FORD

ENVIRONMENTAL MEASURING SYSTEMS

RECENTLY PROTOTYPED BY STAFF OF
THE ENGINEERING SERVICES SECTION,
NATIONAL WATER RESEARCH INSTITUTE
FOR LIMNOLOGICAL AND OTHER WATER
RESEARCH STUDIES
ES - 515

J.S. FORD, HEAD
ENGINEERING SERVICES SECTION

RI/IWD

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ENGINEERING SERVICES AT THE CANADA CENTRE FOR INLAND WATERS

1978

INTRODUCTION

The Engineering Services Section of the Scientific Support Division serves all divisions and agencies at the Canada Centre for Inland Waters as well as detachments of Inland Waters Directorate in various regions of Canada. These services include the design, development, consultation, evaluation, specification, calibration and maintenance of a wide variety of systems used to sample or measure environmental variables and to process, record and display the variables.

The engineering problems involved often require innovative solutions because of the scientific, environmental and operational constraints which apply. To prevent duplication and to be cost-effective, much of the engineering effort is applied to evaluating, adapting and improving commercially available technology for the task at hand. When novel approaches are required, and the goals are transferable and finite, development is normally contracted. Should a suitable supplier not be available, or should the initial development require complicated interaction amongst study team members, development may be undertaken within the Section.

The Engineering Services Section has 9 professional and 20 technical and trades staff members. When necessary, additional personnel are employed under contract for specific activities or the occasional term employee may be hired.

This is the fourth report in a series which reports the accomplishments finished in 1978. See also the unpublished reports of the same or similar title numbered ES-510, ES-512 and ES-514.

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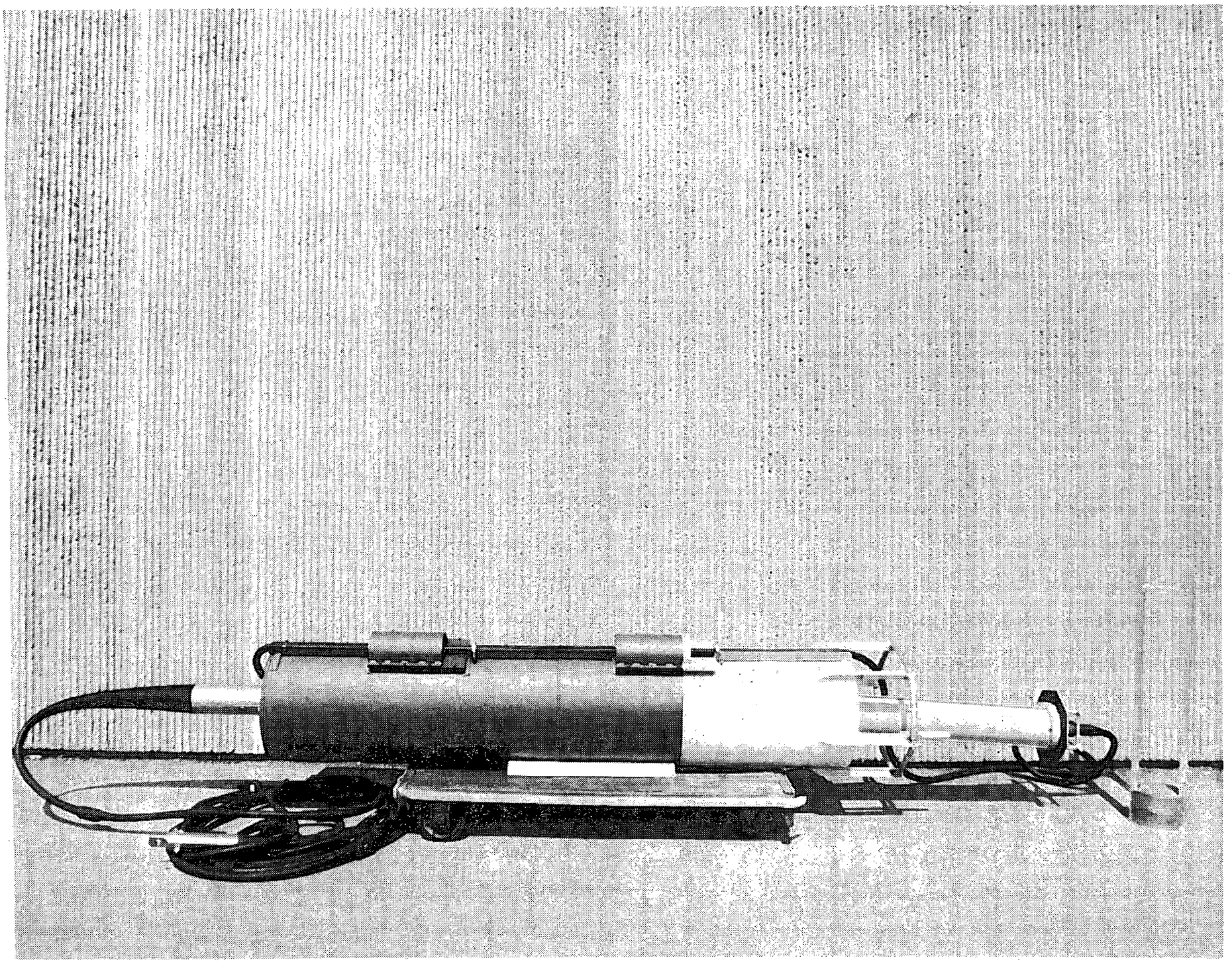


BUOY TO SUPPORT FTP CABLES

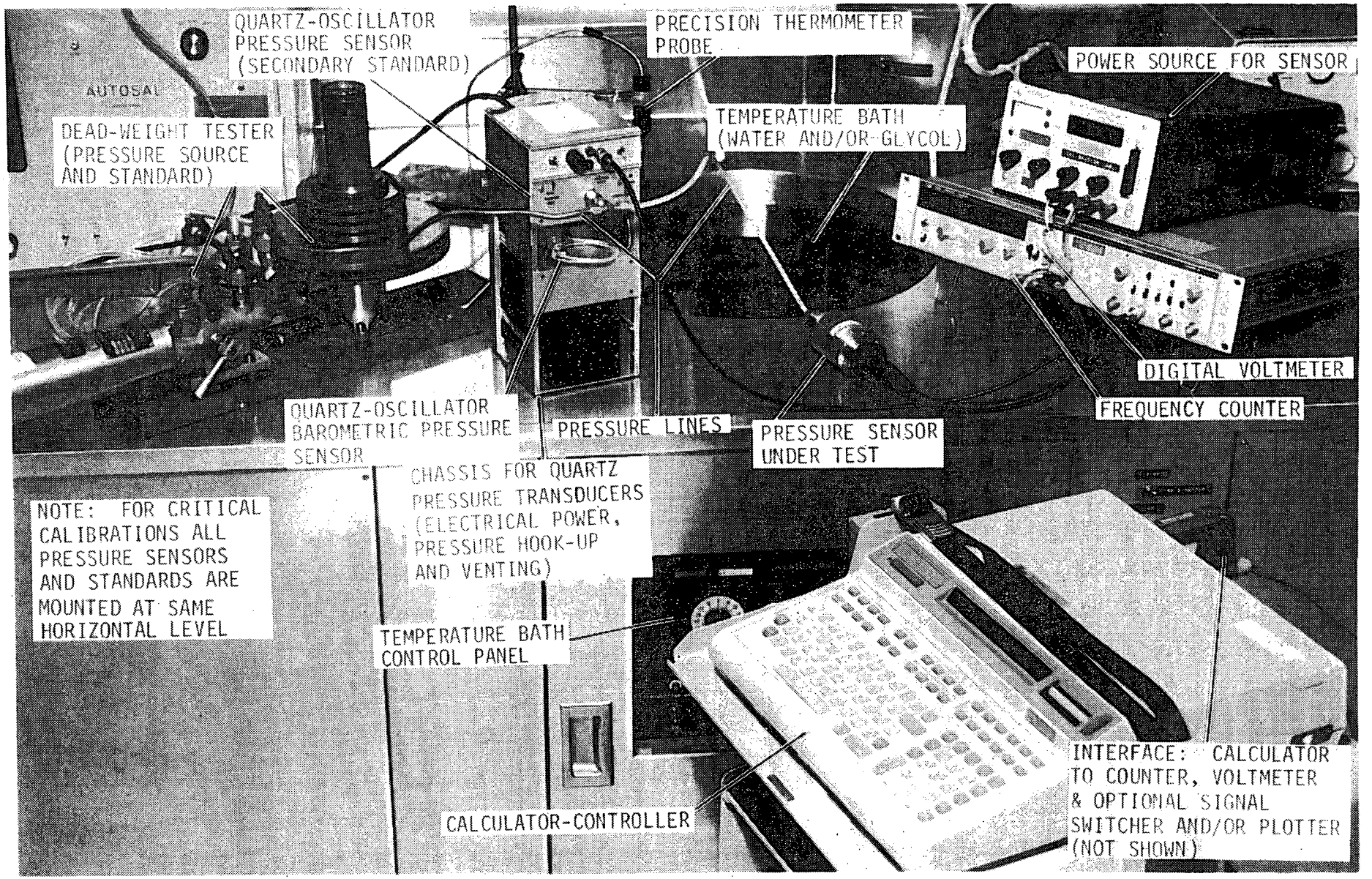
The Fixed Temperature Profiler (FTP) which is a heavy, electromechanical cable and a data logging system, has been supported in the water column by a fibreglass Nun buoy. This buoy is both heavy and susceptible to handling damage. Extensive repairs are required each year.

A new buoy has been designed specifically for the FTP system. It consists of two concentric aluminum tubes welded together. The annular space between the tubes is filled with low density urethane foam. The central tube houses the logger. Lead weights are placed at the bottom of the inner tube to adjust the buoyancy to suit the weight of the various lengths of the cable.

The mounting of the cable to the base of the buoy has also been modified to give increased reliability through avoiding chafing and fatigue of the cables.

SPECIFICATIONS

Maximum buoyancy	1.5 kN/m displacement, 2.7 kN at design water line
Diameter outside	49.5 cm
Diameter inside	22.8 cm
Overall length	2.4 m
Mass	136 kg
Accessories	Ballast wts. 133.5 N each


QUARTZ-OSCILLATOR PRESSURE SENSOR (SECONDARY STANDARD)
PRECISION THERMOMETER PROBE
POWER SOURCE FOR SENSOR
AUTOSAL
DEAD-WEIGHT TESTER (PRESSURE SOURCE AND STANDARD)
TEMPERATURE BATH (WATER AND/OR GLYCOL)
DIGITAL VOLTMETER
FREQUENCY COUNTER
QUARTZ-OSCILLATOR BAROMETRIC PRESSURE SENSOR
PRESSURE LINES
PRESSURE SENSOR UNDER TEST
CHASSIS FOR QUARTZ PRESSURE TRANSDUCERS (ELECTRICAL POWER, PRESSURE HOOK-UP AND VENTING)
NOTE: FOR CRITICAL CALIBRATIONS ALL PRESSURE SENSORS AND STANDARDS ARE MOUNTED AT SAME HORIZONTAL LEVEL
TEMPERATURE BATH CONTROL PANEL
INTERFACE: CALCULATOR TO COUNTER, VOLTMETER & OPTIONAL SIGNAL SWITCHER AND/OR PLOTTER (NOT SHOWN)
CALCULATOR-CONTROLLER

CALCULATOR AIDED CALIBRATIONS

Accurate pressure calibrations are important in accurately measuring water depths. There are many pressure transducers used in this way at CCIW.

The NWRI pressure calibration system uses a pneumatic and a hydraulic dead-weight tester for basic standards. A digital quartz pressure transducer provides readings from the test pressure line, while another provides barometric pressure readings. These transducers have carrier frequency outputs which are amenable to frequency counting techniques. Therefore, they have outstanding sensitivity and resolution in calibration measurements. Accuracy, however, is set by the dead-weight testers.

Calculator programs were written to convert the quartz transducer frequency outputs to some commonly used pressure units such as "depth in metres in fresh (or salt) water". Before each test run, another program standardizes the frequency/pressure conversion coefficients to match the dead-weight output. The redundancy available with two pressure measuring devices gives increased confidence in the validity of pressure calibrations. Automatic reading provides rapid measurement and display of many more points than was normal for previous methods.

SPECIFICATIONS

TRANSDUCER/TESTER	PRESSURE RANGE kPa / METRES OF WATER	PRESSURE ACCURACY	RESOLUTION
Pneumatic Dead-Weight Tester Model	0.7 - 690 kPa ga. 0.07 - 70 m	.025%	0.07 m
Hydraulic Dead-Weight Tester Model	34 - 4137 kPa ga. 3.5 - 422 m 35 - 4220 m 343 - 41 370 kPa ga.	0.025%	3.5 m
Digiquartz Barometric Pressure Sensor	0 - 103.4 kPa abs.	0.025%	0.01%
Digiquartz Pressure Sensor	0 - 633 m 0 - 6206 kPa ga.	0.025%	0.01%

CASETTE TAPE TRANSCRIBER FOR FIELD DATA

A system has been integrated to transcribe Sea Data formatted casettes. It is capable of reading tapes from any Sea Data Logger. This logger produces a high density, data recording on a casette magentic tape. It is highly suitable for unattended operation in the field.

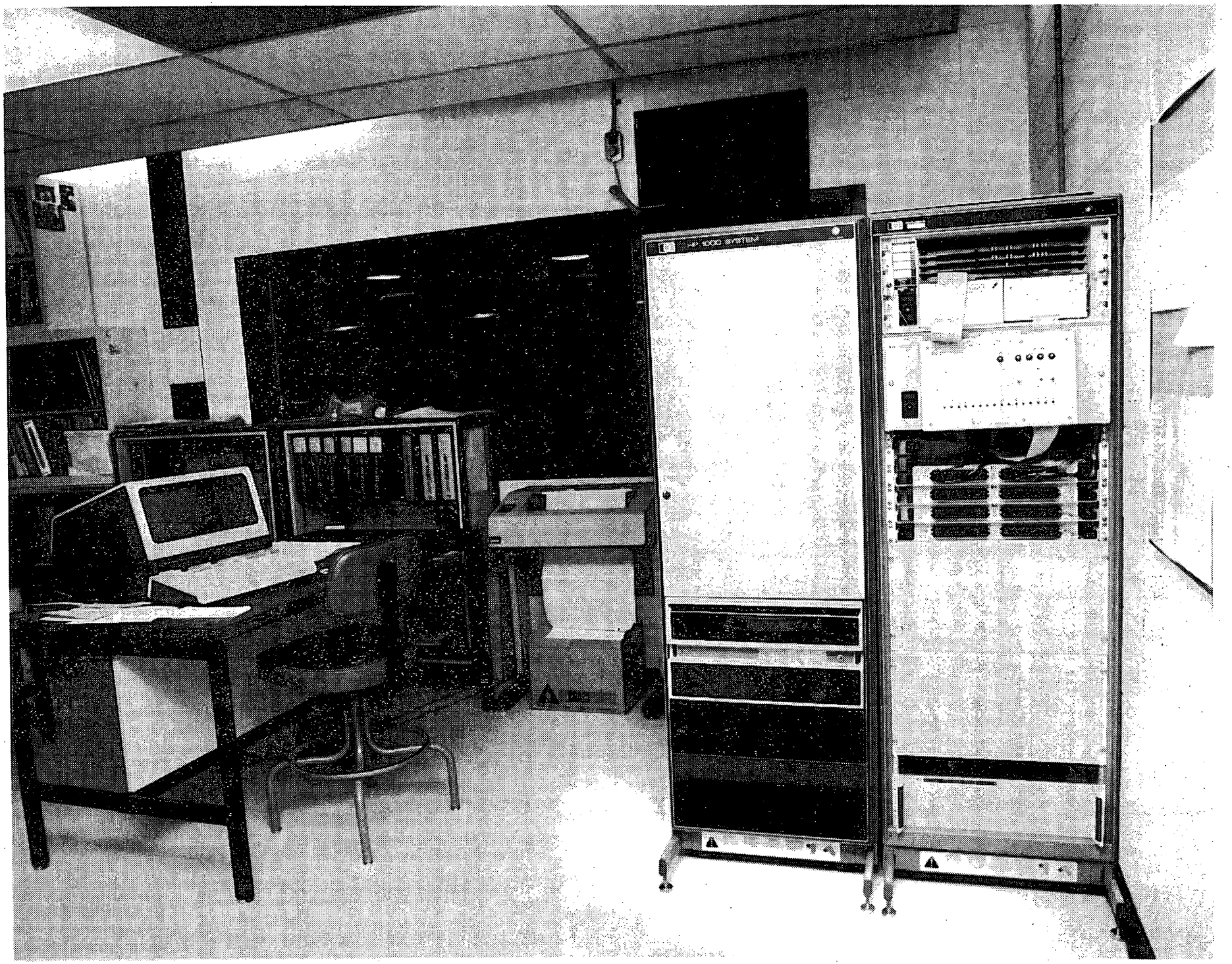
The resulting, half-inch, magnetic tape is compatible with the CCIW computer facility.

SPECIFICATIONS

Sea Data Model 12A	Reader
Speed	7½ IPS; or 7500 4-bit characters/sec.
Errors	Detects and flags short records, parity errors, file gaps, and drop outs.
Controls	level set for each of 4 tracks blocking factor for output records continuous, & file read modes backspace, rewind and stop manual EOF and buffer padding.
Other	2 output interfaces Magtape or Computer. Serial output for real time display on a bit box.

Kennedy Magtape/Reformatter

Dual buffered (1024 bytes/buffer) 7 track 45 IPS system with 10½ inch reel capacity.



COMPUTER FOR PILOT PLANT STUDIES OF WASTEWATER TREATMENT

After consultation with Engineering Services Section, amongst others, a computer system has been installed in the Wastewater Technology Centre of CCIW. It is a general-purpose, real-time system to be used for monitoring and direct control of sewage treatment processes in a pilot plant environment. The control aspect will involve some degree of process modelling with the system. Eventually, two or more processes may be controlled simultaneously.

The input, output capabilities of this system are controlled by an intelligent microprocessor subsystem which offloads the minicomputer. This controller is IEEE bus compatible for standardized instrument interfacing.

