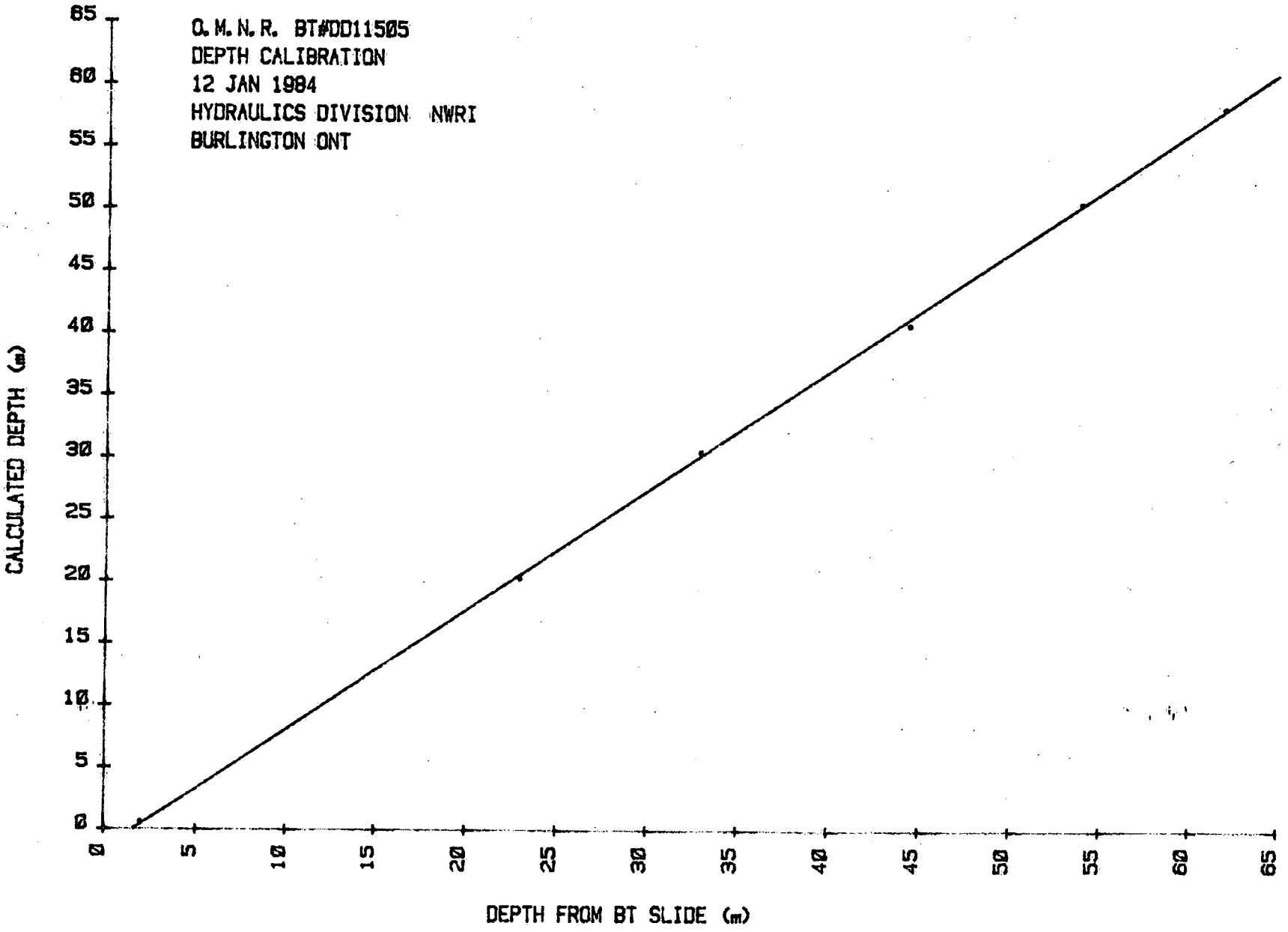
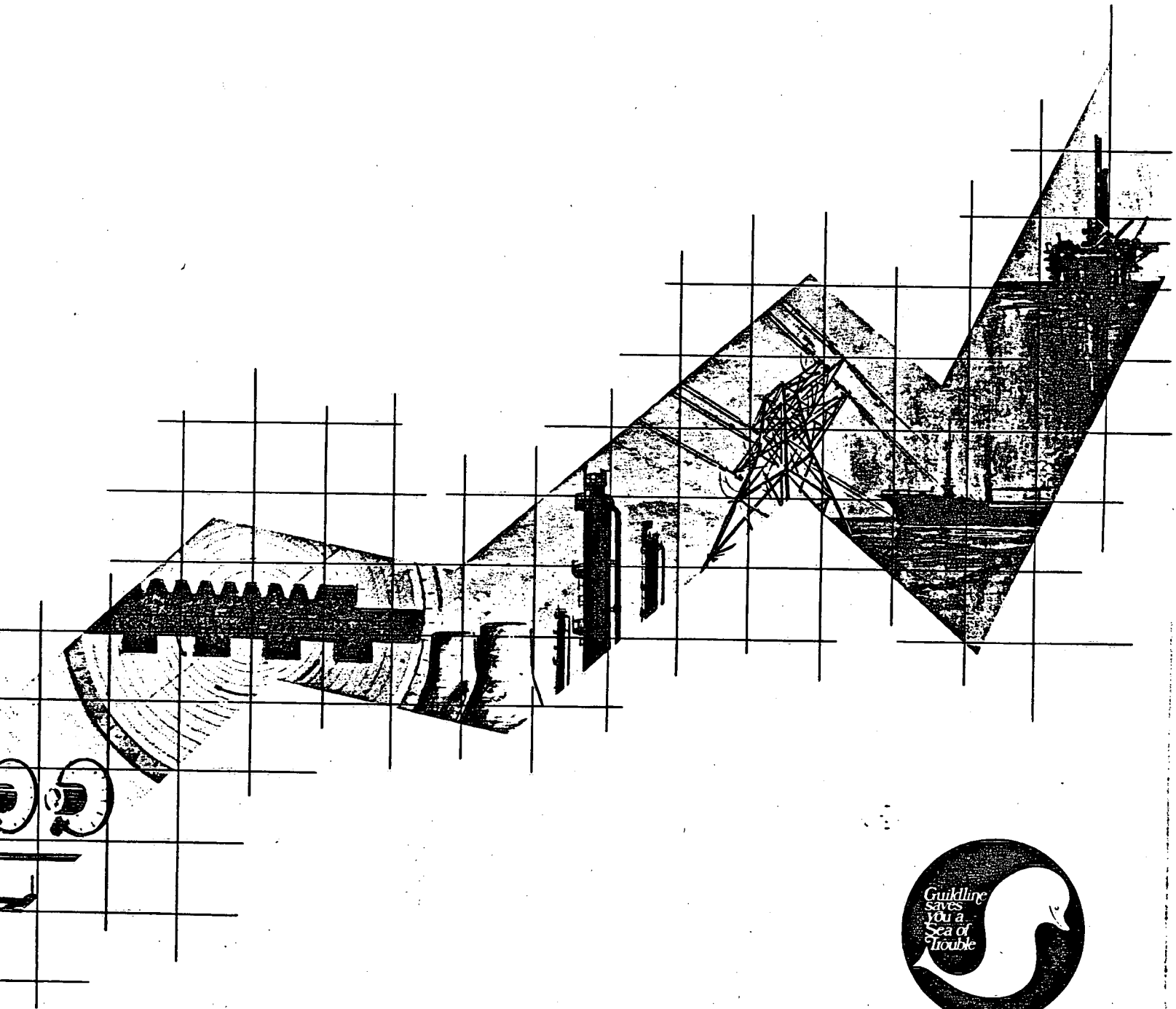

