PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
TECHNICAL UNIVERSITY OF NORWAY

A system for in-situ recording of current speed and direction, and other ocean parameters.

Ivar Aanderaa Nesttun Norway

The in-situ recording of such parameters, requires selfcontained and compact equipment capable of unattended operation over several months. The need for accurate data, demands the use of a digital system, and the need for machine reading of data, demands a recording medium, such as magnetic tape.

During the years 1961 to 1965 the Nato Subcommittee on Oceanographic Research sponsored a development project in Bergen, aiming at developing instruments for automatic collection of oceanographic data. [1)]

According to the result of this project, electrical sensing elements in the form of half-bridges were found to be preferable. A 10-bits binary system, recording data on magnetic tape was chosen. It was further realized that such instruments ought to be able to telemeter acoustically the successive measurements in the water, either for control purposes, or for the purpose of transmitting data for immediate use.

A small series of prototype instruments, recording current speed, direction and water temperature, were built under this project. These were found to be practical instruments, and several successful recordings were obtained with these instruments.

Since the termination of this project, further instruments based upon this recording principle, have been developed and manufactured at my plant at Nesttun near Bergen. Especially the recording current meter and a temperature profile recorder have proved to be successful. Both types of instruments are now widely used all over the world. A comparison of different types of current meters has been undertaken by an international working group. According to their test this type of current meter proved to be the most reliable. [2)]

Typical moorings of the recording current meter are shown in Figure 1, and Figure 3 illustrates different arrangements for use of the temperature profile recorder.

The component employed for carrying out the measurements is called encoder, and is shown in Figure 3. This is a motor-driven device performing the following three functions:

1. Analogue-digital convertion
2. Driving the magnetic tape
3. Advancing a channel selector switch

Owing to its unique design, this component permits construction of compact instruments for recording of data.

Figure 4 shows the 10-bits binary word generated by the encoder for each measurement it performs, and further the format recorded on the magnetic tape. For computer-infed of the data, these are usually transferred to punched paper tape. Figure 4 also illustrates a code commonly used when the data are transferred to punched paper tape.

Figure 5 shows a recording current meter based upon this encoder. This instrument measures 6 channels in series in the course of 24 seconds. These are:

1. Reference (a control measurement)
2. Temperature
3. Conductivity (if sensor has been installed)
4. Depth (if sensor has been installed)
5. Current direction
6. Current speed

This current meter is suited for use below the wave area, down to 2000 meters depth. When 10 minutes sampling intervals are used, the instrument is capable of operating over a period of two months.

The current sensor consists of a potentiometer capable of continous rotation, coupled to a rotor via a magnetic coupling and a reduction gear. This arrangement measures current in integrated form. The direction sensor consists of a compass at the bottom of the recording unit. The compass can be clamped electromagnetically when it is to be read, and it will then act as a potentiometer. The temperature is measured by a thermistor, which is connected in series with a resistor to obtain the half-bridge type sensor required.

The depth sensor consists of a film type potentiometer driven by a buordon tube. The conductivity sensor can either be the electrode type cell, or the induction type cell.

The current meter is equipped with a 16 kHz acoustic transducer, telemetering data in the same code as for the recording, by being swiched on and off. Typical detection range with a tuned hydrophone receiver is 800 metres. Figure 6 shows a hydrophone receiver built for this purpose.

Figure 7 shows the encoder side of the opened recording unit. From the bottom is visible: battery, encoder, channel selector, clock, and rotor gearbox. Above the top end plate are situated: the rotor, the acoustic transducer and the temperature sensor.

Figure 8 illustrates the opened recording unit from the tape recorder side. From the bottom can be seen: compass, take-up-spool for magnetic tape, tape recorder parts and supply spool for magnetic tape.