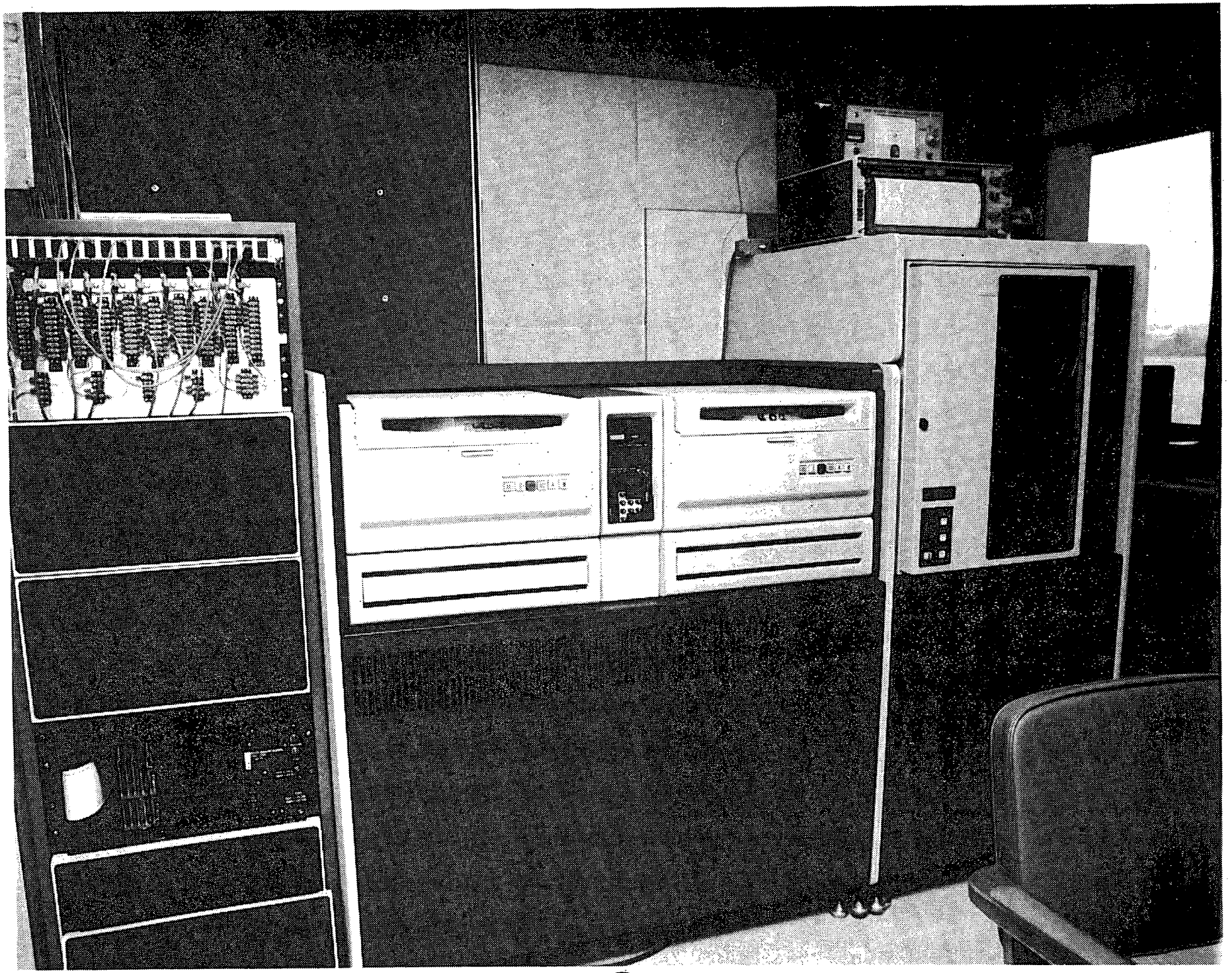
SPECIFICATIONS

Microprocessor Subsystem:

Inputs	16 differential analog ± 10 V F.S. (signal conditioning allows 4-20 mA inputs) 32 TTL/CMOS digital inputs 16 optically isolated event sense inputs
Outputs	16 TTL/CMOS digital outputs 16 relay closure outputs (Form C) 8 analog outputs

Computer Subsystem:

HP 1000 system includes	4.9 M byte disc 32768 words of memory HP 2113 minicomputer HP 2648 buffered graphics CRT HP 2631 line printer RTE-II operating system FORTRAN ALGOL and assembler



COMPUTER HARDWARE SYSTEMS FOR CHEMICAL LABORATORY AUTOMATION

A minicomputer based system has been installed to acquire, process, store and report analytical results from over 375,000 chemical analyses each year done at C.C.I.W. These results are produced by a selection of analytical lab equipment, including autoanalyzers, atomic absorption spectrophotometers, gas chromatographs. A total complement of 30 instruments is connected to the computer for direct data acquisition. Manual entry of results is done through many computer terminals. A relatively simple system architecture is created through serial digital data transmission techniques for all but four instruments. Standardized connectors in each lab allow mobility of both computer terminals and instruments. Presently 13 computer terminals allow users to access the computer for data updates and synopses. The system carries the acronym AWQUALABS for Automated Water Quality Analytical Laboratory Systems.

SPECIFICATIONS

COMPUTER SYSTEM

Digital Equipment PDP-11/60 minicomputer with 253952 bytes of MOS memory, integral cache memory, integral floating point with error correction and battery back-up firmware, and multi-device bootstrap loader.

MASS STORAGE

Two disk drives each with 13.89 million bytes of storage and a 9 track, 45 IPS magnetic tape drive.

COMMUNICATIONS

32 serial digital asynchronous communications ports, allowing full duplex ASC II dialogue between the PDP 11/60 and instruments or terminals with isolated, 20 mA, passive interface ports.

HARDCOPY OUTPUT

Printed reports are available on either a 180 char.sec printer (LA 180) or a 120 char./sec DECWRITER terminal.

TERMINALS

CRT screen display with alphanumeric key board (qty. 11).

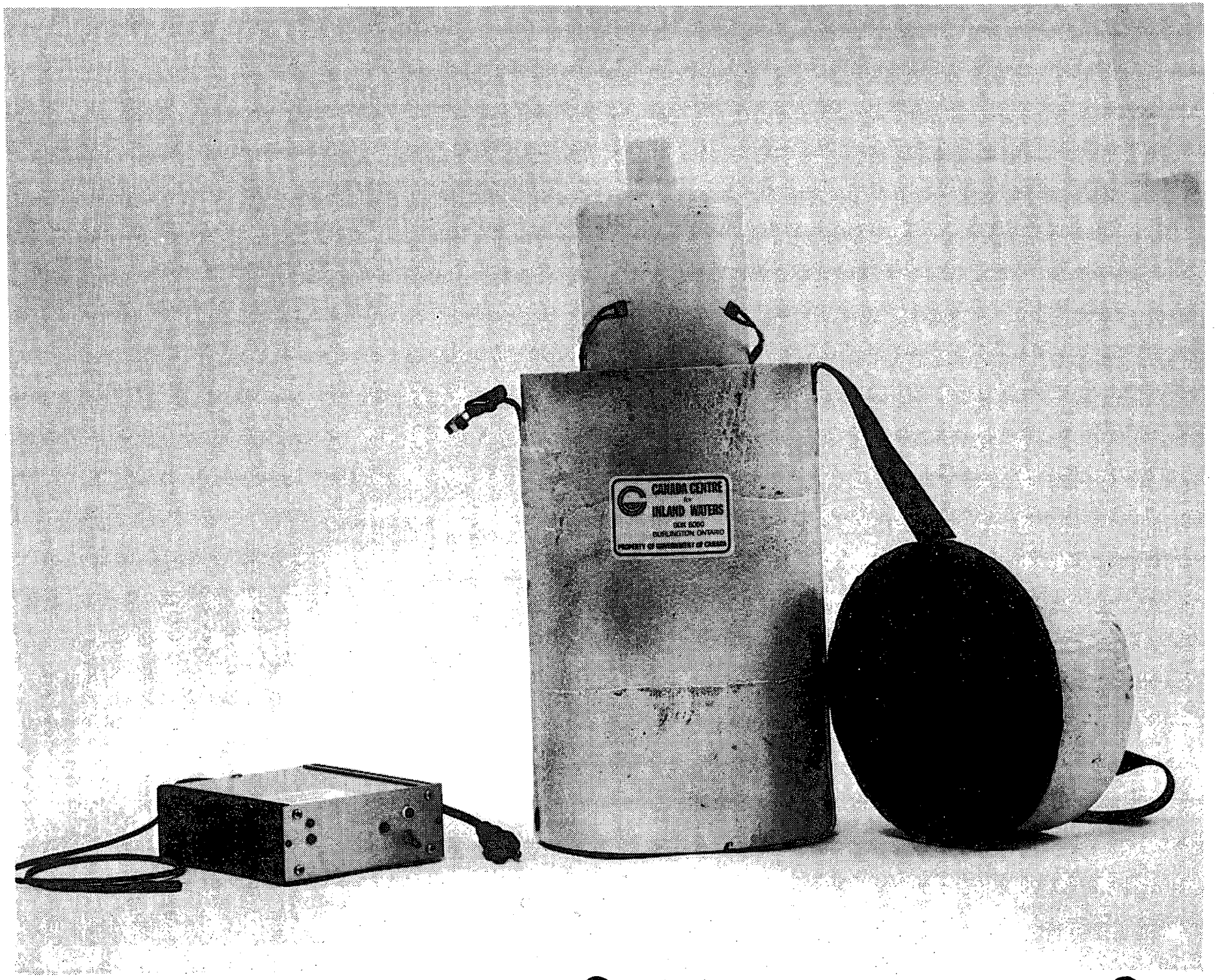
BAR CODE READERS

Digital data can be entered directly into the data bank from adhesive labels and badges to minimise tedium and error.

OTHER INPUT/OUTPUT

An analog and digital input/output subsystem (ICS) handles the six analog inputs from the four non digital instruments.

A communications patch panel allows eight alternate data channels to be used instead of ones normally connected, thus bringing the total allowable number of terminals and instruments to 40.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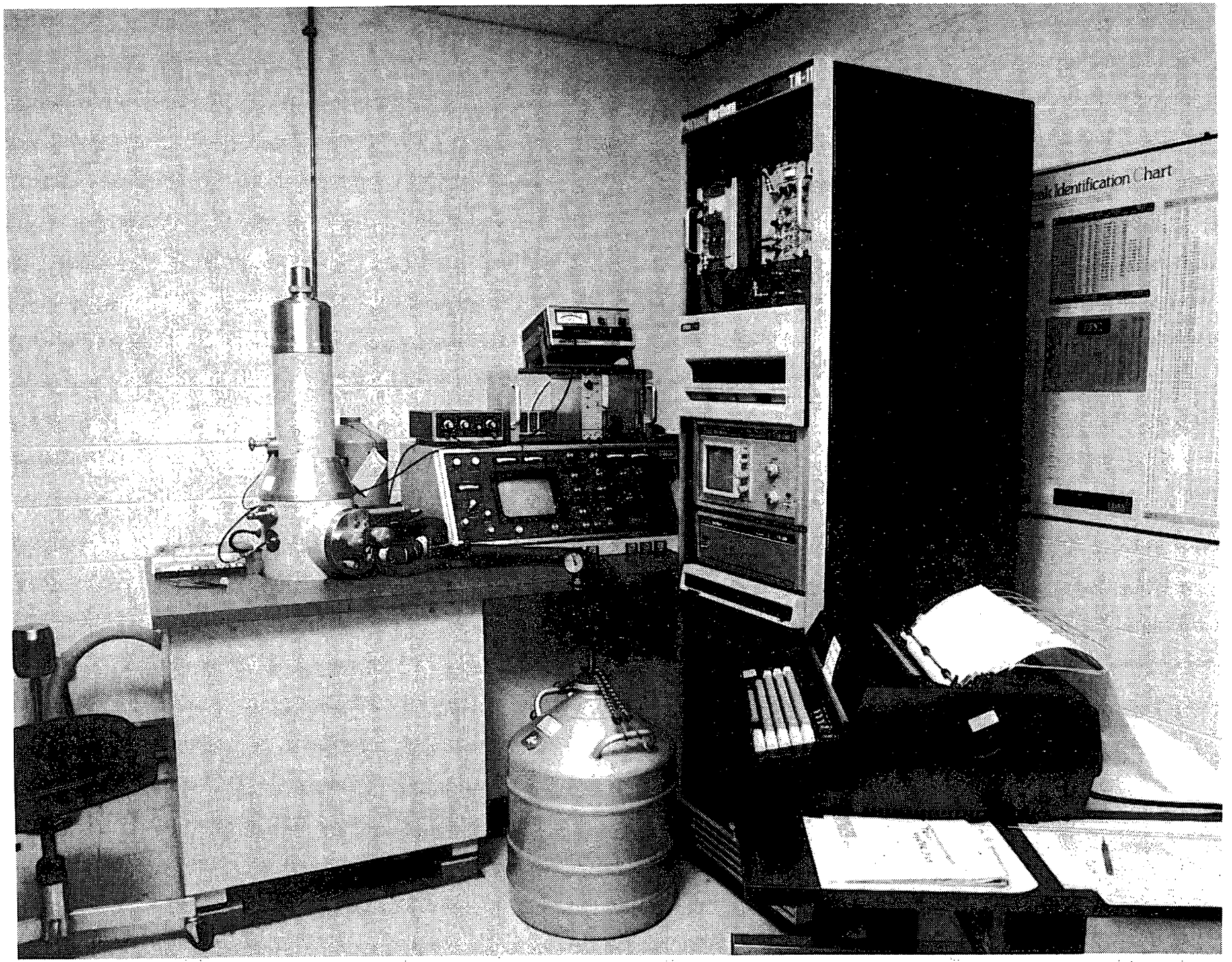
CONTAINERS FOR WATER TRANSPORT IN THE ARCTIC

There is a significant problem in obtaining water samples from arctic areas because the properties of the sample are known to change if it freezes while in transit from the collection site to the laboratory. To eliminate this problem, a special container was designed for lightweight and small size. Two prototypes were manufactured for winter trials. The design requirements were stringent in conforming to the logistical problems in the Arctic, so the task called for extensive optimization studies and laboratory cold-room testing.

The final prototype container consisted of a moulded, polyurethane foam case, containing a thermostatically controlled heater, powered by a gell-cell, rechargeable battery. The container can maintain the water sample temperature at + 2°C for 12 hours in an ambient temperature of - 40°C. For less severe ambients the storage time will be proportionately longer. A separate battery charger is provided to restore battery during overnight stops in heated quarters where 115 VAC 60 Hz power is available.

SPECIFICATIONS

Water Volume	2.0 L
Outside Diameter	21.3 cm
Height	45.0 cm
Mass (empty)	3.5 kg
Mouth Diameter	12.4 cm


Identification Chart

COOLER FOR ELECTRON MICROSCOPE STAGE

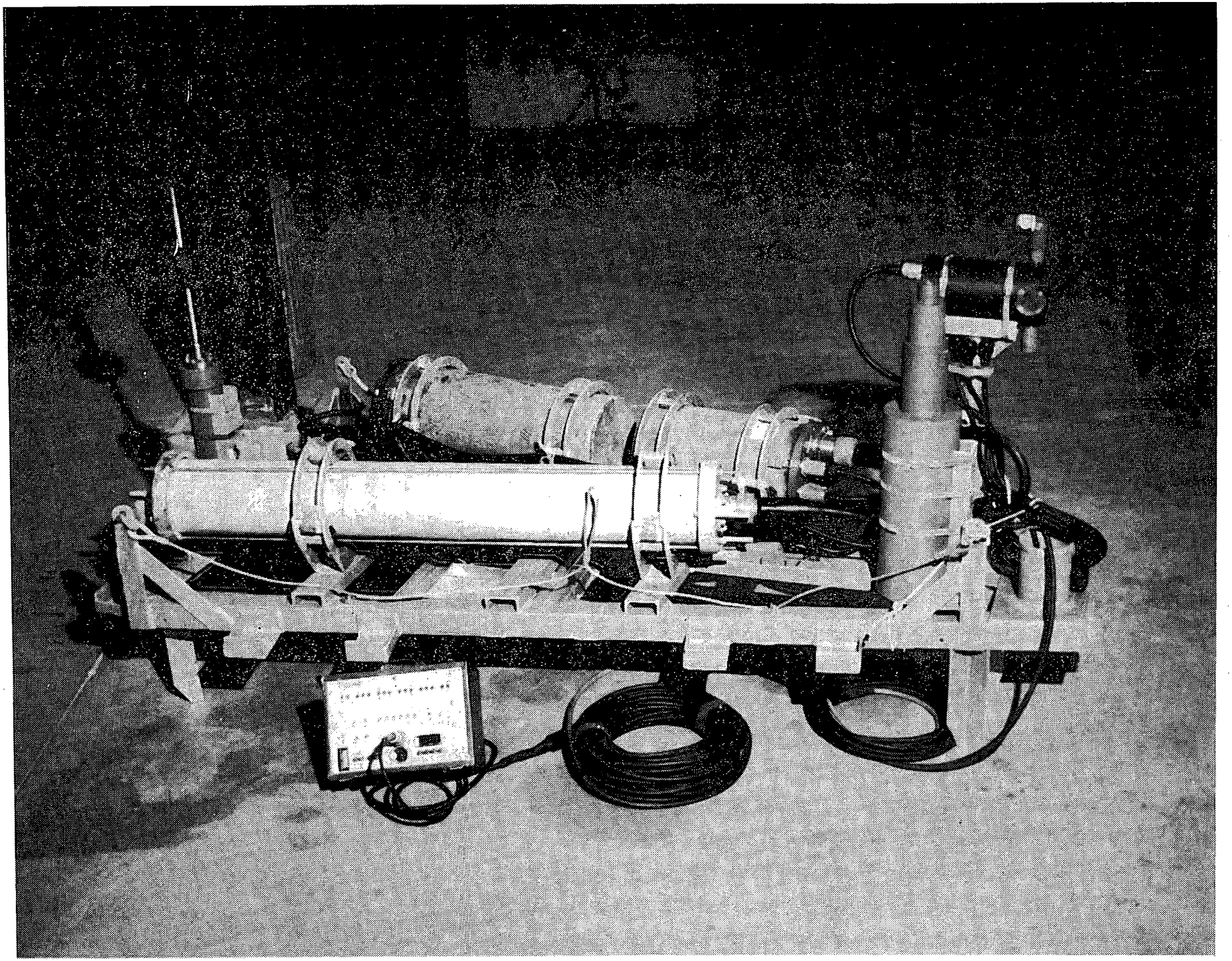
The Scanning Electron Microscope at C.C.I.W. is fitted with an emission-spectrum, microprobe attachment to determine the elemental composition of a sample. It suffers however, from the problem of loss of mercury and other low boiling point contaminants from the sample due to the heating effect of the electron beam, making accurate measurements extremely difficult. In order to minimize the problem, a cooled stage was developed to lower the sample temperature, as it is being bombarded in the high-vacuum chamber of the electron microscope.

The unit circulates liquid nitrogen via flexible metal hoses through an insulated sample holder. By allowing the nitrogen to boil in the system the sample temperature can be greatly lowered initially and held at a somewhat higher temperature, depending on the thermal conductivity of the sample and power of the beam. The unit has been successful in preliminary tests and has achieved better than 60% reduction in mercury losses. During these tests the sample temperature was maintained at -150°C.

The unit allows normal x, y, and z axis motions of the specimen stage, but does not allow for remotely controlled rotation of the stage. A special penetrator plate had to be designed for the microscope chamber to pass the hoses into the vacuum. The unit allows the changeover from the normal to the cooled setup in about one and one half hours, plus the normal pumpdown time.