O.M.N.R. BT#DD11505
DEPTH CALIBRATION
12 JAN 1984
HYDRAULICS DIVISION NWRI
BURLINGTON ONT
CALCULATED DEPTH (m)
DEPTH FROM BT SLIDE (m)
0
5
10
15
20
25
30
35
40
45
50
55
60
65

Figure 4.

Guildline

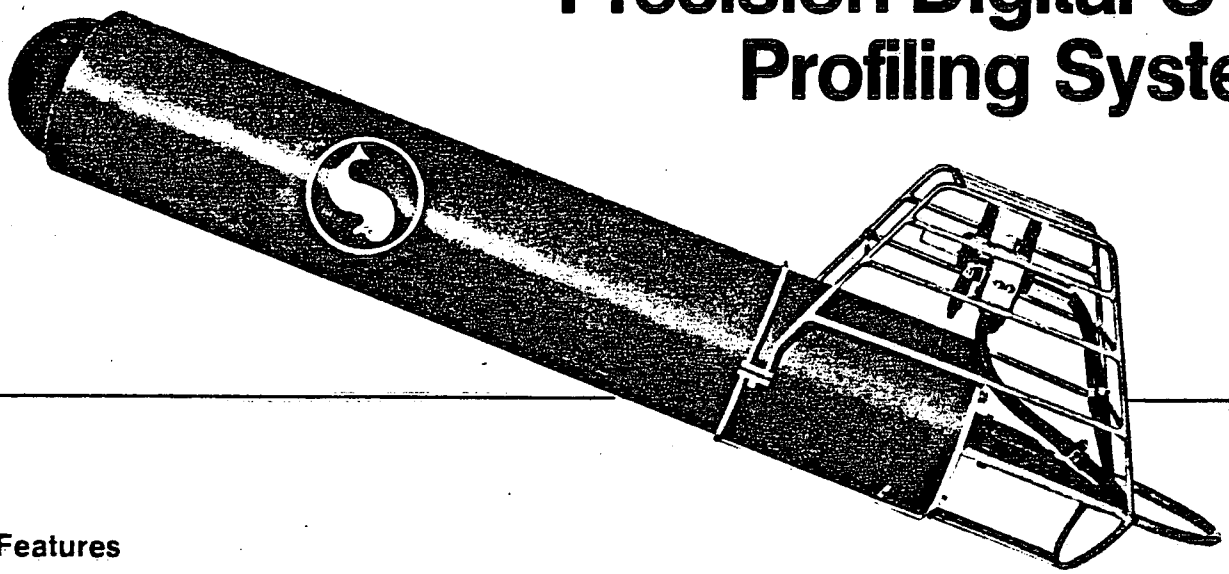
Oceanographic Instrumentation



Guildline saves you a Sea of Trouble

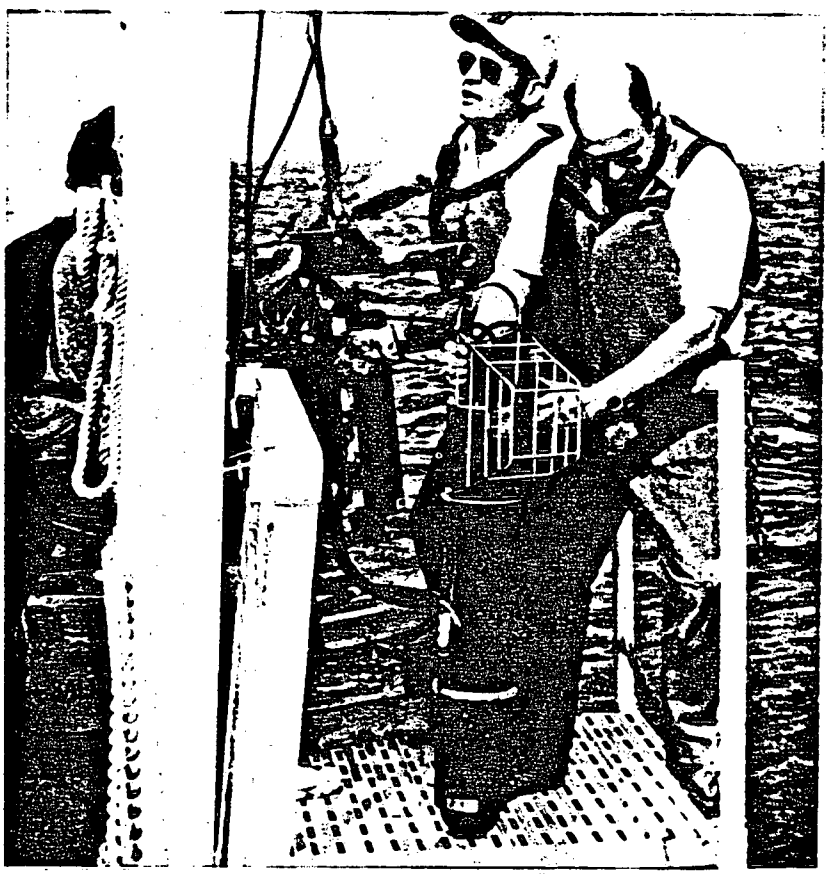
Guildline

Precision Digital CTD Profiling System



Features