The temperature profile recorder has a recording unit similar to the current meter, but furnished with 12 channels. The first channel is reserved for a reference reading for control purpose, and the remaining channels are used for measuring temperatures. Figure 9 shows the opened temperature profile recorder. The temperature sensors, being thermistors, are placed at equidistant positions inside an oil-filled PVC hose up to 50 metres long. The whole unit can be submerged to a depth of 2000 metres.

Figure 10 shows the tape reader used for reading the magnetic tape from the above instruments. Normally it is connected to a paper tape punch, which will punch the data in the code previously described. Reading of a full tape of 60,000 binary words takes 50 minutes. The tape reader can also feed a digital printer directly, in which case the data from a recording current meter are presented as shown in Figure 11.

A vast amount of data has been collected by the two above instruments. Figure 12 shows a record of bottom current in the Norwegian Sea. It is noteworthy that the temperature is below $-1^{o}C$. Figure 13 shows an isoplet diagram from a Sweedish lake, obtained with the temperature profile recorder. A computer program has been employed for plotting lines of equal temperature, and these lines have afterwards been hand-drawn. The vertical coordinate indicates depth and the horizontal one indicates time. The characteristic rise of the temperature contours on August 15. was the result of a depression passing over the area at this particular day.

1) Ivar Aanderaa: A Recording and Telemetering Instrument. Nato Subcommittee on Oceanographic Research. Technical report No. 16. Chr. Michelsens Institute 1964.

2) Report on an experiment at WHOI Mooring Site "D", 16-24 July 1967 by the Working Group on Continuous Current Velocity Measurements. Unesco Technical papers in Marine Science No. 11.