SPECIFICATIONS

Target Temperature	-150 °C approximately
Cooling Liquid	liquid nitrogen
Ambient Vacuum	1.3×10^{-6} mbar



CURRENT TEMPERATURE AND TURBIDITY SYSTEMS IMPROVEMENTS

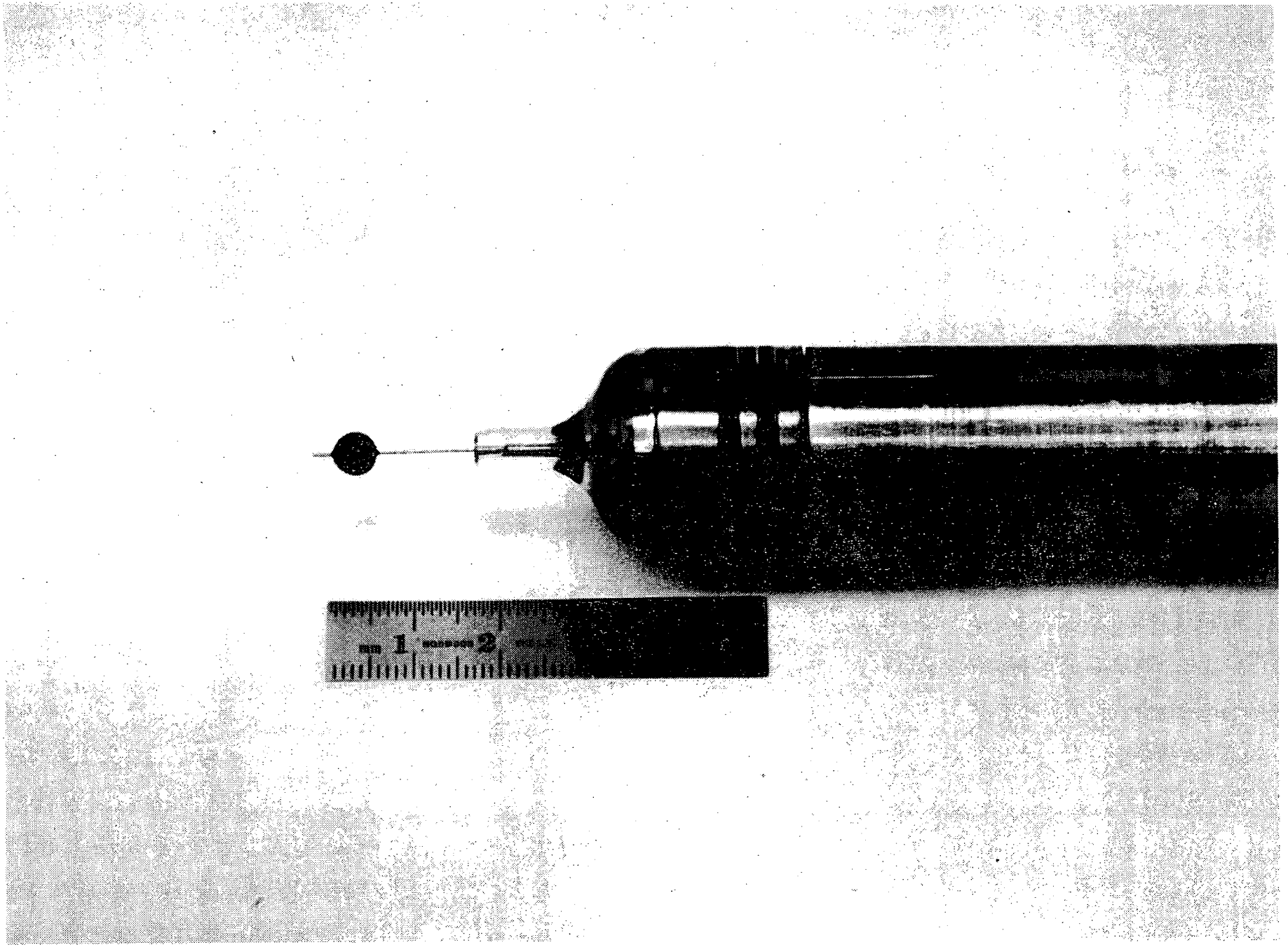
These systems have been under development since 1975 to fill the requirement for current measurement in the nearshore zone. Their history has been dominated by system integration and hardware development problems. The most recent design has shown promising performance in trials. These prototypes are coded CATTS 1 and 2. They are functionally identical and make use of electromagnetic current sensors and a new model of a turbidity sensor.

A third CATTS system coded CATTS 3, was especially configured for the fall 1978 evaluation trial to provide diversity in the measurement techniques which would contribute to the data set. The CATTS 3 system uses an electro-acoustic current sensor and an earlier design of turbidity sensor to provide a diverse set of measurement characteristics. In the absence of an *in situ* standard instrument it is not possible to obtain a true estimate of the system measurement accuracy - only precision may be estimated.

Comparisons of the differences in field data given by the various types of sensors are very revealing about the state-of-the-art.

SPECIFICATIONS

Temperature: K2284 4k-ISO Curve Fenwal Thermistor	
Number of sensors	3 (expandable to 13)
Range	-2 to 40°C
Resolution	15 mC°
Accuracy	±50 mC°
Time constant	4.0 minute (with boot)
Water Velocity: Marsh McBirney E/M Sensor (CATTS 1 & 2) (integraded estimate)	
Range	0 - 100 $cm.s^{-1}$
Resolution	0.4 $cm.s^{-1}$
Accuracy	target ±5% speed ±5° direction at 4 $cm.s^{-1}$
Integration period	5 minutes
Linearity	±2% to 100 $cm.s^{-1}$
Sampling period	10 minutes
Water Velocity: CMI Acoustic Current Sensor (CATTS 3)	
Range	0 - 100 $cm.s^{-1}$ each component
Resolution	0.3 $cm.s^{-1}$
Accuracy	±0.5 $cm.s^{-1}$ ±10% (cosine response)
Integration period	4 minutes
Linearity	±2% to 100 $cm.s^{-1}$
Sampling period	20 minutes
Turbidity: HF Submersible Turbidity Sensor (CATTS 1 & 2)	
Range	10^{-1} - 10^{3} Formazin Turbidity Units
Log conformity	better than ±5% of reading
Integration period	30 s
Sampling period	1 hr
Turbidity: Keene/Ashman/CCIW (CATTS 3) - Original Turbidity Sensor	
Range	0.1 - 300 FTU
Response	linear in log vs log space
Integration period	2 minutes
Sampling period	2 hours
Endurance:	
Mooring Period (CATTS 1 & 2)	60 days (design life)
Mooring Period (CATTS 3)	45 days (battery limited)
Batteries	Alkaline D-Cells
Time:	
Resolution	8 s minimum
Drift	1 minute/month maximum
Physical:	
Mass	≈200 kg
Dimensions	Base 2 m x 1 m x 1 m



FLOWSPHERE CURRENT METER

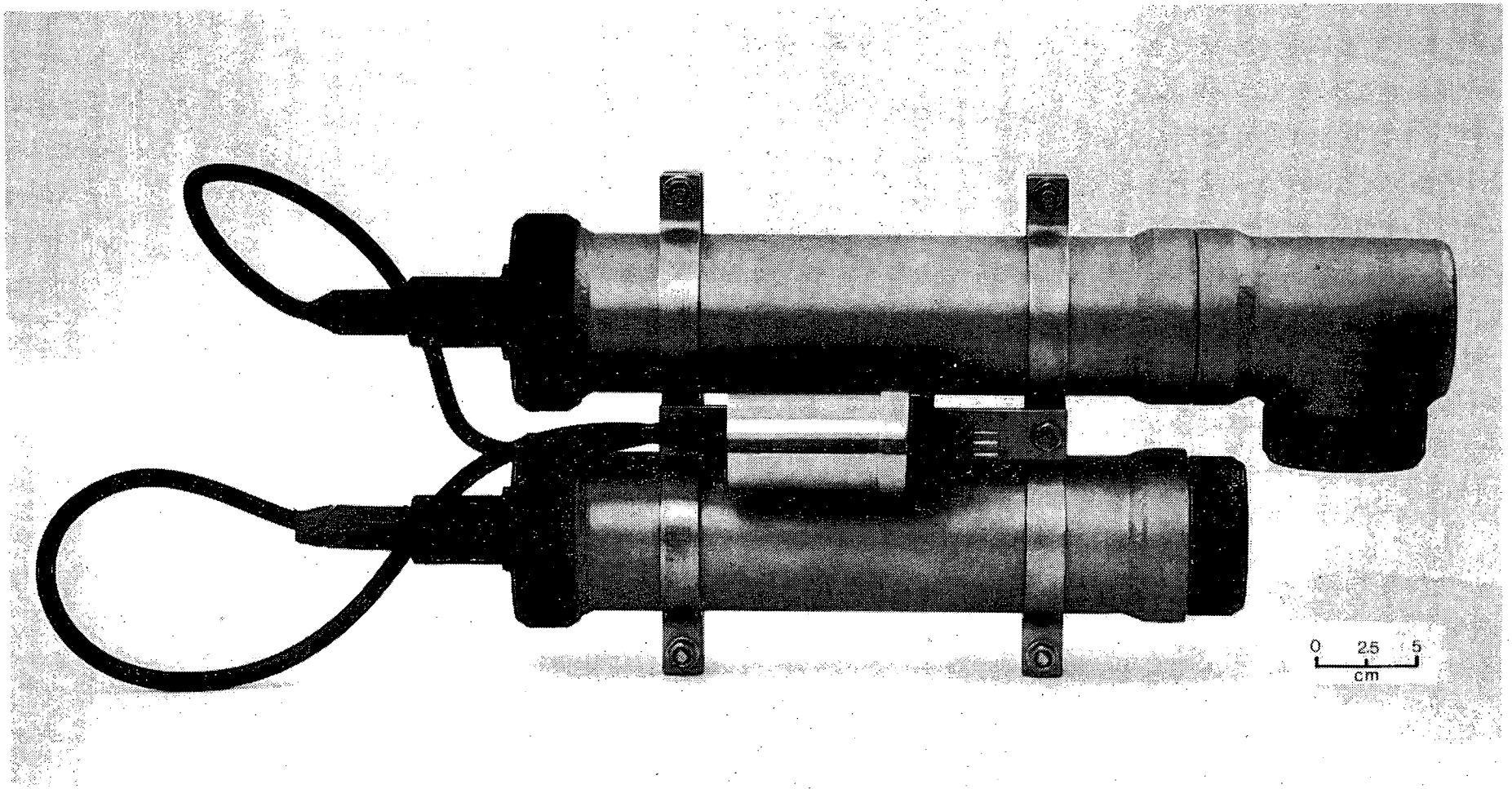
Consultation and test services were provided the co-inventors of a miniature dragsphere sensor for measuring the three orthogonal water velocity components in turbulent regimes. It is intended for probing the zone of near surface turbulence, in support of ongoing C.C.I.W. studies into air/water interaction processes in lakes. The probe uses a small, neutrally-buoyant dragsphere mounted on a thin stalk and pivoted centrally on a cruciform having four arms which act as compliant cantilevers. Integrally bonded to each arm are a pair of self-temperature-compensating, sub-miniature, piezoresistive, silicon straingauges which sense current-induced forces in the arm. The probe is oil-filled; water intrusion is prevented by the oil-water interface around the stalk in the neck of the probe. The interface is kept intact by surface tension. This arrangement minimizes hysteresis and dynamic pressure effects.

Each of the four straingauge signals is offset, filtered and amplified prior to digitization and data logging by the host system. The three orthogonal water velocity components are recovered by subsequent data processing.

Two production prototypes have been tested and accepted.

SPECIFICATIONS

Measurement Range	± 20 to 200 cm/s
Accuracy	± 2% (x,y) + 5% (z)
Frequency Response	flat to 40 Hz (-3 db)
Output Sensitivity	0.1 V/mN
Operating Depth	6 m
Operating Temperature Range	0 to 40°C
Power	110 VAC, 60 Hz, 2 W


0 25 5
cm

FLUOROSENSOR, IN-SITU, IMPROVEMENTS

Until now, older models of the Impulsphysik fluorosensor have been used at NWRI as in-situ profilers of chlorophyll "a". Because these models had asymmetric rise and fall times, their utility for profiling applications was marginal. Through efforts with the supplier, a new prototype model, Mark 4, was delivered to NWRI. This sensor incorporates improvements to speed up the sensor and reduce noise. The prototype was extensively evaluated in the laboratory and in the field at Kootenay Lake. The instrument response was considerably better than previous Mark 2 and Mark 3 units. Noise characteristics at low chlorophyll "a" levels were noted and remain to be fully explained. Correlations between readings and mass appear variable - sometimes being quite good in the laboratory and being poor in the field. Further work is needed

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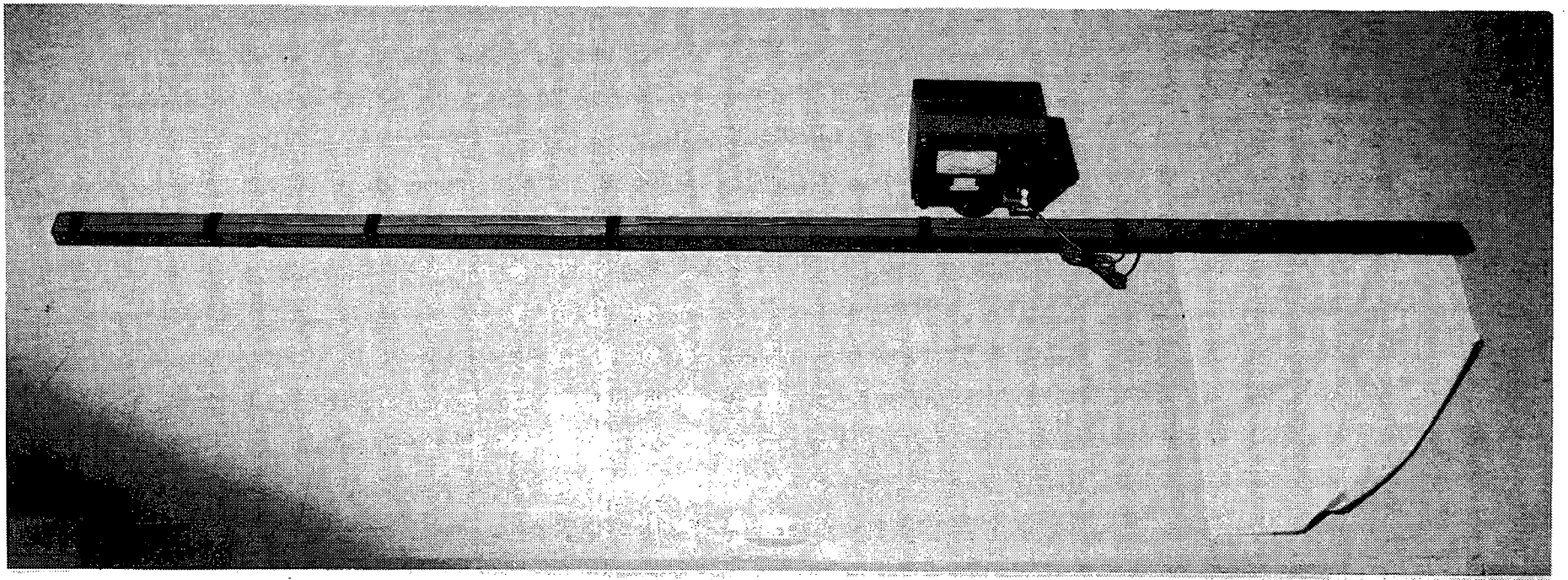
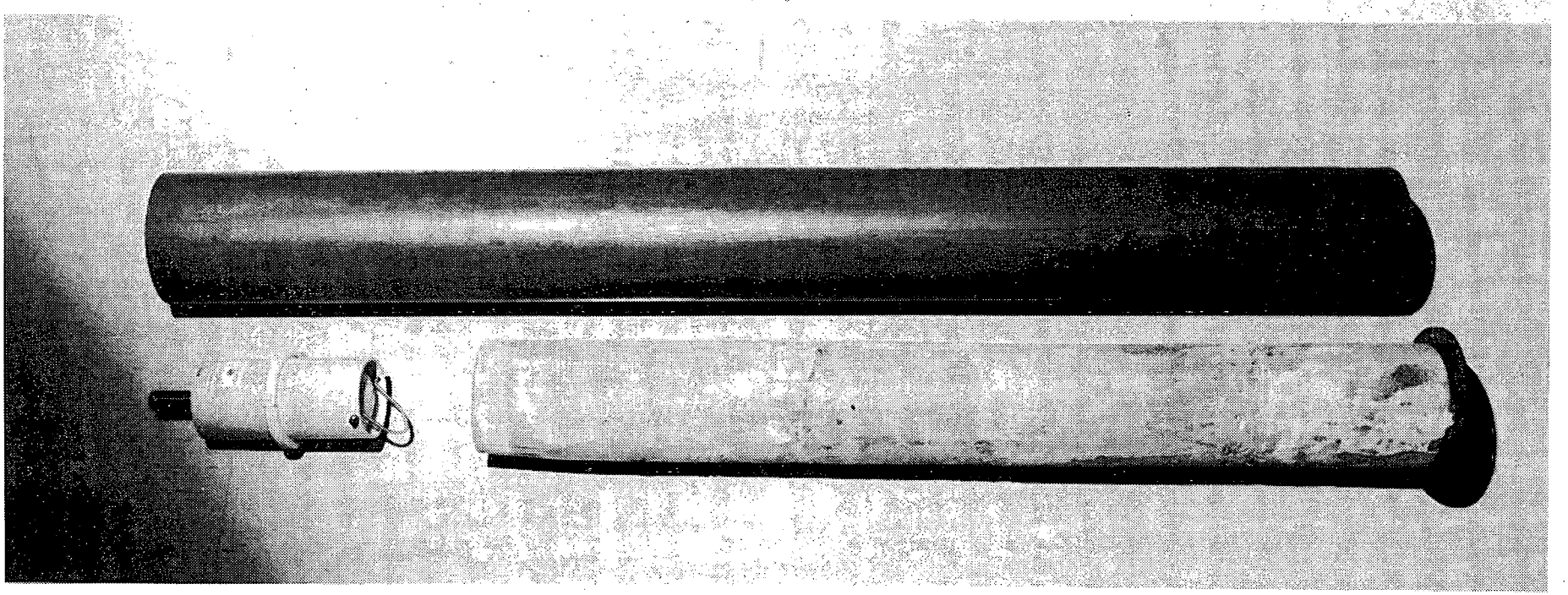
SPECIFICATIONS

Dynamic Range	< 1 mg.m^{-3} to 100 mg.m^{-3} chlorophyll "a" (live)
Precision	$\pm$ 15% of reading
Accuracy	dependent on reference accuracy
Speed of response	rise and fall times to 95% final reading $<$ 300 ms
Sampling rate	10 Hz
Drift	at $\approx$ 3 mg.m^{-3} value $< \pm$ 15% of reading
Temperature drift (detector)	$<$ 2% source drift over + 3°C to 35°C
Source energy	8.5 µJ/pulse at the target
Ambient light	maximum solar radiation has no effect with baffle in place.
Output	0 - 1 mA current output (0 - 3^{V} across 3 kΩ load)
Input	$\approx$ 35 VDC, 200 mA at the source/receiver
Depth rating	200 metres
Mass	15 kg





GROUNDWATER TEMPERATURE ARRAY

A small engineering task was done where sensors for an array for measuring the temperature of soil were purchased and calibrated. The array will be used to produce data which are useful for remote sensing studies of groundwater. Each sensor is buried in the ground in such a way that the sensors are accessible for routine checks and measurements.