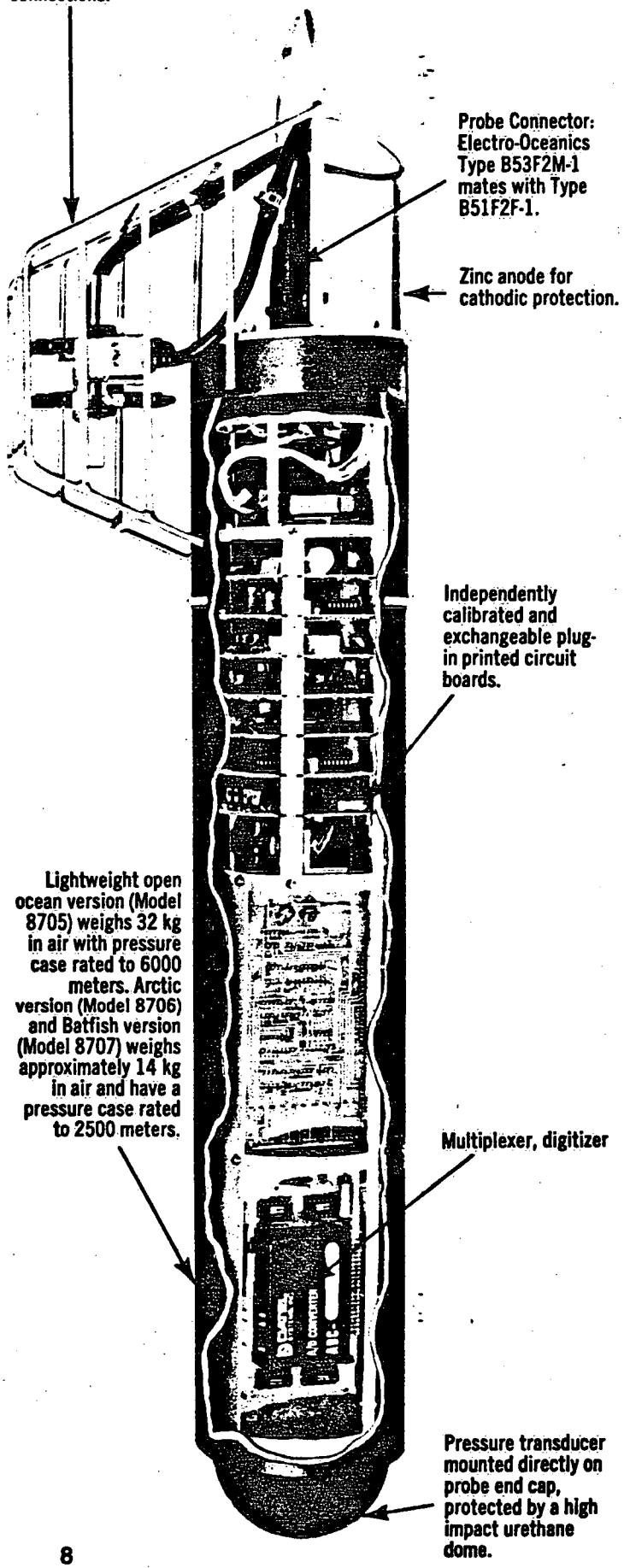
- Precalibrated, exchangeable plug-in sensors and printed circuit boards
- Sensor calibration independent of probe; can be replaced at sea without opening pressure case
- Fast response time: less than 50 milliseconds on all channels including sensor and electronics
- Data record/playback with low-cost audio cassette recorder
- Automatic error flag; system checked every cycle
- Analog output