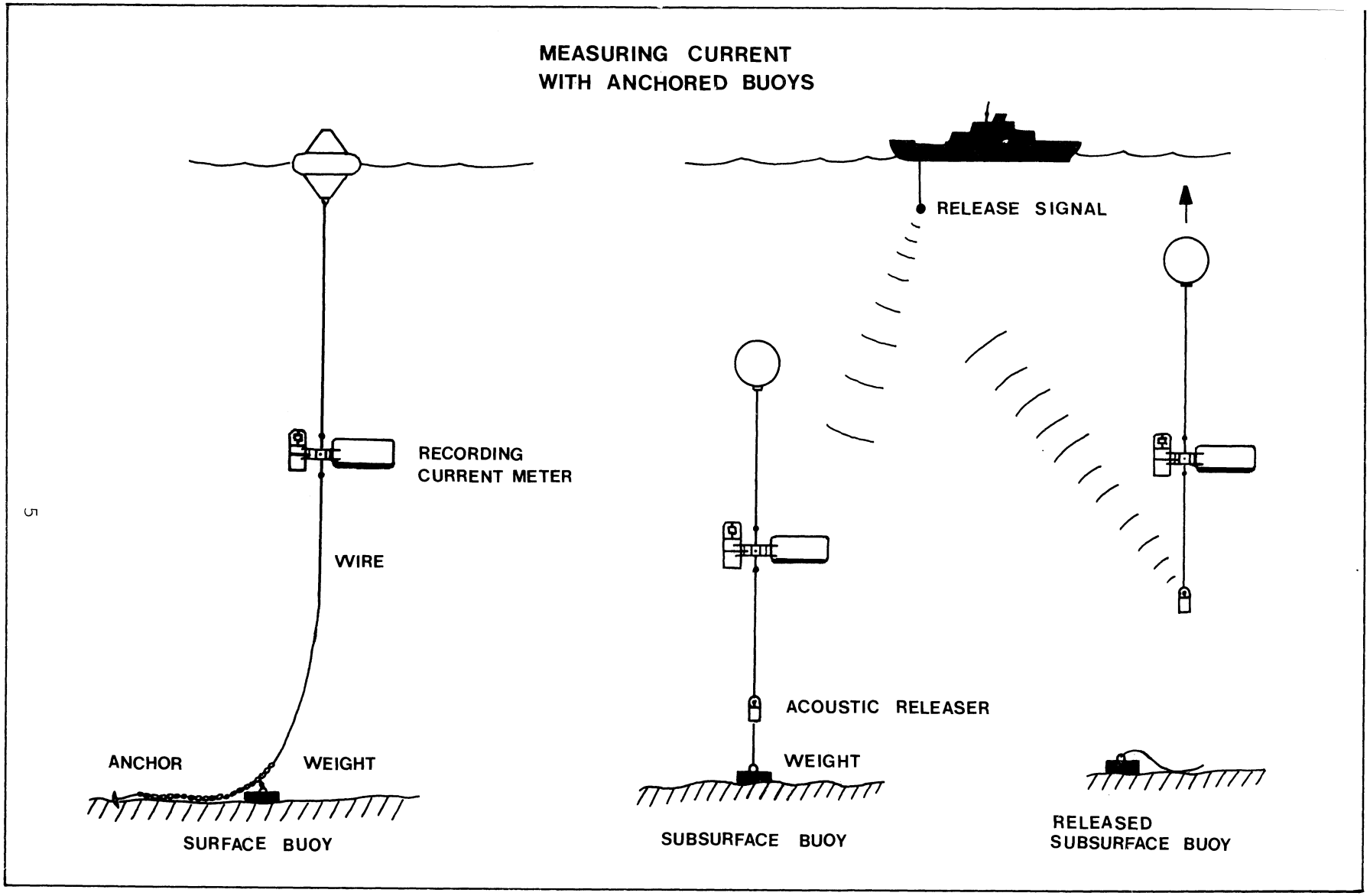

MEASURING CURRENT
WITH ANCHORED BUOYS
RECORDING
CURRENT METER
WIRE
ANCHOR
WEIGHT
SURFACE BUOY
RELEASE SIGNAL
ACOUSTIC RELEASER
WEIGHT
SUBSURFACE BUOY
RELEASED
SUBSURFACE BUOY