SPECIFICATIONS

Ryan Waterproof Thermograph Model J-180 (six months):

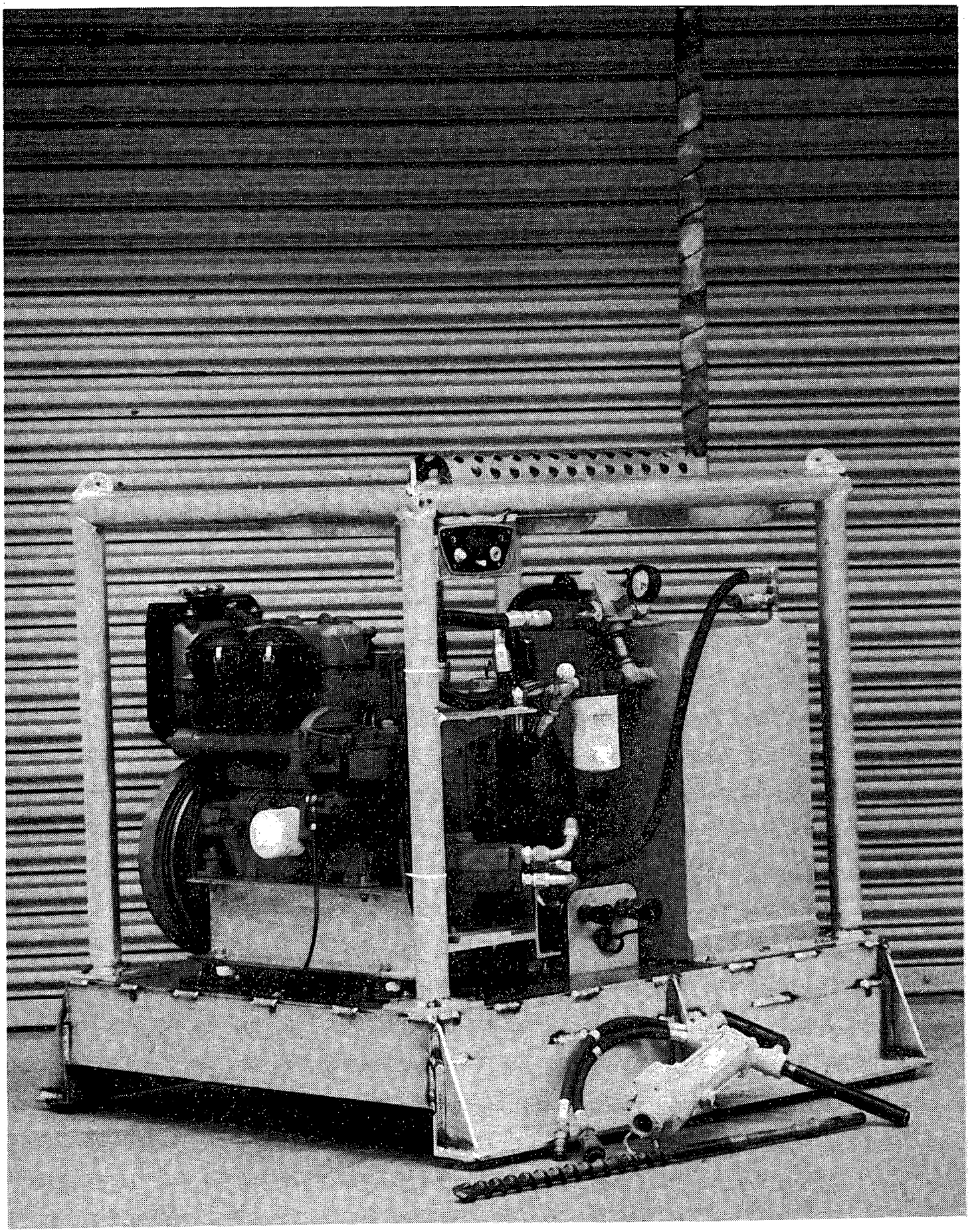
Sensing element	Hi-expansion, liquid filled system operating a bellows mechanism.
Temperature Range	-5°C to 25°C
Accuracy	Temperature ± 2 percent full scale

Thermistor Probes y S1 Model 401:

Range	-80 to 100°C
Time constant	7 seconds
Accuracy	±0.1°C

y S1 Model 46, Tele-Thermometer:

Span	0 - 51°C
	11°C each range
Accuracy	±0.15°C



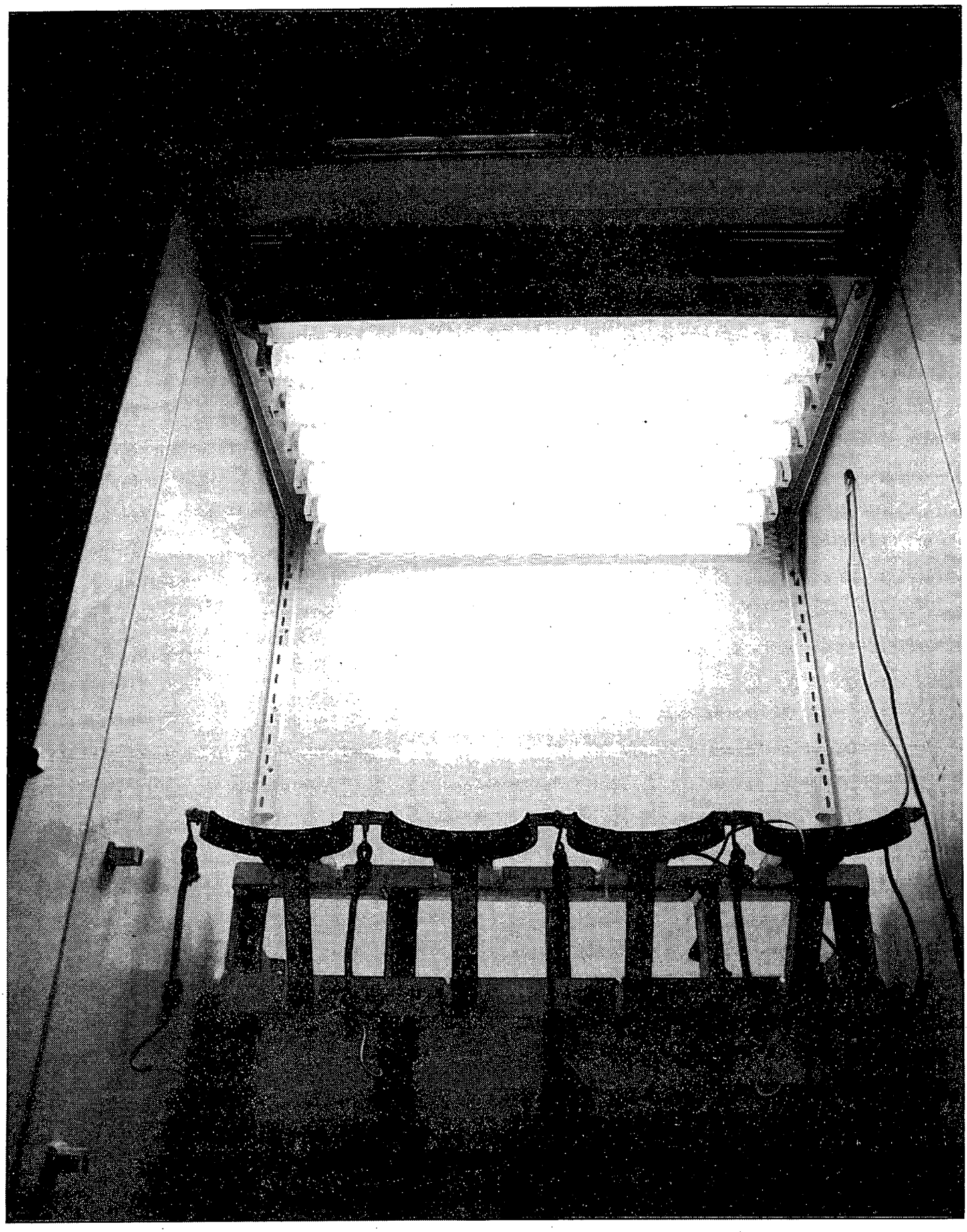
HYDRAULIC POWER PACK

A diesel-hydraulic portable power supply was designed and built to power diver-operated underwater hydraulic tools (described elsewhere). It is also capable of powering winches, other hydraulic equipment, and acts as a spare power unit for the Jackhammer Corer. The unit is housed in a cubic frame and is totally self-contained.

The high pressures and low flows of a hydraulic system give an advantage over pneumatic systems because of the lower power losses and the long hoses that are used in diving operations.

SPECIFICATIONS

Pressure (maximum)	1.4 MPa
Flow (maximum)	27.0 L/min.
Power rating	20 kW
Dimensions	1.3 metres each side
Mass	450 kg



INCUBATOR LIGHTING IMPROVEMENTS

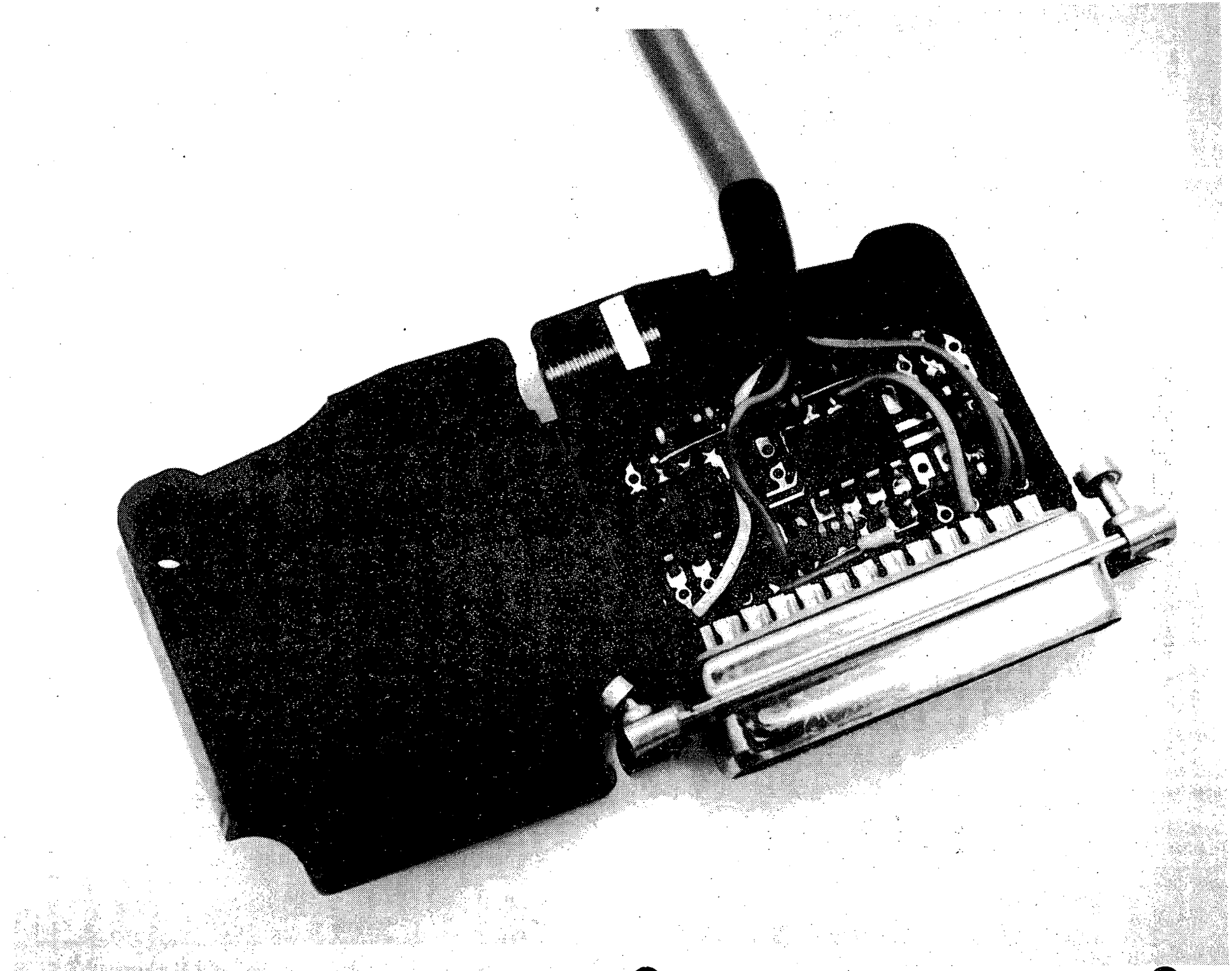
Some water samples are inserted in a special incubator to maintain them in as natural a state as possible between the time taken and the time they are analyzed.

In earlier studies, while temperature was maintained, the ambient illumination was not. A very simple prototype lighting system was designed to give predetermined light levels using a calculator program developed at NWRI. The system was built under contract and then tested.

The fluorescent lamps produce less light at cooler temperatures, therefore, correction curves have been provided with the system to assist the operator.

SPECIFICATIONS

Illuminance (maximum) @ 40 cm & 20°C	9000 lux with 6 lamps on.
Control	Reduced in stepwise linear fashion with fewer bulbs lit.
Lamp type	fluorescent F20T12/W
Chamber size	1.2 x 0.4 x 0.5 m

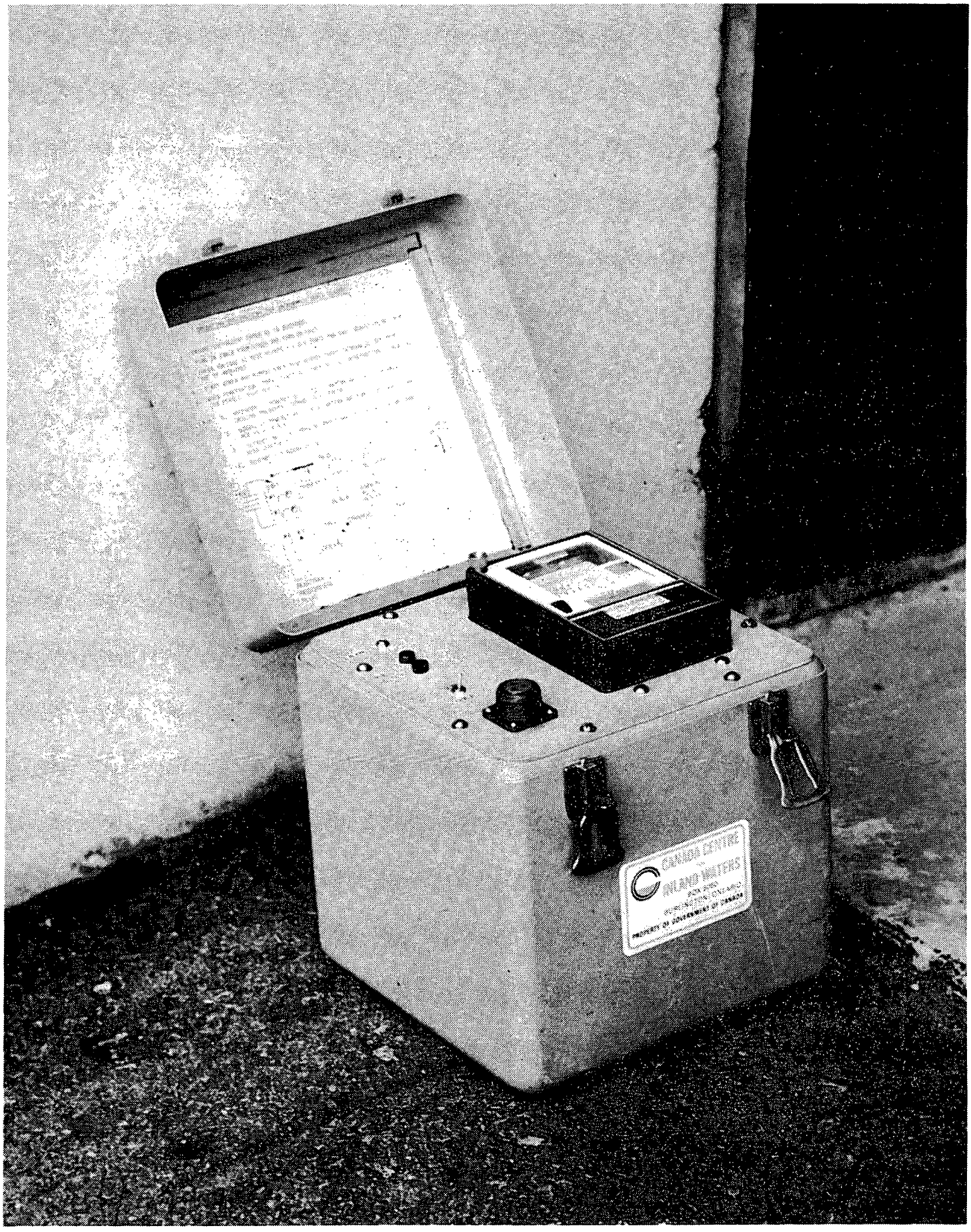


SERIAL INTERFACE

Sometimes when connecting two digital communication systems together, there is a need to keep the grounds isolated and some digital signals must have their voltage references shifted to be compatible with the next system. A compact interface was designed to meet both these needs. This interface, mounted in the connector shell, is the simplex type, that is, transmission in one direction only.

SPECIFICATIONS

Input	20 mA current loop
Output	± 3 to ± 6 V
Power	± 6 or ± 12 V @ 1 mA
Isolation	input to output 2500 V
Speed	4800 baud (480 characters per second)
Size	45 x 40 x 15 mm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JACKHAMMER CORER MODIFICATIONS

The hydraulically-operated Jackhammer Corer was modified to provide better core retention through the use of internal check valves on the core liners.