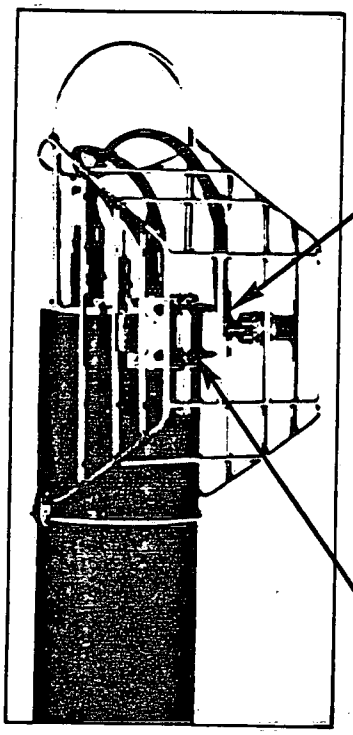


Designed for optimum reliability, ease of maintenance, integrity of data transmission and compatibility with conventional data acquisition equipment, the Guildline Model 8705 digital CTD represents the maximum performance/reliability combination possible with present technology.

The basic probe features independently calibrated and exchangeable plug-in printed circuit boards for easy maintenance, stainless steel cage for protection of T and C sensors and cable connectors, and a multiplexer accommodating eight extra channels for the addition of other sensors. For added versatility, the probe may be adapted for horizontal or hybrid profiling in towed bodies (Model 8707), as well as for use in Arctic studies in which a minimum diameter probe (Model 8706) is desirable for operating through a hole in ice. Both these configurations have lighter pressure cases suitable for depths to 2500 meters.

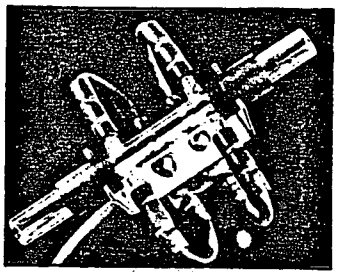
The Conductivity Sensor is a pre-calibrated, plug-in four-electrode cell. This unique sensor exhibits a negligible proximity or "area" effect normally associated with induction type cells. The Temperature Sensor is a pre-calibrated, plug-in copper resistance thermometer arranged in a four-terminal configuration. The Pressure Transducer is mounted directly on the probe end cap, protected by a high impact urethane dome. An optional Test and Calibration Kit (Model 87905) is available for use as a convenient method for checking the system performance ashore or at sea.

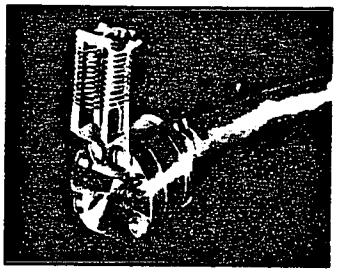


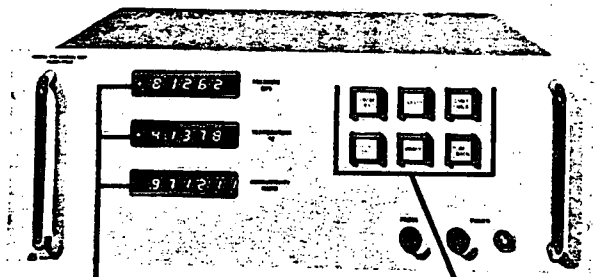


Temperature Sensor, pre-calibrated, plug-in, copper resistance thermometer arranged in a four terminal configuration.

Conductivity Sensor, pre-calibrated, plug-in, four electrode cell—This unique sensor exhibits a negligible proximity or "area" effect normally associated with induction type cells.







Readout: LED display of conductivity ratio, temperature in degrees Celsius, and pressure in percentage of full scale.

Controls: Push button, illuminated, POWER ON—OFF, PROBE ON—OFF, TEST RESET, ERROR flag indicator, tape PLAYBACK, and CABLE<100Ω.

The Model 87102 Control Unit for the system features illuminated push-button controls and an LED readout for display of conductivity ratio, temperature in degrees Celsius and pressure in percentage of full scale. As an option to considerably reduce equipment requirement aboard ship, a low-cost stereo cassette recorder and control unit can be connected to accept conditioned serial data from the deck unit. Upon completion of the cruise the recorder and control unit are taken ashore where the serial data are played back through the deck unit and converted to TTL compatible parallel binary code for digital data logging or use by an on-line computer. Guildline can supply suitable equipment to interface with the user's digital tape recorder and computer. If cassette tape playback is required in order to process data ashore or at sea while the control unit is in use for profiling, a combined playback/translator and interface package can also be supplied.

Specifications

MEASUREMENT RANGE AND ACCURACY:

PARAMETER	RANGE	ACCURACY	RESOLUTION
Conductivity Ratio	100ppm to 40ppt	±0.005ppt	0.001ppt
Temperature	−2°C to +30°C	±0.005°C	0.0005°C
Pressure	As selected to 6000 dbar	±0.25%FSP	0.01%FSP

Statement of Accuracy:

CONDUCTIVITY RATIO:
Expressed in Equivalent Salinity — Accuracy specified includes linearity, resolution, repeatability and calibration uncertainty relative to standard seawater.
STABILITY: 6 months . . . . . ±0.002ppt
TEMPERATURE:
Accuracy is as specified at the time of calibration and includes resolution, system linearity and repeatability (±0.003°C) plus calibration uncertainty relative to the "International Practical Temperature Scale of 1968" (±0.002°C).
STABILITY:
30 days . . . . . ±0.002°C reduced to zero by ice point recalibration
6 months . . . . ±0.005°C
PRESSURE:
Accuracy specified includes linearity, hysteresis, and temperature coefficient.