FIGURE 1

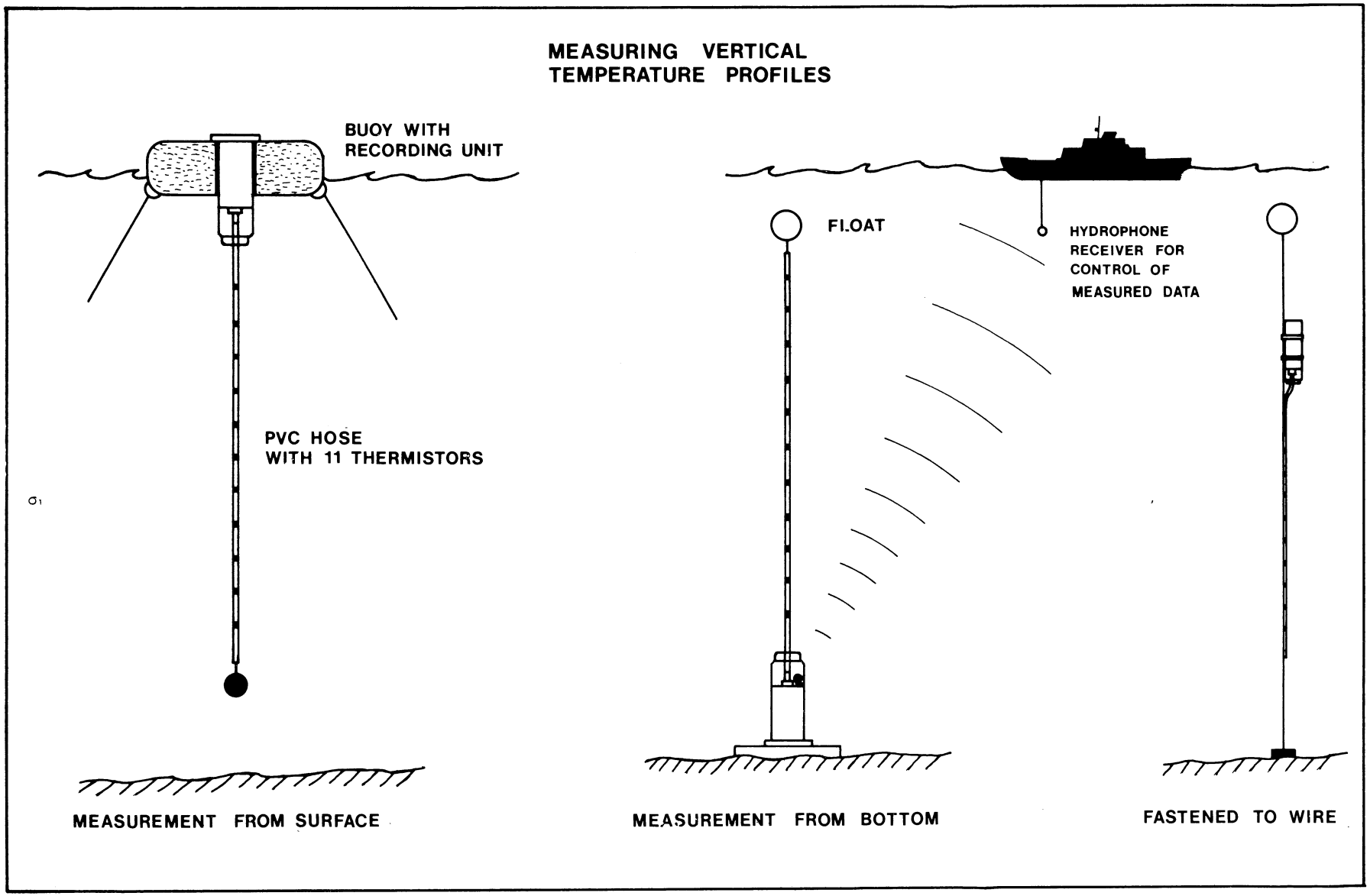
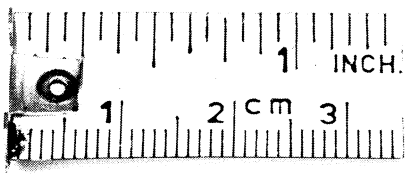

MEASURING VERTICAL
TEMPERATURE PROFILES
BUOY WITH
RECORDING UNIT
PVC HOSE
WITH 11 THERMISTORS
MEASUREMENT FROM SURFACE
FLOAT
HYDROPHONE
RECEIVER FOR
CONTROL OF
MEASURED DATA
MEASUREMENT FROM BOTTOM
FASTENED TO WIRE

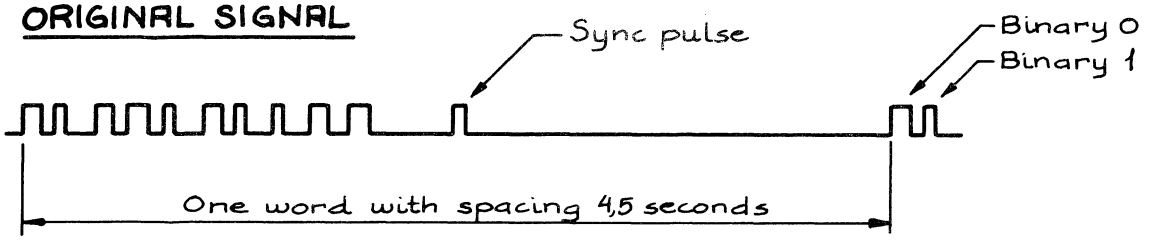
FIGURE 2



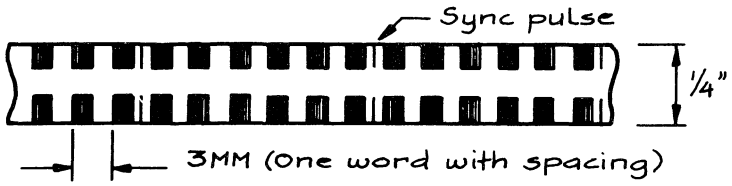
ENCODER
for
Converting data to 10-bits binary code
Driving magnetic tape
Advancing channel selector switch