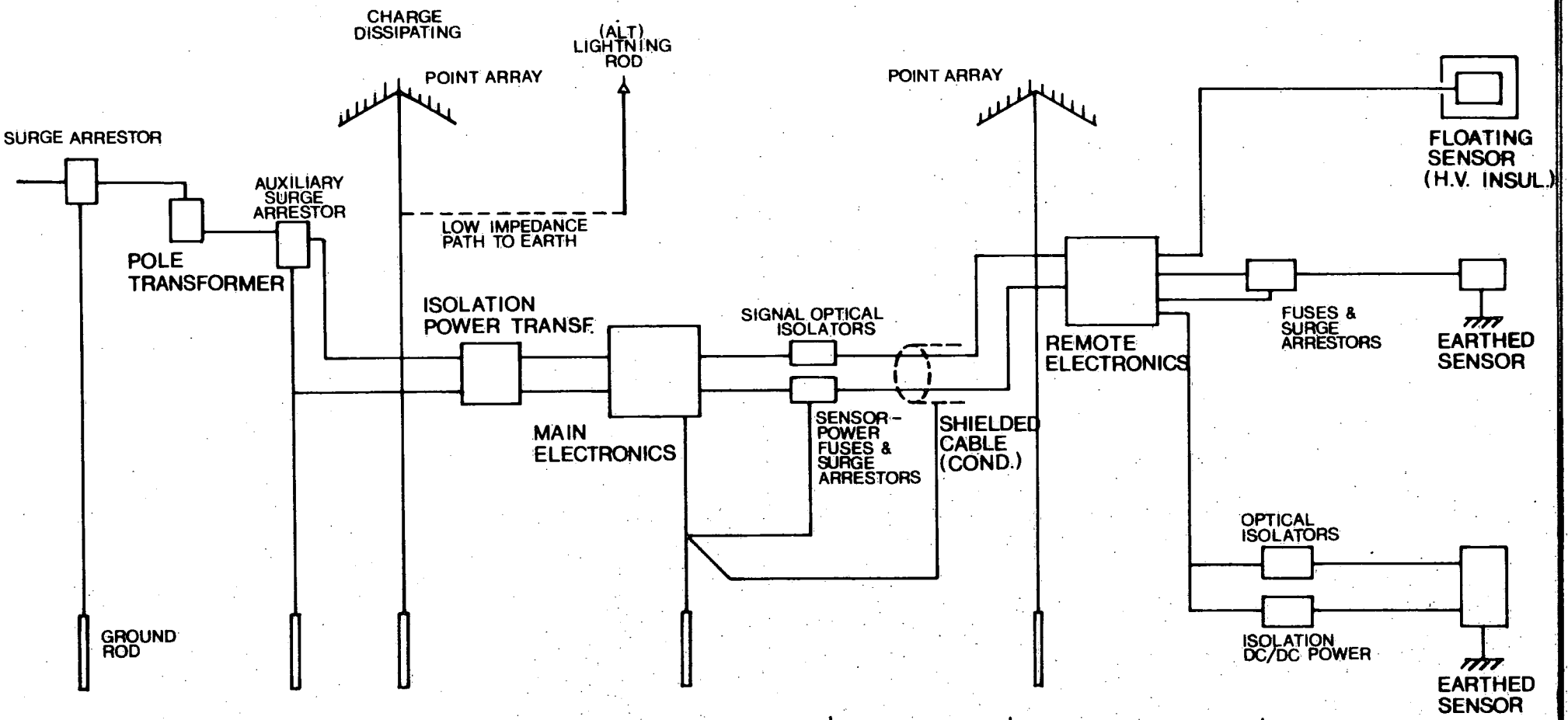
A screw-type vertical extraction method of the core and liner was developed to allow the mud/water interface to remain relatively undisturbed.

A 10 cm heavy-wall core pipe has been added to the system to allow cores to be taken in glacial till. An hydraulic core-extruder was added to the equipment to facilitate the extraction of tough cores.

An improved penetrometer was designed and built which gives both rate of penetration and penetration depth data continuously in graphic form. These give valuable soils engineering data about the bottom hardness. As well, they improve the chances of a good sample recovery. The penetrometer recorder is shown in the photograph.

SPECIFICATIONS

Std. core size	6.25 cm diam. x 2.0 m long
Till core size	12.7 cm diam. x 1.0 m long



Environment Canada — Canada Centre for Inland Waters

Environnement Canada — Centre Canadien des Eaux Intérieures

TITLE: LIGHTNING PROTECTION METHODS USED IN NWRI LONG-LINE MEASUREMENT SYSTEMS.

DESIGNED BY	CHECKED BY	APPROVED BY
DRAWN BY	CHECKED BY	DRAWING NO. 4278
SCALE	DATE	SHEET OF

LIGHTNING SURGE ARRESTING AND DIVERTING TECHNIQUES

Lightning protection is crucial on long-line systems because of the high probability that one end or the other will be subjected to induced voltage surges. Even when direct lightning hits are diverted to ground, sensors which are underground or underwater see high voltage differences. These differences travel rapidly through the system cables and the earth or water. Characteristics and circumstances dictate which components in a system warrant the most protection. In the eroding bluffs study, for example (p. 88, 1976) the buried piezometers are very difficult to replace, therefore, they were carefully protected at the nearest point available.

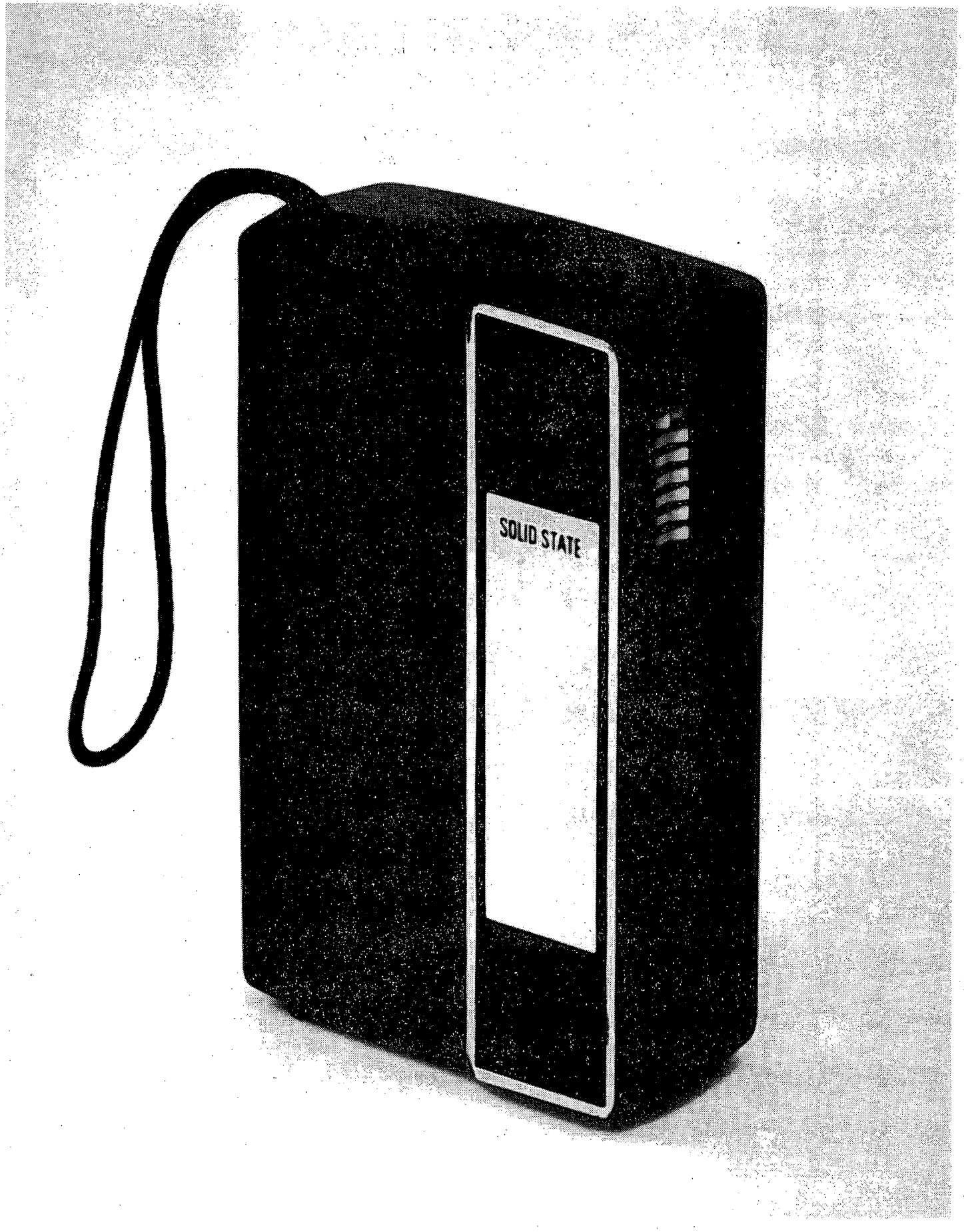
The protective methods can be divided into several categories:

a) Discharge of direct hits into the earth through good grounding and lightning rods.
b) Minimization of direct hits by charge-dissipating point arrays.
c) Power-line, voltage-surge arresting.
d) Transformer-coupled power isolation.
e) Optically-coupled, signal isolation.
f) Signal line and power supply voltage limiters such as breakdown diodes.
g) Signal line current limiters such as fuses.
h) Electrically-floating sensors using high voltage insulation techniques.
i) Choice of system components which are not prone to damage.

All of the above methods have been used on various NWRI systems, as shown in the table. Special care must be taken to avoid designing systems which are hazardous to personnel because of the lightning protection measures such as ungrounded chasses.

TABLE

SYSTEM (cable length)	TYPE OF PROTECTION (a) Good Grounding	(b) Point Array	(c) Special Power Arrestors	(d) Transformer Isolation	(e) Optical Isolation	(f) Signal Arrestors	(g) Signal Fuses	(h) Floating Sensors
WAVES Tower/Trailer (1 km)	✓	✓		✓	✓	✓		
Pt. Burwell Sensors/Trailor (.2 km)	✓		✓	✓		✓	✓	
Solar Radiation at Kenora Sensor/Recorder (.5 km)	✓					✓		✓
Kootenay Vertical Profiler (1.5 km)	✓			✓	✓			


SOLID STATE

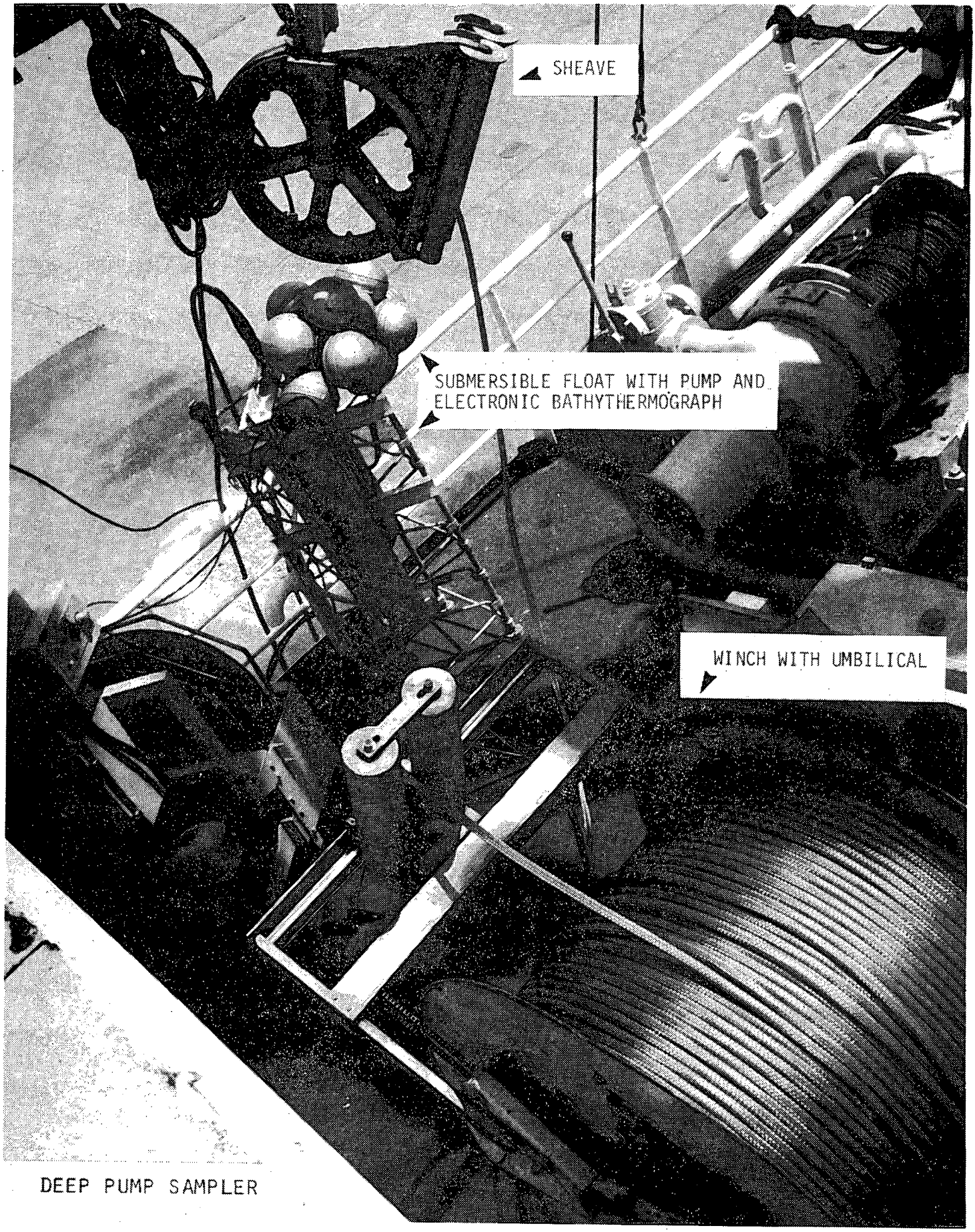
METRONOME FOR WILDLIFE STUDIES

A timing device was required by Canadian Wildlife Service for bird environmental behaviour studies. Two electronic metronomes were designed and built. These are very small, crystal controlled and programmable devices which emit a short audible signal at precise intervals that are presettable from 1 to 127 seconds.

The metronomes are powered by a common 9 volt transistor battery and consume very little power. They have an ON/OFF switch, volume control and earphone jack (with speaker turn-off) for easier use in noisy environments.

SPECIFICATIONS

Sound intervals	1 to 127 s - selectable at 1 s resolution
Sound interval accuracy	± 0.001 s
Sound duration	250 ms
Sound frequency	1024 Hz
Average power consumption	10 mW @ 9 volts
Operating voltage	3 to 19 volts
Operating temperature	-15 to +50°C
Size	3 x 6 x 10 cm
Mass	0.2 kg
Battery	9 V, MN 1604, 340 mA·h



DEEP PUMP SAMPLER

PUMP FOR DEEPER WATER SAMPLES

A submersible pump system has been developed to operate from a ship or launch to obtain continuous-flow water samples from moderate depths.

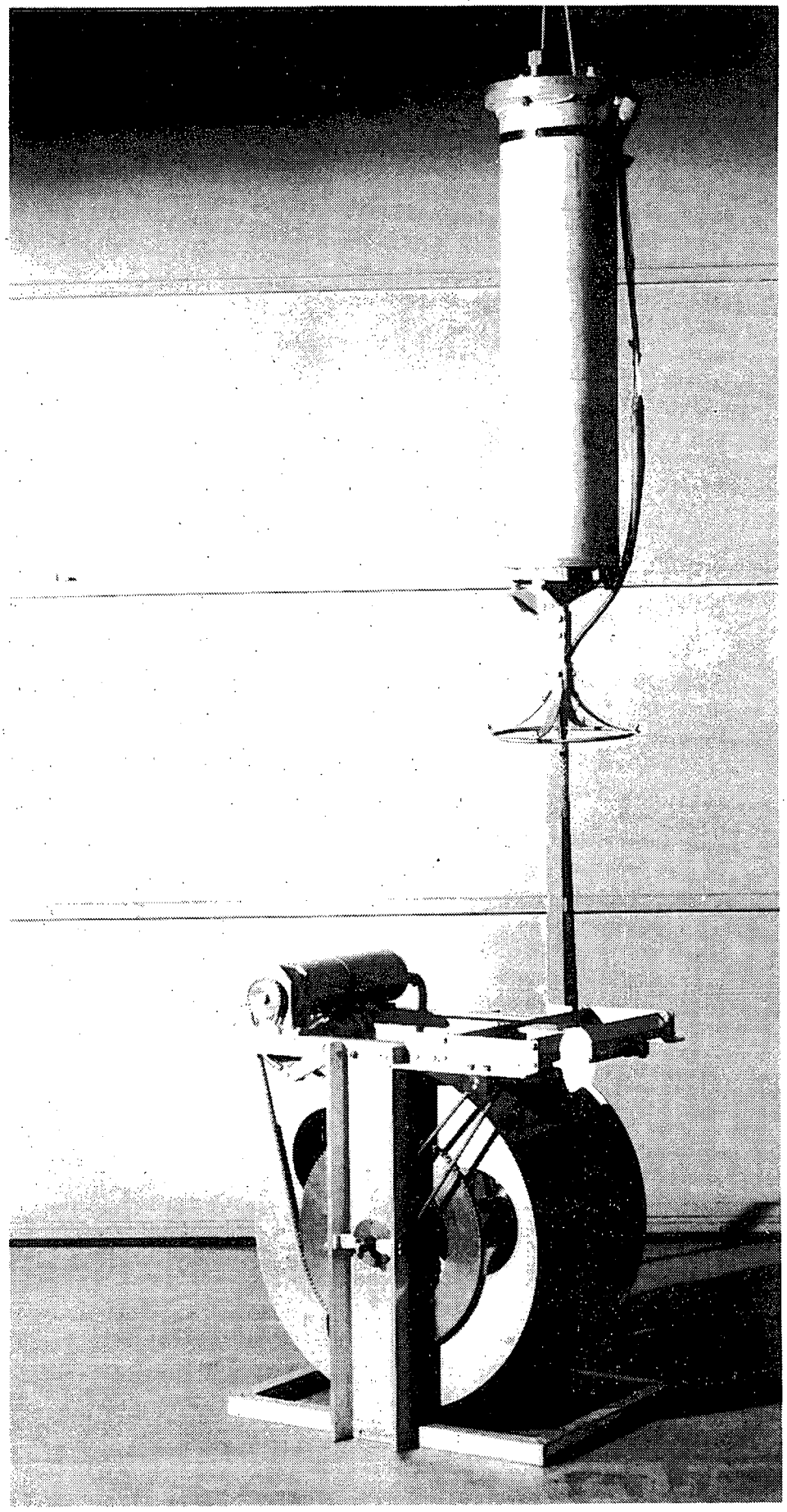
The winch is a Nordic unit, modified by considerable stiffening, addition of electric wiring and slip rings, and a different rotational speed. The hosing cable consists of a central core member of nylon-11 tubing, surrounded by a layer of stranded electrical conductors, plus a stainless steel braided sheath, and a urethane jacket.

A Moyno car-wash pump is used in the sample head at the bottom of the cable, and is driven by a Franklin submersible motor through a gearbox which had to be built inhouse. The pump has a chrome-plated, lobular rotor, running in a soft Buna-N stator. The relatively gentle action has a reduced tendency to destroy the zooplankton in the pumped sample. Smearing of the sample concentrations is acceptable because of the low, volume-retention time in the hose and pump.

The precise location of the intake and the nature of the water at the intake is known from the temperature and pressure sensors incorporated in the sample head. These measurements are displayed on the usual X-Y recorders associated with electrobathythermographs at NWRI.

SPECIFICATIONS

Output	8 litres per minute
Depth	70 metres nominal, greater depths possible with different hosing cable.
Temperature	0 to 25°C
Power	120 VAC, 1 Ø and 380 VAC, 3 Ø.