Response Time Constant: Less than 50msec. on all channels, including sensors and associated electronics.

Nominal Probe Drop Rate: Two meters per second.

Sensors:

CONDUCTIVITY
Four electrode cell, spatial resolution in vertical plane approximately 5cm — Nominal conductance is 10mmhos @ 35ppt, 15°C.
TEMPERATURE
Resistance thermometer consisting of a fine copper wire sensing element, encased in an oil-filled stainless steel capillary tube terminated in a four terminal configuration — Nominal ice point resistance is 46Ω.
PRESSURE
Strain gage transducer having an output of 2mv/v — Available in ranges to 6000 decibars, overrange capability 50%.

SIZE AND WEIGHT:

PROBE MODEL	DIMENSIONS DIAMETER-LENGTH	WEIGHT IN AIR
Open Ocean	15cm—113cm	32kg
Arctic	13cm—142cm	18kg
Batfish	13cm— 97cm	14kg

Cable Requirements: Single conductor, contra-wound double armor.

Probe Connector: Electro-Oceanics type B53F2M-1, mates with type B51F2F-1. Other connectors may be specified.

Slipring Requirements: Two section slipring assembly, Guildline Model 8600/2.

Control Unit: Supplied for standard 48cm rack mounting, 18cm high, 38cm deep with handles and anodized dust cover.

Front Panel: Separately illuminated push button switches for PROBE ON and PROBE OFF, POWER ON, RESET, ERROR flag indicator, CABLE <100Ω, PLAYBACK (for data playback of optional audio cassette feature) — Fuses for probe and line power.

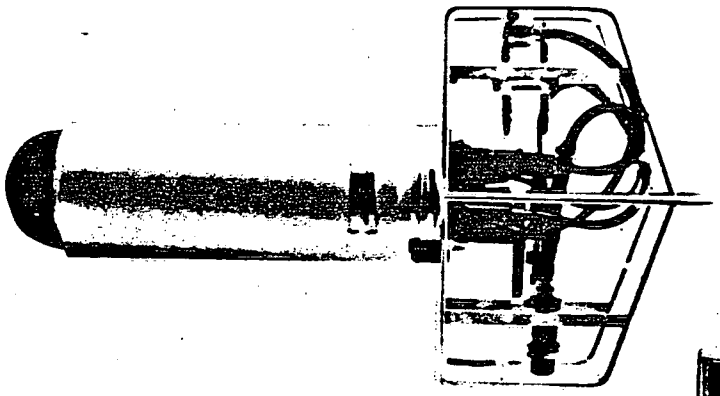
Display: Digital 0.63cm LED display for readout of conductivity ratio, temperature, and pressure — Update interval 120msec.

Rear Panel Connectors:
1. Analog outputs C, T, D.
2. Parallel binary output.
3. Tape recorder I/P and O/P.
4. Probe I/O.
5. Line power input.

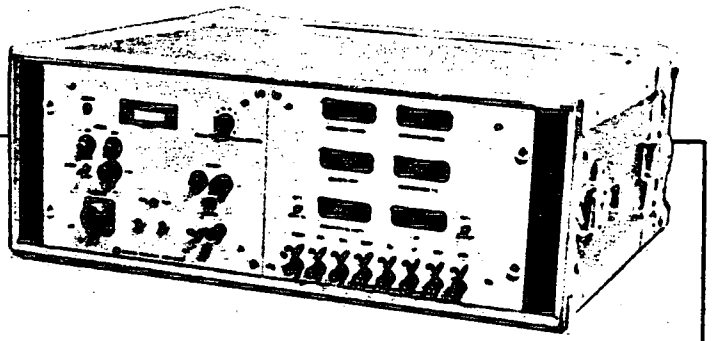
Output From Control Unit:

SERIAL:
2 channel (clock, data) TTL compatible for audio recorder — Message content in accordance with channel allocation.
PARALLEL:
TTL compatible 5 volt positive logic — Message content: 12 bit binary word, 4 bit channel address, 1 bit error flag, 1 bit read command 20μsec — A complete cycle for conductivity, temperature, and pressure consists of six messages; the first and second words of the measured parameter, plus channel address, error flag and read command for each word.
POWER TO PROBE:
270mA constant current at a compliance of 150V.
POWER REQUIREMENTS:
120 or 220V ±10% (switch selectable) 50/60Hz ±10%, approximately 200 watts.
Option 01
Three channel digital-to-analog convertor provides DC analog outputs of ±5 volts at 2ma for use with an XY, Y_2 chart recorder.
Option 02
Audio cassette tape record/playback feature provides separate clock and serial data outputs. Recorder included, complete with prerecorded test tape and three blank tapes.