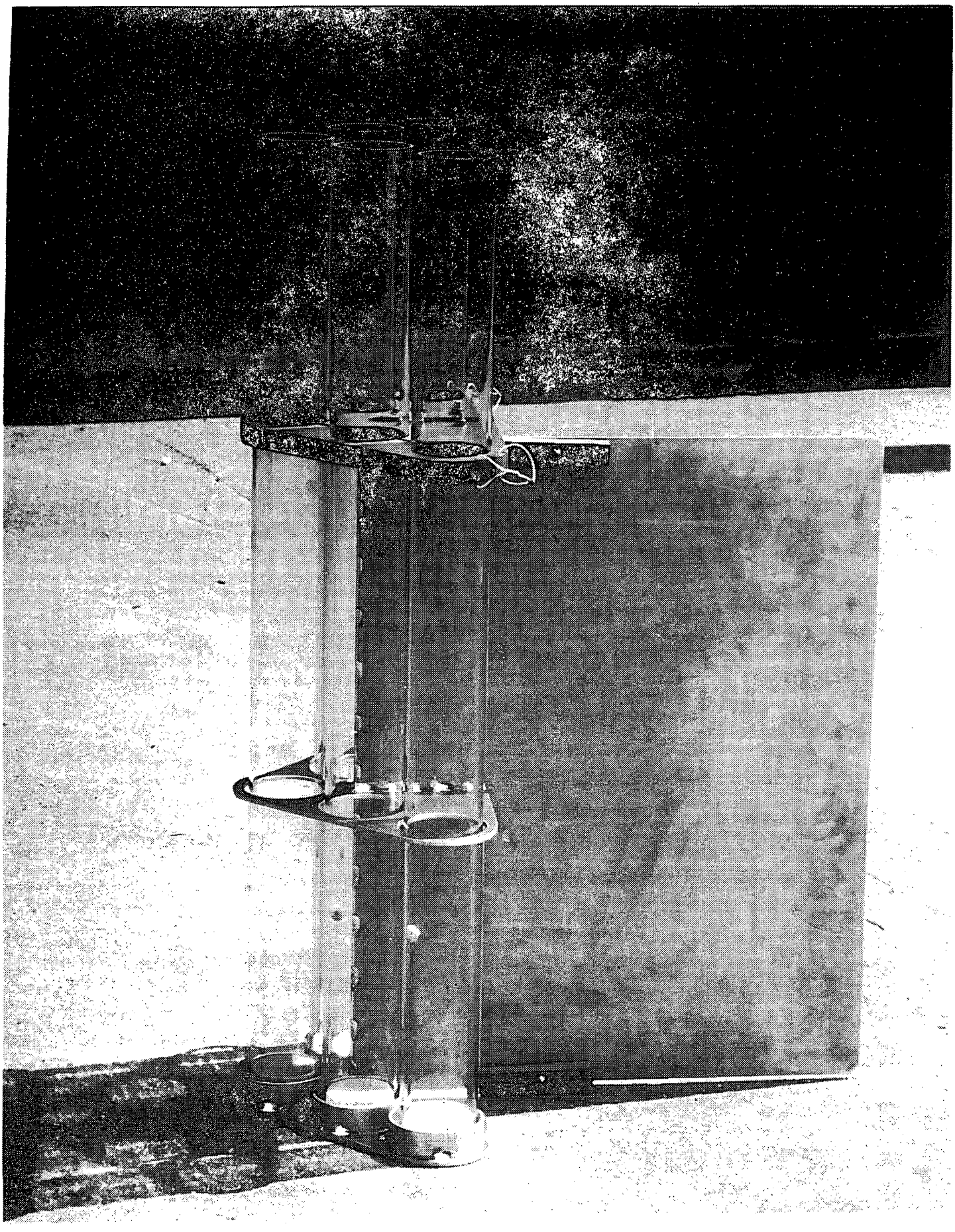


SAMPLE INTAKE PROFILER

The Sample Intake Profiler (S.I.P.) is an addition to the Remote Experimenter System (R.E.X.). It enables water samples to be taken at various depths in the water column, for analyses by REX in a bottom-mounted, remote-controlled chemical processor. SIP consists of an underwater winch that is bolted to the REX frame, an umbilical consisting of a hose with electrical cable, and a buoyant vehicle which carries a pump for forcing the water sample down the hose to REX. The winch is powered by a standard motor module from REX and responds to commands from the remote control system.

SPECIFICATIONS

Cable	
3 Lengths	37, 53, and 60 metres
Teflon hose	0.5 cm bore
Conductors	#22 AWG, stranded 50 V, Qty. 10
Kevlar braid	for estimated 220 N (500 lb.) breaking strength
Nominal O.D.	1.1 cm over urethane jacket
Weight in water	0.52 N/m (0.036 lb/ft)
Minimum bend diameter	25 cm
Strain terminations	Kellems grips
Electrical termination	
--top	Glenair 8 pin, shroud sockets
--bottom	Electro Oceanics 8 contact 4 pin male
Winch	
Drum capacity	62 m of cable in single layer at 110 N (25 lb.) pull
Line speed	17.9 cm/s @ 8800 rpm motor speed
Maximum continuous line pull	142 N (32 lb.)
Passive brake	Operates automatically to control overhauling load and hold position during shut-down
Bottom-stop	provides a safe cable stop and a bottom limit detector
Top stop	stops drum at top limit before end of cable is reached
Loss of buoyance force	sensed from motor current and leaves full motor brake on
Vehicle	
Mass	23.4 kg (51.5 lb.), including 7.3 kg. (16 lb.) counterweight
Net positive buoyancy	110 N (25 lb.), including 70 N lead counter weights
Pump output	2.4 L/min., through 37 m hose



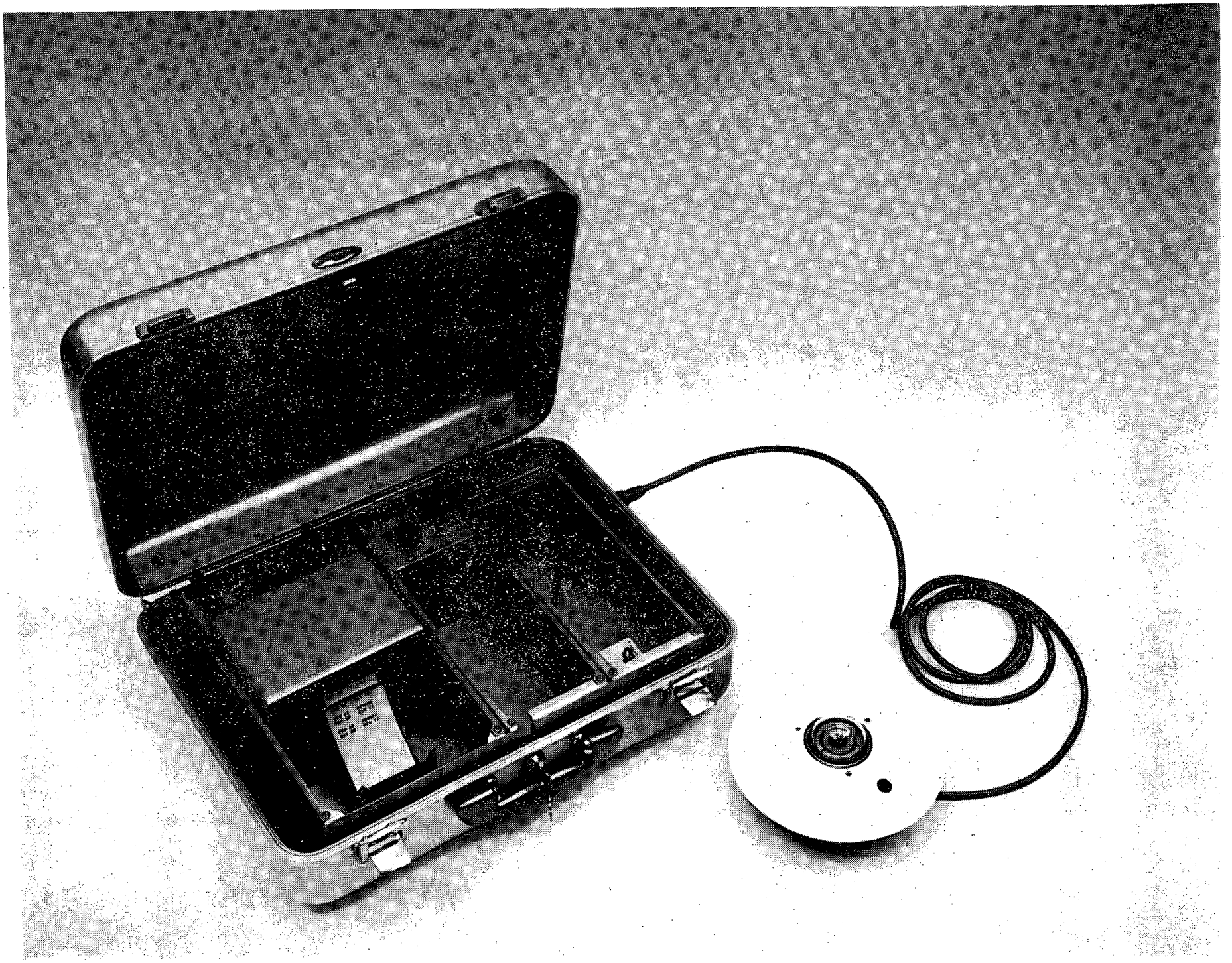
SEDIMENTATION TRAP

A sedimentation trap for use in water with intermittent or continuous currents was developed. This cylindrical trap is based on the observation by the NWRI Hydraulics Research Division that the resuspension of particles in the trap, because of ambient flow past the open end, is dependent on the aspect ratio (length/diameter) of the trap and the Reynolds Number of the flow about the cylinder.

The tubes are mounted in a holder which attaches to a vertical moored cable with swivel clamps. A vane directs the tube array toward the current at speeds above 5 cm/s. The tubes are individually removeable from the frame, or the whole assembly may be readily removed and replaced on the mooring cable. There is a drain plug above the bottom of the tubes for removal of surplus water without disturbing the sample. The bottom is removable for complete recovery of the sample.

SPECIFICATIONS

Number of Tubes	5
Tube Size	67 mm diameter by 915 mm long
Aspect Ratio	10:1
Ambient Speed Range	$\leq$34 cm/s; Re $\simeq 2 \times 10^6$



SOLAR RADIATION INTEGRATOR

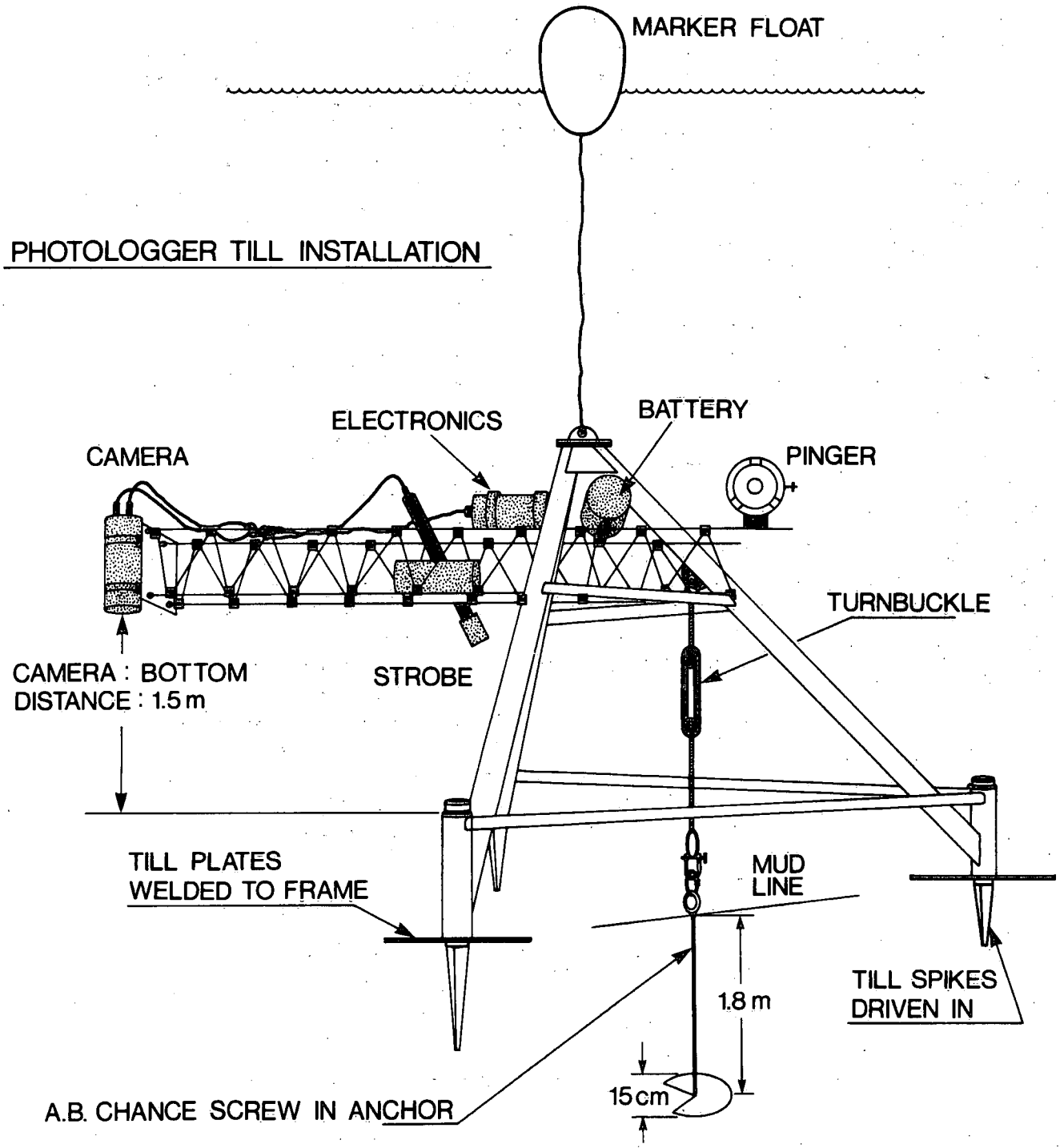
The Solar Radiation Integrator is a portable, self-contained, very low power, modular and versatile instrument which produces, at selected time intervals, a printed record of temperatures and integrated values of solar radiation. This Digital Recorder/Integrator can be used, with optional modules, to measure and record other parameters from a wide variety of scientific and micrometerological sensors.

This commercial instrument from Campbell Scientific, has been thoroughly tested for N.W.R.I. purposes and is now being incorporated in the radiation monitoring network. Further field evaluations from this network will give a good indication of the effectiveness of the instrument. Large savings in effort per station in the network are anticipated.

SPECIFICATIONS

N.W.R.I. Version

Printer	
Printhead	Seiko, 18 column
Data Format	2 channels/line (2 digits channel ID, 1 sign and 3 digits data)
Print rate	100 channels/minute
Paper	5.7 cm wide fanfold
Data points per pack	7000
Current drain	0.35 mA - standby 100 mA - printing
Power Supply	
Composition	8 D-cells, alkaline in series
Battery life	7 ampere-hours, or 80,000 data points
Time Control Oscillator	Crystal controlled
Integrating time intervals	5, 10, 15, 30 and 60 minutes 2, 3, 6, 12 and 24 hours
Date controls	Preset batteries and thumbwheel switches for day, hour and minute
One Channel Millivolt Integrator Module	
Signal input range	800 µV F.S. to 100 µV F.S.
Accuracy of integration	±0.2% from 0°C to 40°C ±0.5% from -25°C to 50°C
Amplifier Input Drift	<0.1 µV/°C
Input current	<10 nano amps
Input resistance	>50 MΩ
Offset adjustment	± full scale
CMRR	>130 dB at 60 Hz
Common mode tolerance	±2 volts
Two Channel Temperature Module	
Input option	resistance or voltage
Excitation	precision reference voltage to thermistor
Accuracy	±2% from 0°C to 40°C ±5% from -25°C to 50°C
Input resistance	>1 MΩ
Offset, Adjustments	± full scale
Instrument in Case	
Size	46 cm (W) x 35 cm (D) x 15 cm (H)
Mass	14 kg


MARKER FLOAT
PHOTOLOGGER TILL INSTALLATION
ELECTRONICS
BATTERY
CAMERA
PINGER
TURNBUCKLE
CAMERA : BOTTOM
DISTANCE : 1.5 m
STROBE
TILL PLATES
WELDED TO FRAME
MUD
LINE
TILL SPIKES
DRIVEN IN
1.8 m
15 cm
A.B. CHANCE SCREW IN ANCHOR

SUPPORT FRAME FOR INSTRUMENTS MOUNTED ON LAKE BOTTOMS

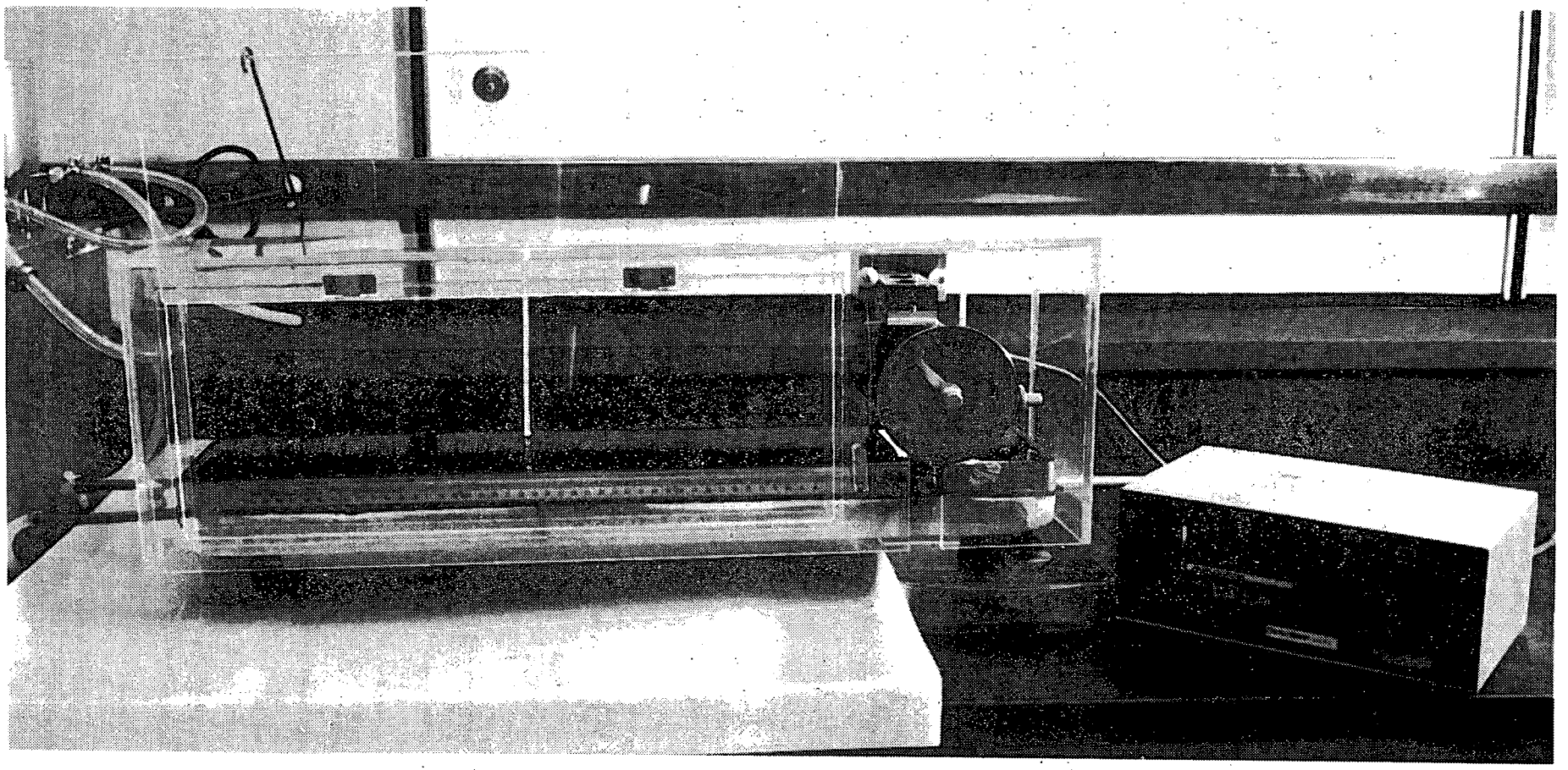
Modifications were made to a special support frame to provide a firm instrument stand on a hard glacial till bottom, near the shore of a lake. In this zone, the wave and current energy can be quite high. Shifting and toppling are highly likely.

A large lug was welded to the upper structure of the frame to lie over the center of the tripod base. Below this lug an A.B. Chance screw anchor was embedded into the till with divers' assistance. The screw anchor was then connected to the lug by cable and turnbuckle. The three tripod feet were modified by adding circular plates to prevent excess penetration into the till, and spikes were driven through each base, into the till. Also, the frame was modified to provide a selection of distances from the lake bottom for mounting the instruments such as a camera.

These modifications have been successful, and the system has remained stable over several months since its implantation.

SPECIFICATIONS

Frame height	2.1 m
Frame base	3.0 m x 3.0 m
Anchor dimensions	15 cm diameter by 2 m long
Anti penetration plates	60 cm diameter
Spikes	cm diameter by 30 cm long



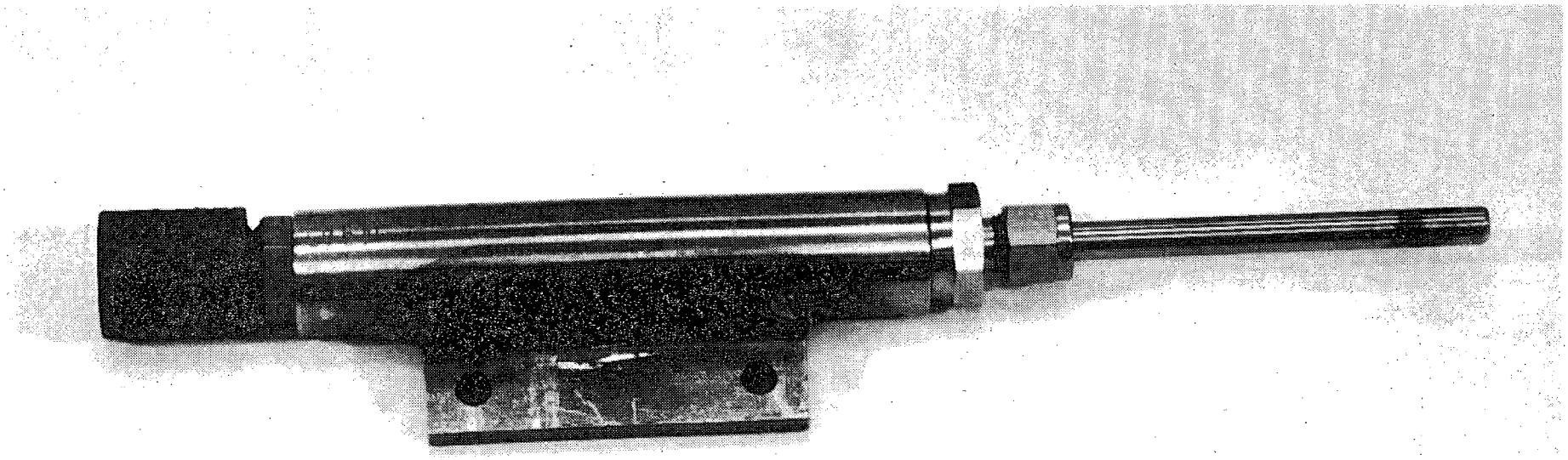
SURFACE TENSION SENSOR

A commercially available Langmuir Film Balance has been modified electronically and mechanically to increase its sensitivity and accuracy by a factor of 1000. By using finer torsion wires, and extremely lightweight torsion arm, and an electronic position sensor, the forces of immiscible liquid layers floating on water can be measured.

Higher forces can be measured with some decrease in absolute accuracy by increasing torsion wire diameter or by adding counterbalancing weights to the cross arm. This modification follows the plan of another researcher reporting in the journals.

SPECIFICATIONS

Measurement range	0-2 μN/cm
Sensitivity	1 nN/cm
Accuracy	±1 nN/cm at 10 nN/cm
Absolute error	±0.1% F.S.
Power	115 V, 60 Hz, 20 V·A

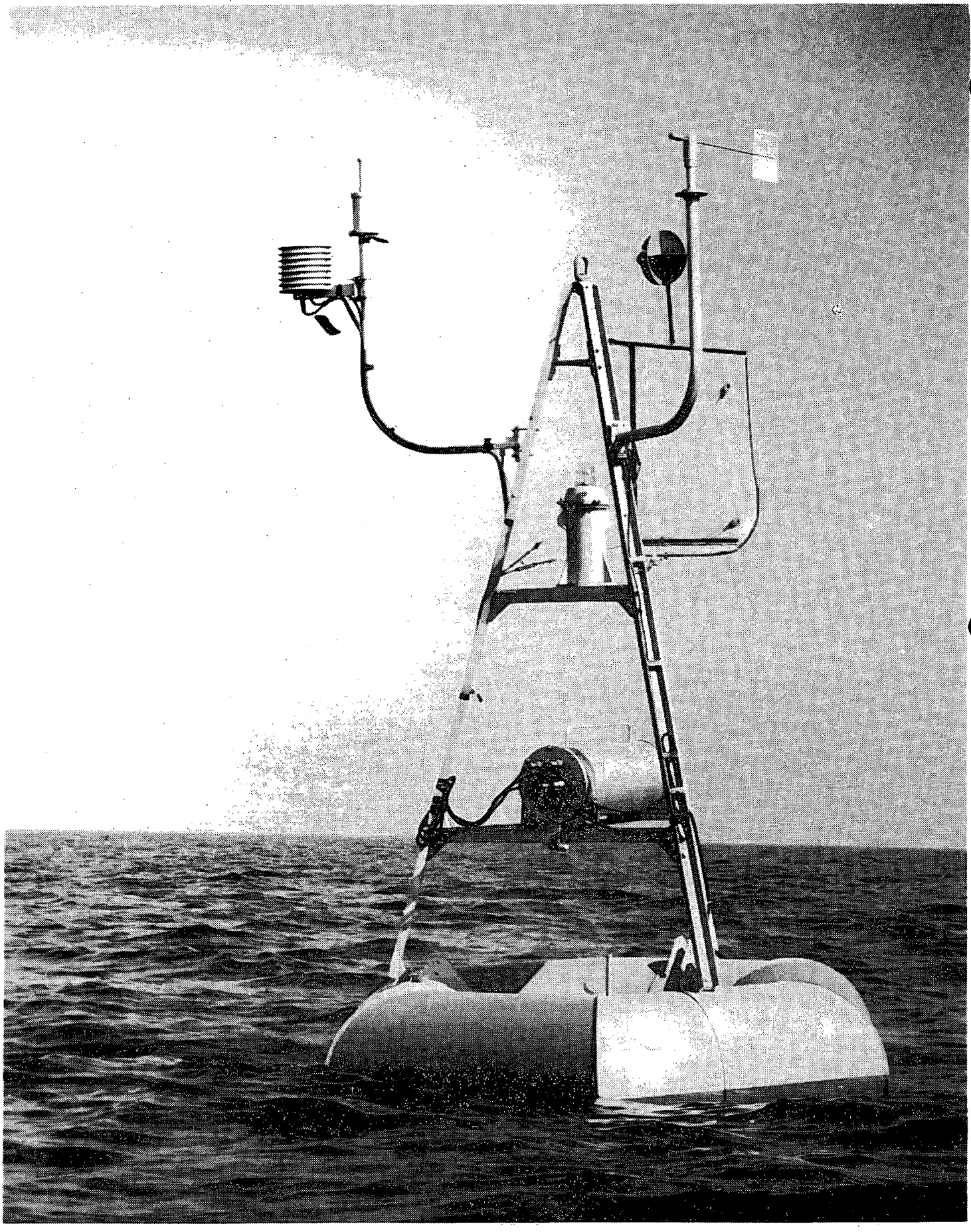


TEMPERATURE SENSOR FOR SURFACE WATER

A low cost temperature sensor is required for a tower based monitoring system. Good performance at low cost was achieved by making a commercial, solid-state, temperature sensor fully waterproof. The temperature sensing is based on the linear heat sensitivity of a silicon transistor's base to emitter voltage drop. A proprietary circuit, (bridge and feedback amplifier near the sensing transistor) makes the transducer's output a large linear voltage which is directly proportional to the ambient temperature. All electronics are contained in the sensor head which is easily replaced in-situ because an underwater connector is fitted to the unit which can be connected by a diver.

SPECIFICATIONS

Range	-15 to 25°C
Accuracy	±0.1°C
Linearity	±0.1% of span
Sensitivity	100 mV/°C
Supply voltage	+12 Volts ±0.1% regulated
Output impedance	25 ohms
Output signal	0.98 to 5 Volts
Time constant	15 s
Power consumption	15 mW
Self heating error	0.004°C/mW
Stability	±0.1°C over 90 days
Size	2.5 cm diameter x 25 cm length
Mass	0.7 kg
Material	Stainless steel



TOROID BUOYS FROM CODS PROJECT

The contracted design and prototype manufacture of medium capability buoys for both Atmospheric Environment Service (AES) and for Environmental Management Service (EMS) has been done by Hermes Electronics Ltd., in consultation with Engineering Services Section personnel. This work was done as a part of the Canadian Ocean Data System (CODS) program.

The study by Hermes has resulted in a torus shaped floatation buoy being selected. Two methods of buoy construction have been used, the first uses urethane foam with a protective skin of fibreglass, the second uses rolled aluminum plate to build the torus. Six sealed radial bulkheads prevent sinking in case of leakage, accident or vandalism.

The two types of buoy have been evaluated by structural damaging tests and field tests. An existing CCIW torus buoy was used as a control. Significant advantages in cost and mass are expected.

SPECIFICATIONS

IWD Fibreglass Buoy:

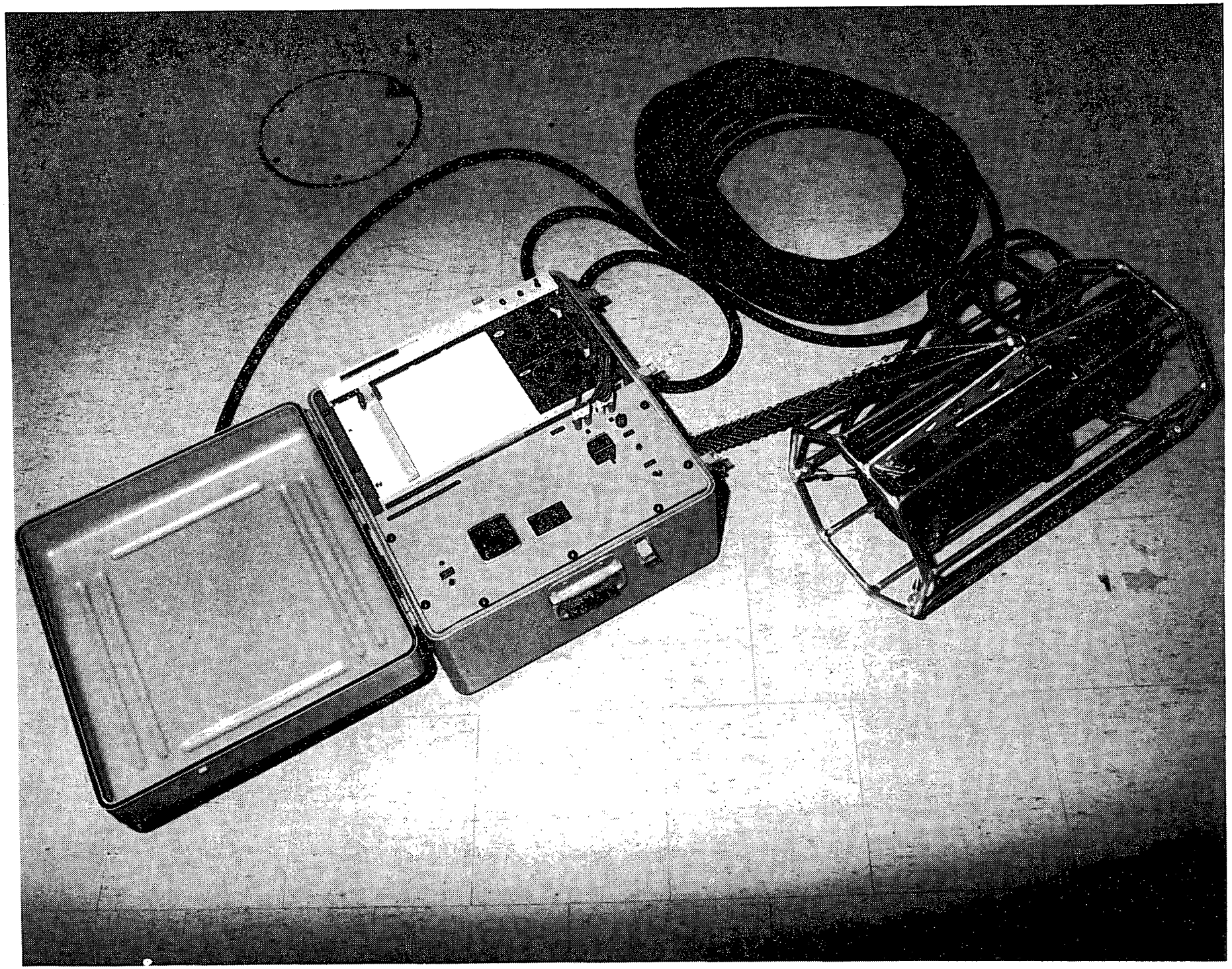
Diameter	2.4 m
Mass	261 kg
Sensing height of mast	4 m
Total displacement volume	2.4 m^3

IWD Aluminum Buoy:

Diameter	2.3 m
Mass	147 kg
Sensing height	4 m
Total displacement volume	2.2 m^3

AES Same as IWD Fibreglass:

Diameter	2.3 m
Mass	238 kg
Sensing height	7 m
Total displacement volume	1.96 m^3



TRANSMITTANCE PROFILER, PORTABLE AND MULTIBAND

A new addition to NWRI's portable profilers is the portable multiband transmittance profiler. This unit has a 1/4 metre Martek transmittance sensor, modified to produce a more stable output, and to measure transmittance in visible light bands which are selected through the surface console. Transmittance, together with accurate depth signals are displayed on an X-Y recorder mounted in a portable box. This enables good multiband transmittance profiles to be obtained from small craft in remote locations.

SPECIFICATIONS

Power transmittance range	99 to 1% 20 dB dynamic range
Equivalent attenuation coefficient range	0.04 - 18.4 m^{-1} 0 - 3^{V} F.S. output
Band center wavelengths	430, 480, 530, 580, 630 nm ±5 nm
Spectral bandwidth	30 nm nominal
Linearity + precision	< 3%
Time drift	< 1% after 1/2 hr. warmup
Temperature drift	< 0.1%/$^{\circ}$C F.S.
Sample dimensions	5 mm Ø x 250 mm (1/4 metre instrument)
Speed of response	< 100 ms
Temperature range	0 - 30°C
Depth range	0 - 100 m
Depth accuracy	±0.25% F.S.
System power	120 VAC
System mass	Surface unit 20 kg, sensors + cage 20 kg, cable 25 kg.

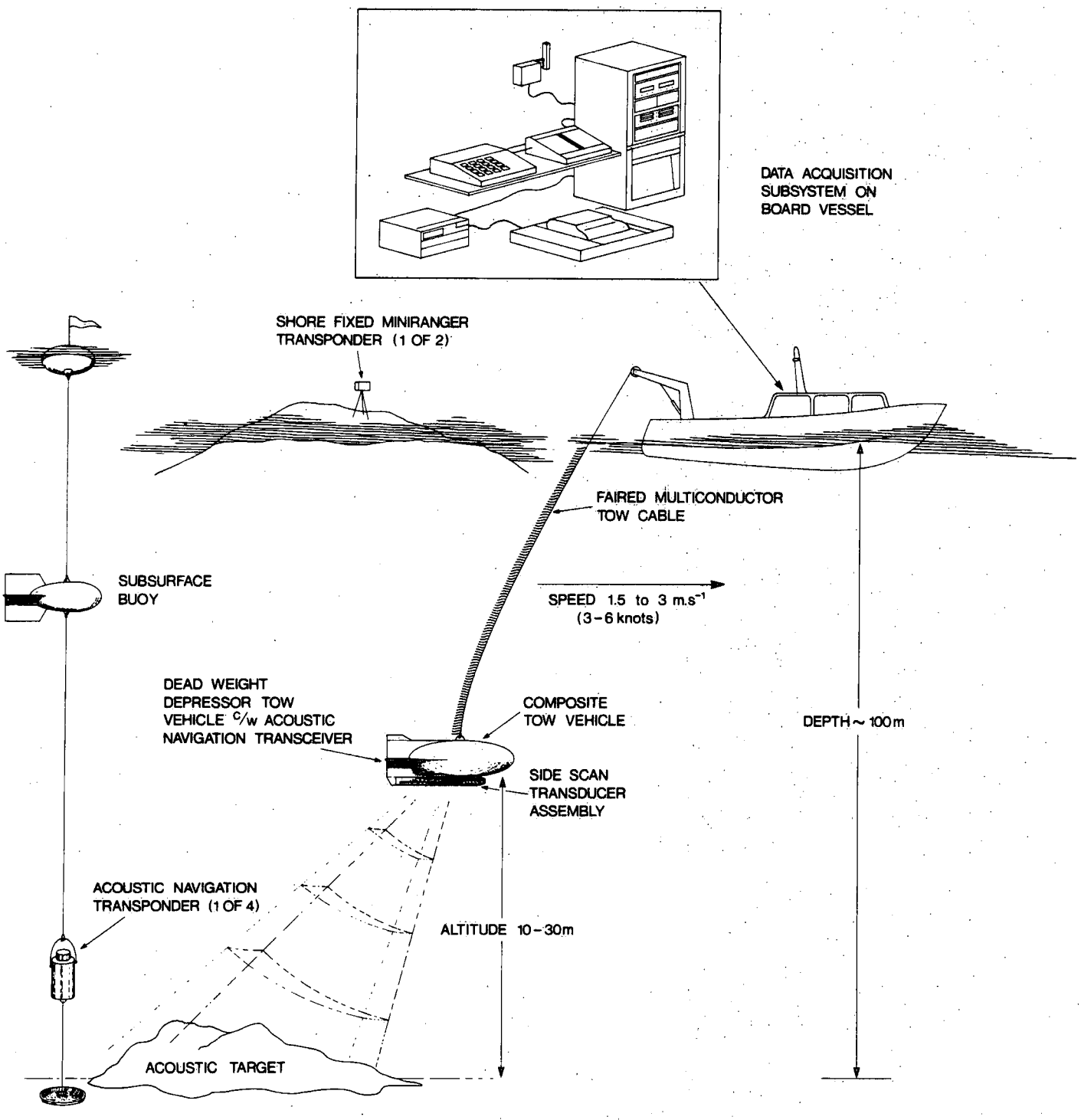


FIG. 1 ACOUSTIC SURVEY TECHNIQUES: SIDE SCAN SONAR - TOWED MODE CONCEPT SKETCH.