Guildline

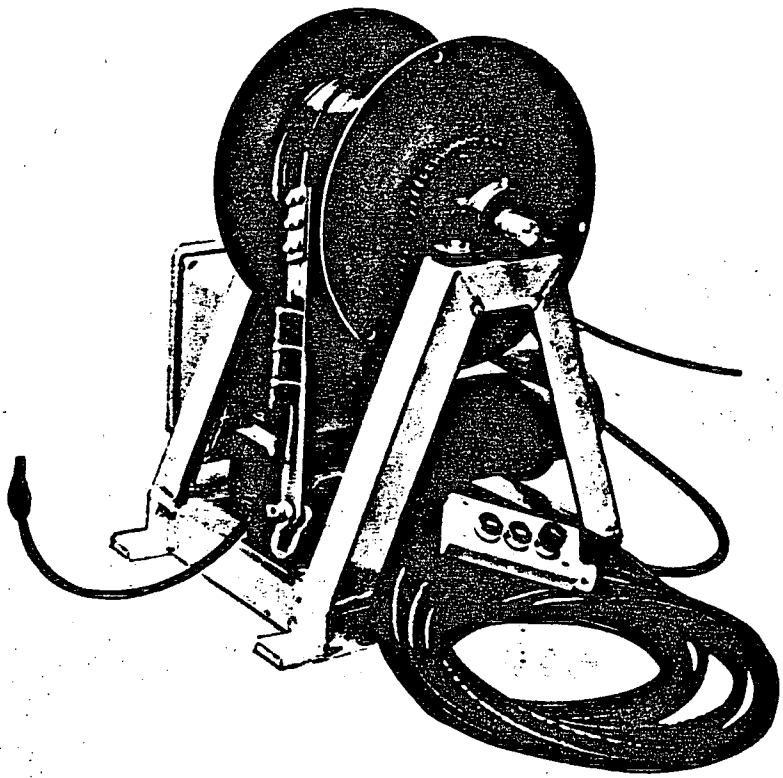


Portable CSTD System



Features

- Self contained in situ profiling system for measurement of conductivity, temperature and depth and optionally dissolved oxygen (DO) and pH.
- Lightweight and compact for ease of transport and deployment.
- Uses same sensors and measurement techniques as the precision Guildline CTD systems that have proven accurate and reliable over many years of field use.
- Plug-in sensors for ease of calibration and maintenance.
- Versatile—may be adapted for horizontal or hybrid profiling in towed bodies.
- Minimum cross section arctic version available for "thru the ice" studies.
- System is DC powered from 22-34V (two automobile type batteries) for maximum portability.
- Control unit has built in micro-processor capable of computing salinity, dissolved oxygen and pH.
- Analog output of all data standard on full control unit.
- IEEE 488 data output optionally available.
- Three system compatible winches available for various portable applications.



Probe Features

General

- Maximum operating depth 1000 meters.
- 316 stainless steel pressure case for maximum corrosion resistance.
- 8 channels available for acquisition and encoding of data.
- Maximum sampling rate is 22 channels per second for a CTD system — sampling rate reduced as additional parameters added.
- Data is encoded in 13 binary bits arranged for maximum parameter resolution.
- Start, stop and parity bits transmitted with each data channel used to check data integrity.
- Phase encoded transmission format yields high noise immunity.
- Spare card slot and uncommitted data channels built in for future system expansion.
- Calibration requires only simple zero and gain adjustments for each sensor in use.

Sensors

- All sensors plug-in external to the pressure case except for the pressure sensor which is internally mounted.

  Conductivity Sensor — 4 terminal electrode type in H configuration Pyrex glass cell.

  Temperature Sensor — 4 terminal copper resistance element in stainless steel capillary tube.

  Depth Sensor — strain gauge element in 4 arm resistance bridge configuration.

  Dissolved Oxygen Sensor (optional) — Beckman polargraphic membrane type with temperature compensating thermistor.

  pH Sensor (optional) — glass combination electrode type with built in reference junction.

Pressure Case

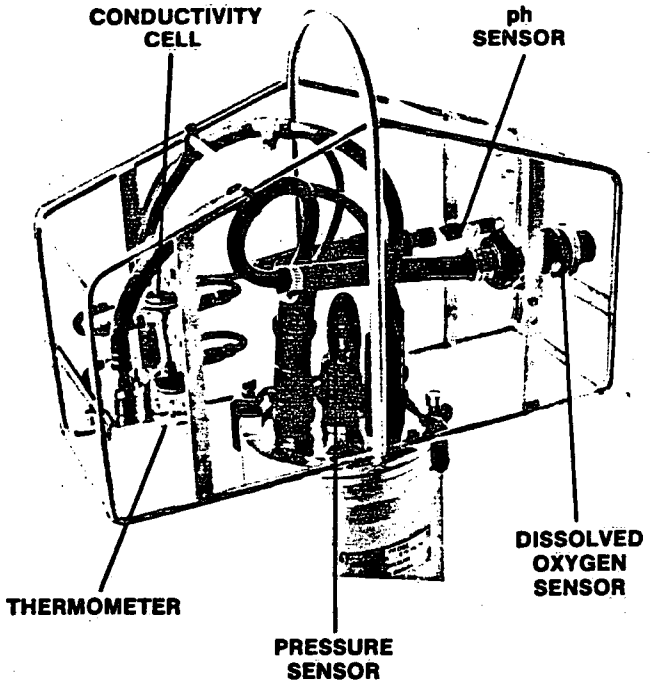
- The probe unit may be adapted to any of the following interchangeable configurations.

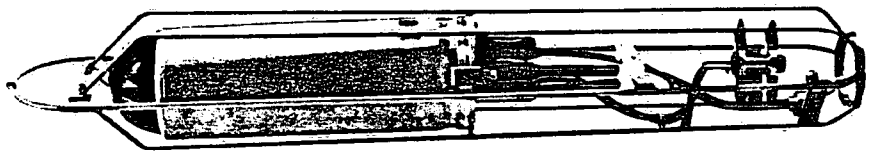
  Open Ocean Version — double winged stainless steel sensor cage. Sensors mounted clear of probe body to ensure undisturbed measurements. Bottom end of probe streamlined to increase stability while lowering.