UNDERWATER IMAGING WITH ACOUSTICS, BOTTOM MOUNTED SCANNING

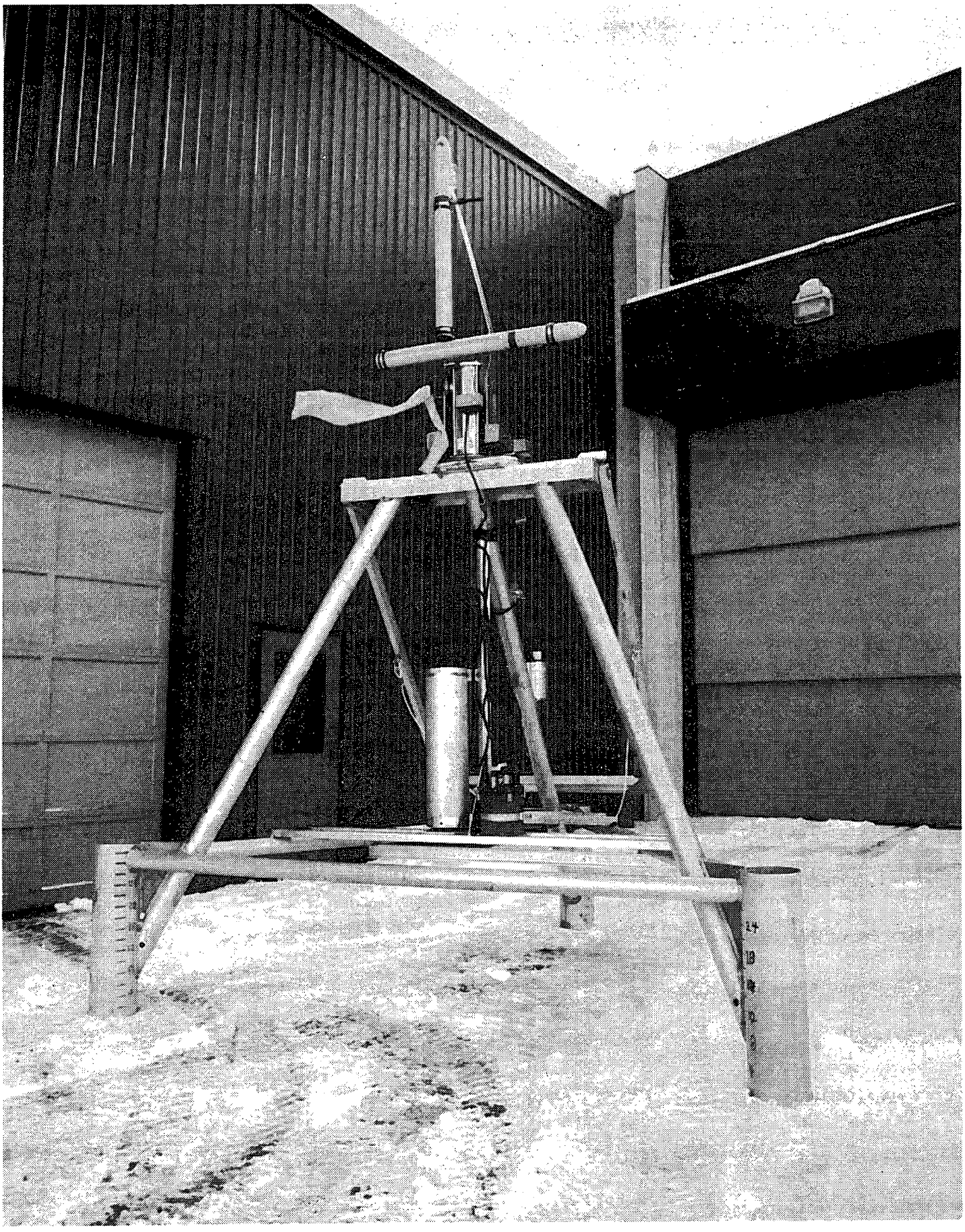
A bottom-mounted, pencil beam sonar system using side-scan-sonar equipment has been developed as a feasibility experiment. The sonar consists of a pair of crossed side-scan-sonar towfish mounted on a pan and tilt unit, atop a tripod. The intersection of the acoustic beams of the two transducers is scanned over the subject in a "creeping spot" pattern. The echo returns are to be built up into a three dimension image. The towfish transmitters can be independently enabled for operating the sonar in various modes.

The pan and tilt unit has been modified to give very slow rotation rates on each axis. Position transducers provide feedback of the pan and tilt relative to the base for the surface monitors. The initial attitude and orientation of the tripod itself is monitored by means of an underwater television camera viewing an illuminated, oil-filled, ship's compass. This monitors any settling of the tripod while on the bottom.

All data are logged on a combination of digital and analog data recorders for further processing when the image is synthesized. Work is continuing toward producing image synthesis techniques from the data collected in May, 1978.

SPECIFICATIONS

Maximum Depth	100 m (cable and position sensor limited)
Sonar Frequency	100 kHz, 0.1 ms pulse duration (nominal)
Sonar Directivity	$3/4^\circ \times 50^\circ$, $50^\circ \times 3/4^\circ$ yielding $1^\circ \times 1^\circ$ (nominal)
Pan and tilt rates	1 degree per second
Pan Range	180°
Tilt Range	90°
Angle Sensor Hysteresis	2.3°
Height off bottom	3 m (6 m with optional extension)
Maximum bottom slope	18%
Maximum current	0.5 $m \cdot s^{-1}$
Tripod Attitude Monitor	Heading resolution 5°, tilt resolution $0.5\text{-}2.5^\circ$
System Size	4 m^2 deck space, 6 m^2 lab space
Mass	600 kg



UNDERWATER IMAGING WITH ACOUSTICS - TOWED SYSTEM

The NWRI deep tow side-scan-sonar system has been expanded. The towed sonar subsystem has been improved through the reconfiguration of the tow vehicle. This gives better acoustic directivity characteristics of the sonar. The system now includes an acoustic navigation subsystem to fix the position of the tow vehicle relative to bottom mounted transponders. The new tow cable has more conductors to support the acoustic navigation subsystem and has hair fairing to improve the characteristics at low speeds.

The data acquisition subsystem has been expanded to allow analog recording of the sonar returns and the encoded real time clock on an instrumentation magtape. A digital data acquisition subsystem has been added. It collects data from a real time clock, a Miniranger ship positioning subsystem, and the acoustic navigation subsystem. A programmable calculator (HP 9825A) formats the digital data and stores it on a computer compatible, 1/2 inch, 7 track magtape. The calculator processes the positioning data and plots the ship tow vehicle positions in real time. These features permit high resolution surveys to be made with good control of coverage and accurate determination of target positions.

The analog and digital magnetic tape records are linked by the time information. These data are used in post-field, data processing to produce registered side-scan mosaic images of underwater features.

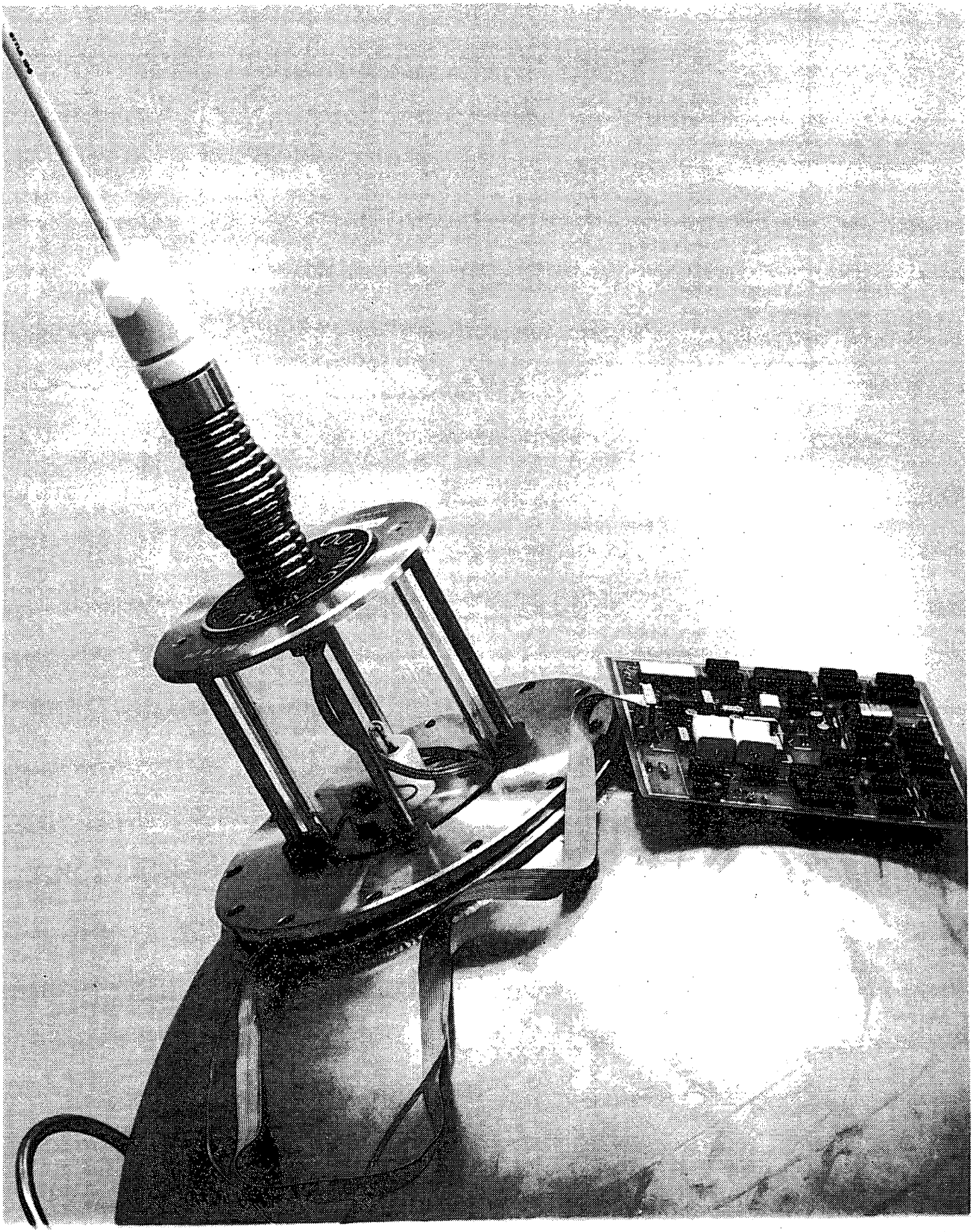
PERFORMANCE SPECIFICATION SUMMARY

Towbody Subsystem

Maximum depth	100 m (cable limited)
Towing speed	1.5 to 3 $m \cdot s^{-1}$
Side-scan-sonar frequency	100 kHz, 0.1 ms pulse duration (nominal)
Side-scan-sonar directivity	$3/4^{\circ}$ x 50° (nominal)
Acoustic Navigation Subsystem Frequency	25 - 30 kHz
Number of transponders	4 (maximum)
Maximum range	3 km (nominal)
Positioning rate	0.2 Hz (maximum for less than 4/4 reply)

System Outputs (Displayed and Recorded Data)

Side-scan Data Display	Realtime display (twin-helix chemical) recorder). Approx. 500 range-elements per channel.
	Taped analog data with IRIG time decoder for correlation with position data.
Surface Display	2 x 6-digit BCD range readouts
	XY plot of surface position
Subsurface Display	4 x 4-digit BCD slant range readouts
	XY plot of subsurface position
Time, Underwater and Surface Navigation Data Recorded	7 channels of digital data logged on 1/2 inch, 7 track, computer compatible magtape
	Calculated positions logged on HP magtape cartridge
System size	4 m^2 deck space, 6 m^2 lab space
Mass	600 kg



VALVE CONTROLLER FOR CHEMICAL ANALYSIS

This controller was developed to assist the automate of the analysis process in the Water Quality Laboratories. The unit can be programmed to have a motorized valve assume a preset number of positions and at the same time to control the fraction collector to complete a preset number of positions.

SPECIFICATIONS

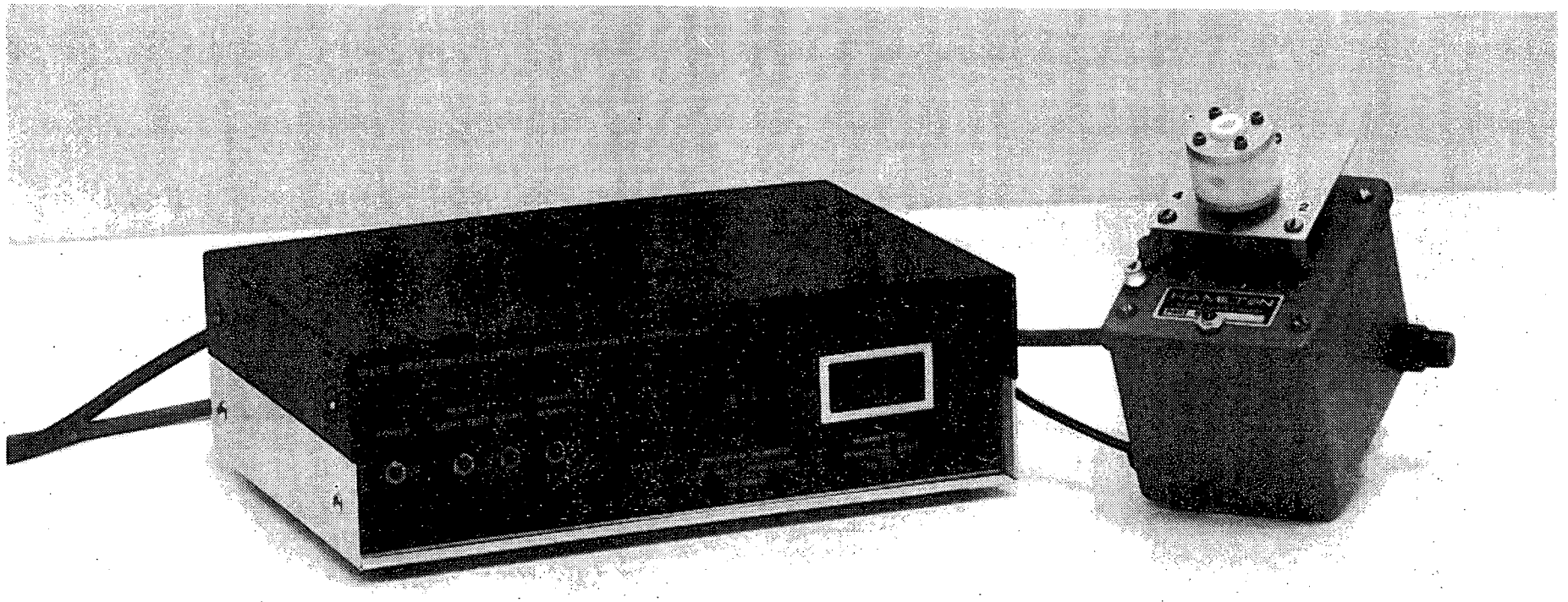
COMPONENTS:

Time Control	external timer, drop counter - Brinkmann ST2
4 way valve	4 positions, 115 VAC operation - Hamilton Co.
Fraction Collector	Brinkmann Linear II
Number of Valve Positions	0 - 99 externally programmable
Number of Fraction Collector Positions	0 - 188 or 0 - 99 internally programmed

CONTROLLER:

Power on Switch (automatic reset)
Reset Light Test
Start
Manual Advance
Thumbwheel set switches 00 - 99
Digital display of position left to go

Power	115 VAC, 60 Hz, 10 VA
Size and Mass	260 x 180 x 80 mm - 2 kg



WAVERIDER ON-BOARD, SIGNAL PROCESSING DEVICE

In the present mode the 6000 Waverider derives wave displacement through integration of an accelerometer signal, and transmits this information on an F.M. subcarrier via a radio link. The receiver demodulator has a magnetic F.M. tape recorder and analog chart recorder facilities.

For the purpose of deriving dominant wave periods from long term data without the time consuming post field spectral analysis, it is sufficient to extract and transmit only the RMS values of wave velocity and displacement. This is done in digital format, following 20 minutes continuous sampling of displacement and velocity signals.

Displacement and velocity signals are tapped off the existing waverider and each channel is sampled and converted to 8 bit absolute magnitude data. The square of this magnitude is derived using two rate multipliers in series. This frequency is counted into the 16 bit output registers for accumulation.

Following the accumulation period the registers are read out in sequence as a pseudo analog signal to the transmitter. This pseudo analog output is picked up by the main computer when the tapes are processed.

While the system is under evaluation, the normal, continuous, displacement signal is transmitted at other times so that the old and new methods of deriving significant wave height can be compared.

The circuitry was designed under contract to Tensor Design and Engineering Company, Markham.

SPECIFICATIONS

Frequency band	0.25 to 1.0 Hz
Radio link band	HF
Modulation	FM or AM
Sample period	20 minutes
Displacement resolution	8 bit
Velocity resoltuion	8 bit
Digitization rate	4 per second
Pseudo analog bit rate	one per six seconds (for chart recorder)
Max. RMS displacement	adjustable
Max. RMS velocity	adjustable

ACKNOWLEDGEMENTS

This year, I wish to acknowledge the N.W.R.I. Technical Operations people. The reader will have noticed how much of this equipment is field oriented. When it leaves N.W.R.I., it is in the hands of the field party who must set it up, often in very difficult situations. We greatly value the good attitude of these people who must view our products with skepticism as they wrestle with the imperfections common in developmental field gear. Without their understanding, much equipment would not have worked as quickly or easily.