  Batfish Version — pressure case has no sensor cage. For mounting inside towed bodies. Sensors are mounted to exterior of the towed body on suitable extension leads.

  Arctic Version — narrow elongated sensor cage designed for ease of deployment through a hole drilled in the ice.

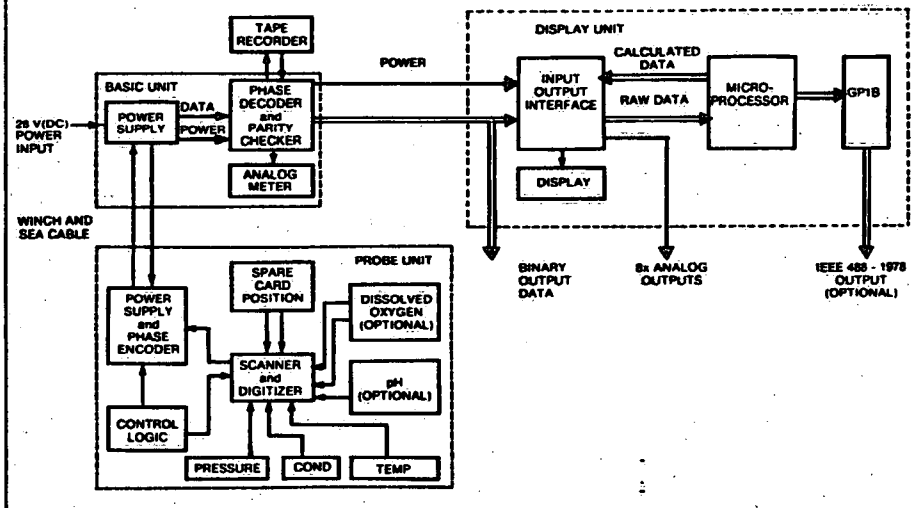
Probe





ARCTIC CONFIGURATION

System Block Diagram



CONTROL UNIT

Features

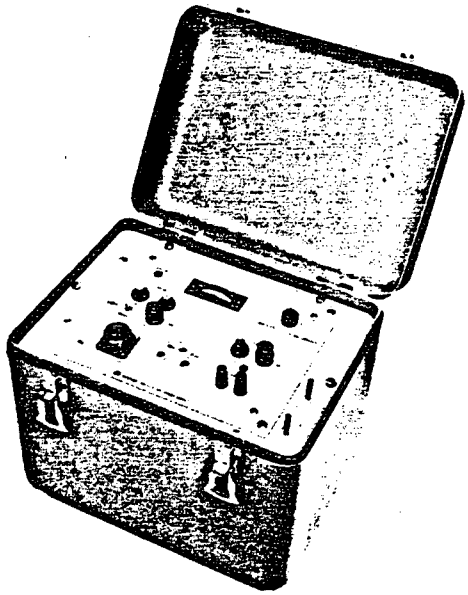
Basic Unit

- Provides operating power for the underwater probe.
- Safety circuit disconnects power when cable connections are broken.
- Receives and decodes the serially transmitted data from the probe.
- Records the data on an inexpensive single channel audio recorder (user supplied).
- Operates from a 22-34V DC power source—two automobile batteries in series.
- Monitors power to the probe and displays selected data on an analog meter for simple operational checks.
- Checks received data for validity and disables outputs if errors present.
- Provides binary output of all data to interface with companion display unit or external calculator/computer via appropriate interface.
- Housed in splash proof case for field use.

Full Unit

BASIC UNIT as above plus following:

- Displays all data as received by the basic control unit from the probe or tape recorder.
- Converts the binary C,T,D, data to decimal values.
- Built-in microprocessor calculates and displays salinity, dissolved oxygen and pH.
- Provides Analog outputs of all probe and calculated data for use with a strip chart or XY type recorder.
- Power up routine provides fixed display numbers and analog outputs for easy set-up of chart recorders.
- Optional IEEE 488 output of all data available.
- Unit will mount in 19 inch rack when transit case removed.



Basic Control Unit in Splash Proof Case

WINCH

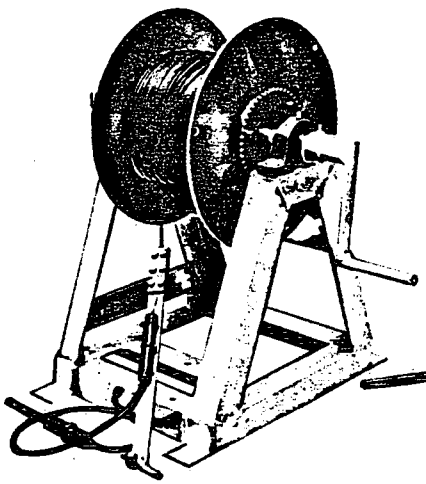
Features

Hand Crank Unit

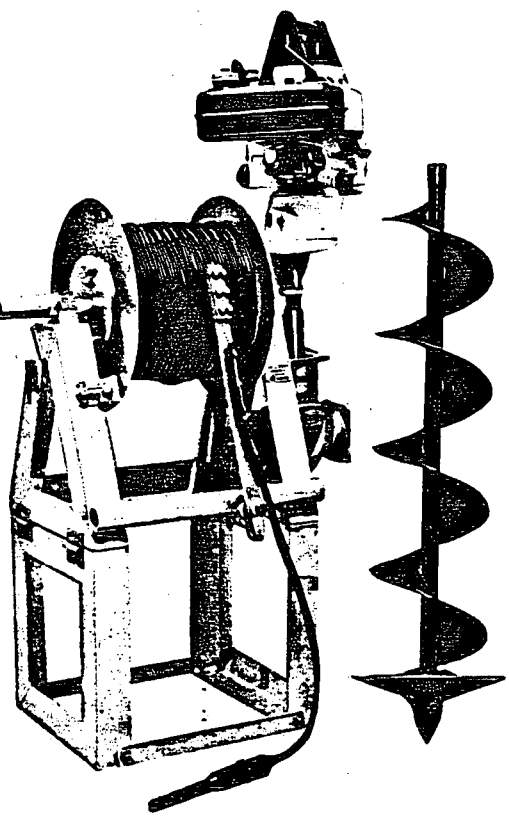
- Lightweight and compact for ease of transport
- Direct drive removable hand crank stores inside frame during transport
- Supplied with 350 metres of single conductor armoured oceanographic cable
- Cable is mechanically and electrically terminated at both ends for use with the CTD Probe
- 3.6mm cable has 590 kg breaking strength
- Built-in high reliability slip rings — designed for ease of maintenance or replacement
- Locking pin provided to secure drum in a fixed position
- Maximum safe working load — 45 kg.

Motor Drive Unit

- Same features as above with the addition of a reversible 12/24 Volts DC motor drive
- Remote control of cable direction (up/down) and speed (0.35m/s or 0.7m/s) via hand control on a 10 metre extension cable



Hand Crank Winch



Arctic Winch

Arctic Unit

- Uses a gasoline ice auger motor (user supplied) as the power source to wind the cable in the "up" direction
- Bottom frame portion folds inwards to reduce overall transporting size

Parameter Specifications

Parameter	Range	Accuracy — 180 Days (see Note 3)	Display Resolution (Front Panel)	Scale Value Lowest Significant Bit (Binary Data Buss)	Response Time
Depth (Pressure)	0-1000 dbar 0-500 dbar 0-200 dbar	Linearity ±5% Hysteresis ±25% Zero Offset ±1% Sensitivity Error ±1% (see Note 5)	0.1 dbar	0.123 dbar	<1 msec
Temp	−3 to 38.99°C	±0.02°C	0.01°C	0.00512°C	60 msec
Conductivity Ratio	0.0010 to 1.600	±0.0004	0.0002	0.000195	60 msec
Salinity Calculated	0.10 to 40 ppt	±0.04 ppt	0.01 ppt	N/A * (see Note 1)	—
p.H.	6 to 9 2 to 12	±0.05 ±0.1	0.01	0.002 @ 20°C (see Note 1)	30 sec to 90% of final value for a 6 pH or 10°C change −5 sec to 90% of final value for a change in Oxygen only −3 min to 50% of final value for a 10°C change in temp. −10 min to 90% of final value for a 10°C change in temp.
DO Sensor Current	0.1 nA to 1.0 μA	±0.02 μA (see Note 3)	0.01% F.S. (see Note 2)	0.122 nA	
DO Sensor Temp	−5 to +40°C	±0.2°C (see Note 3)	0.01% F.S. (see Note 2)	.0045 to .0067°C (see Note 4)	
Diss. Oxygen Calculated	0-15 ppm (mg/l)	±0.5 ppm (see Note 3)	0.01 ppm	N/A (see Note 1)	

Notes: (1) Calculated parameter outputs available only with IEEE 488 O/P option.
(2) Front Panel Display can be selected to display % of Full Scale for DO current and Temp. in place of Calculated DO and Conductivity Ratio and also % F.S. in place of p.H.
(3) Dissolved Oxygen accuracy specified for 90 days only — warranty on sensor also 90 days.
(4) Oxygen Sensor uses thermistor for temperature measurement — relationship is non-linear.
(5) Zero offset and sensitivity error are nulled at 20°C during calibration.

Mechanical Specifications

UNIT	LENGTH	WIDTH	HEIGHT	WEIGHT
PROBE				
Standard	73cm	14cm (dia) 37cm (across cage)		16.0 kg (9.3 kg in water)
Batfish	56cm	14cm (dia)		14.5 kg
Arctic	105cm	19cm (dia)		19.1 kg
CONTROL UNIT				
Basic	30.5cm	23cm	32cm	5.9 kg
Full	47cm	57.2cm	21.6cm	10.5 kg (w/transit case)
WINCH				
Hand crank	45.7cm	50.8cm	61cm	30 kg
Motor drive	56.8cm	50.8cm	61cm	57 kg (w/cables)
Arctic	53.4cm	35.6cm	91.5cm (with crank) 46cm (stored)	34 kg

Environmental Specifications

UNIT	TEMPERATURE RANGE	
	OPERATING	STORAGE
PROBE	-3°C to +39°C	−40°C to +70°C
CONTROL UNIT	-0°C to +39°C	−40°C to +70°C
WINCHES		
Hand Crank and Motor Drive	-20°C to +40°C	−40°C to +70°C
Arctic	-40°C to +40°C	
NOTE: SYSTEM WARM-UP TIME — 5 MINUTES		

Power Requirements

Probe with basic control unit	22-34V DC @ 2 Amps (nominal).
Probe with full control unit	22-34V DC @ 3 Amps (nominal).
Motor drive winch	12/24V @ 30 Amps. continuous at full load (45 kg.)

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GUILDLINE INSTRUMENTS

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