FIGURE 3

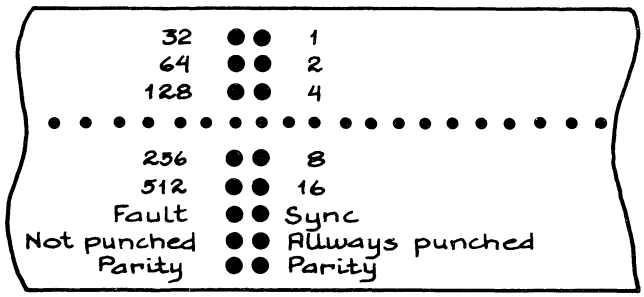
ORIGINAL SIGNAL



FORMAT ON MAGNETIC TAPE



CODE ON PUNCHED PAPER TAPE CODE FFI-PS



Tape moving direction →

Two characters for each word. Hole is punched for binary "one", and for fault. Sync is punched for last word in each record. Odd parity.

CODES AND DATA FORMAT
RANDERAA
RECORDING INSTRUMENTS

FIGURE 4

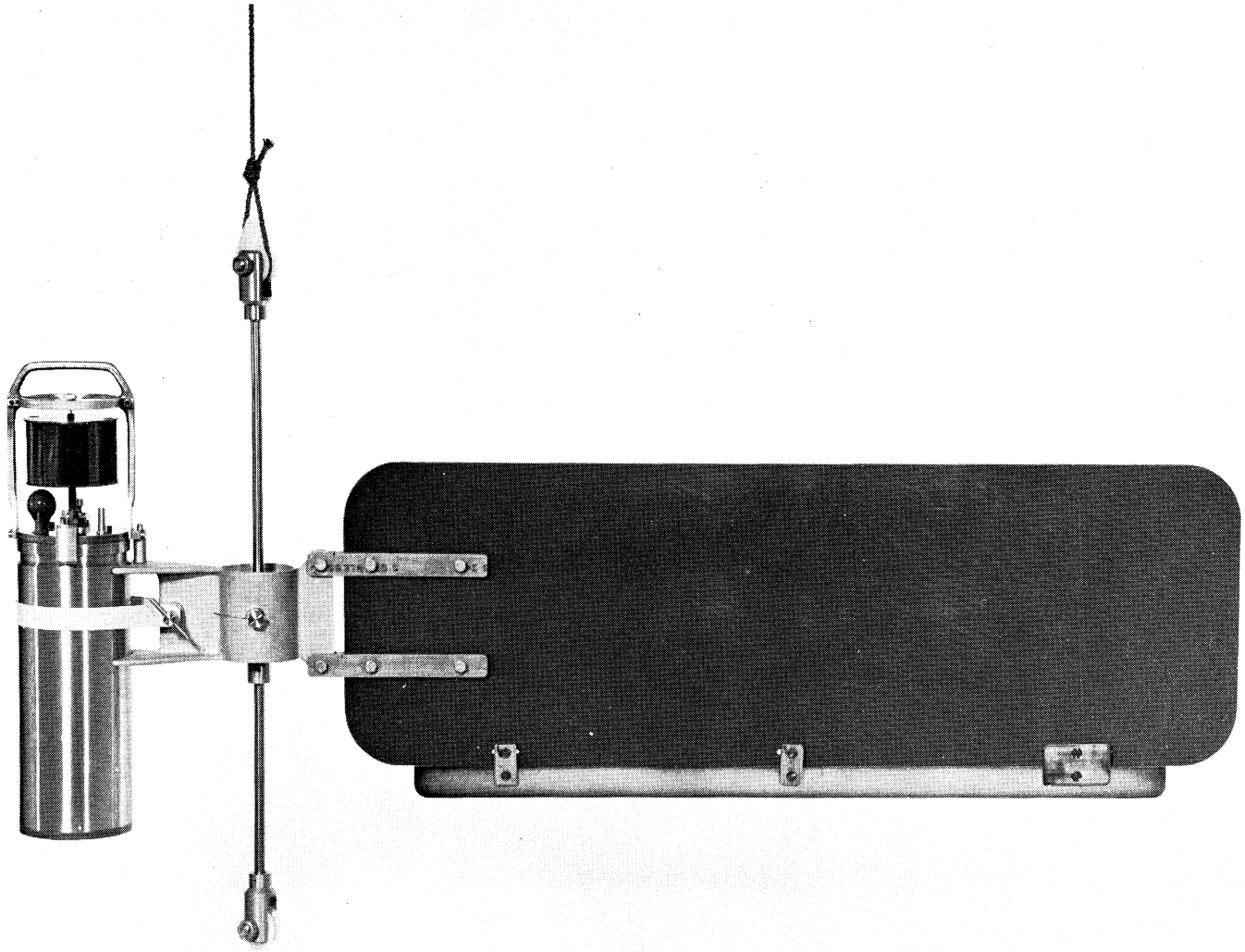


FIGURE 5

RECORDING CURRENT METER, MODEL 4

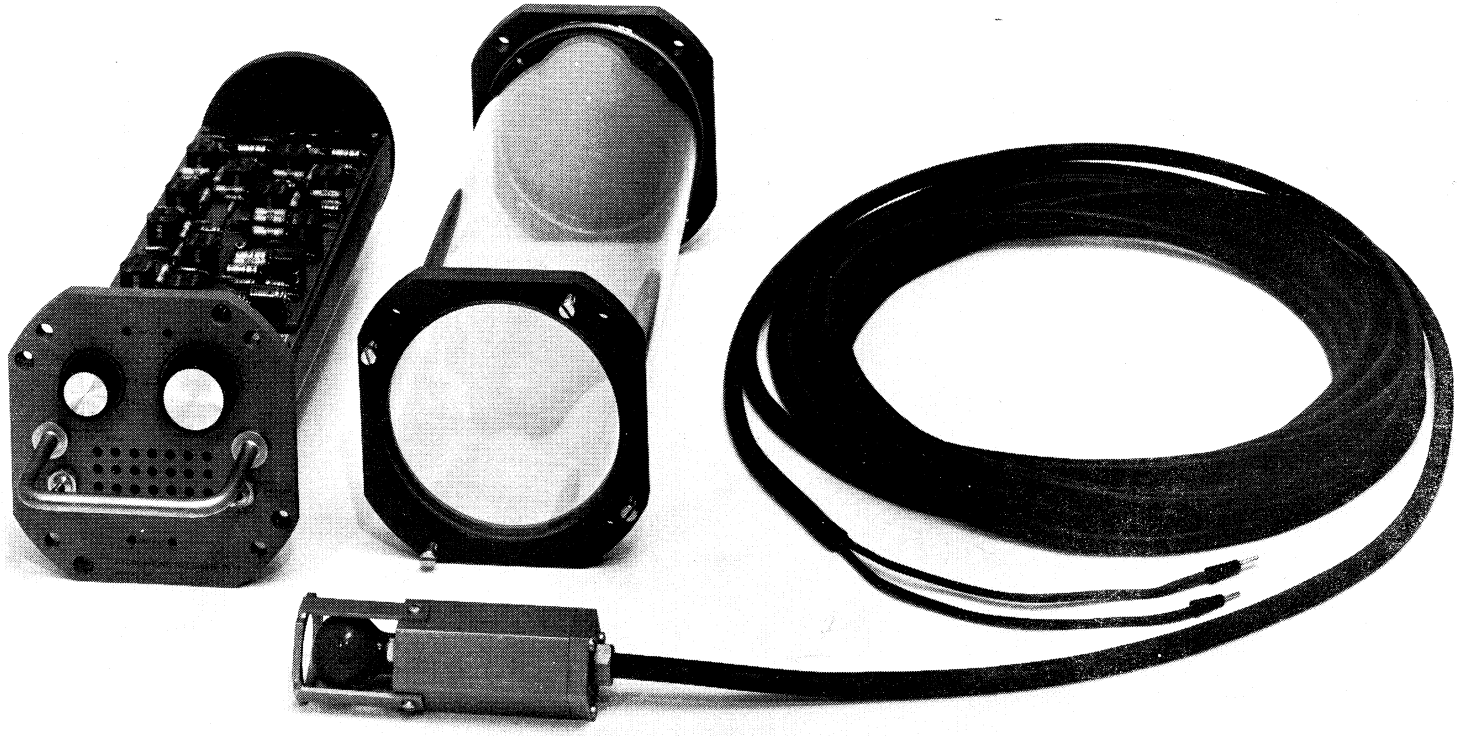
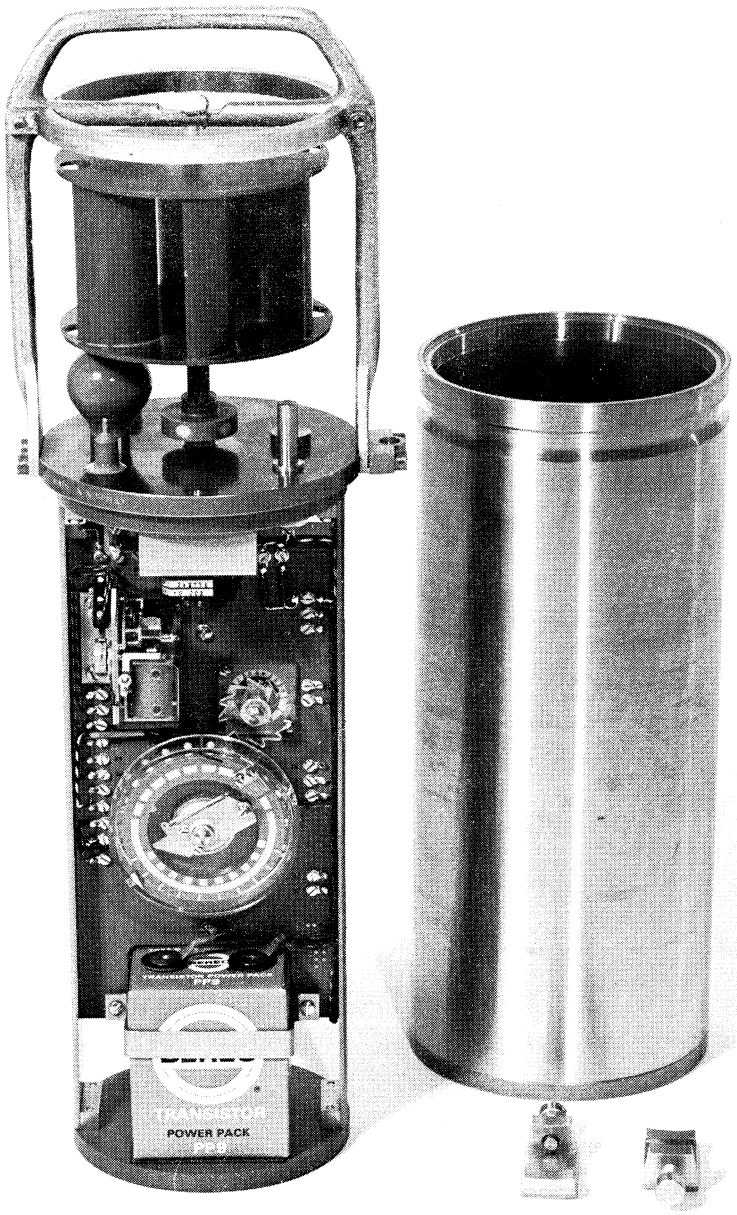


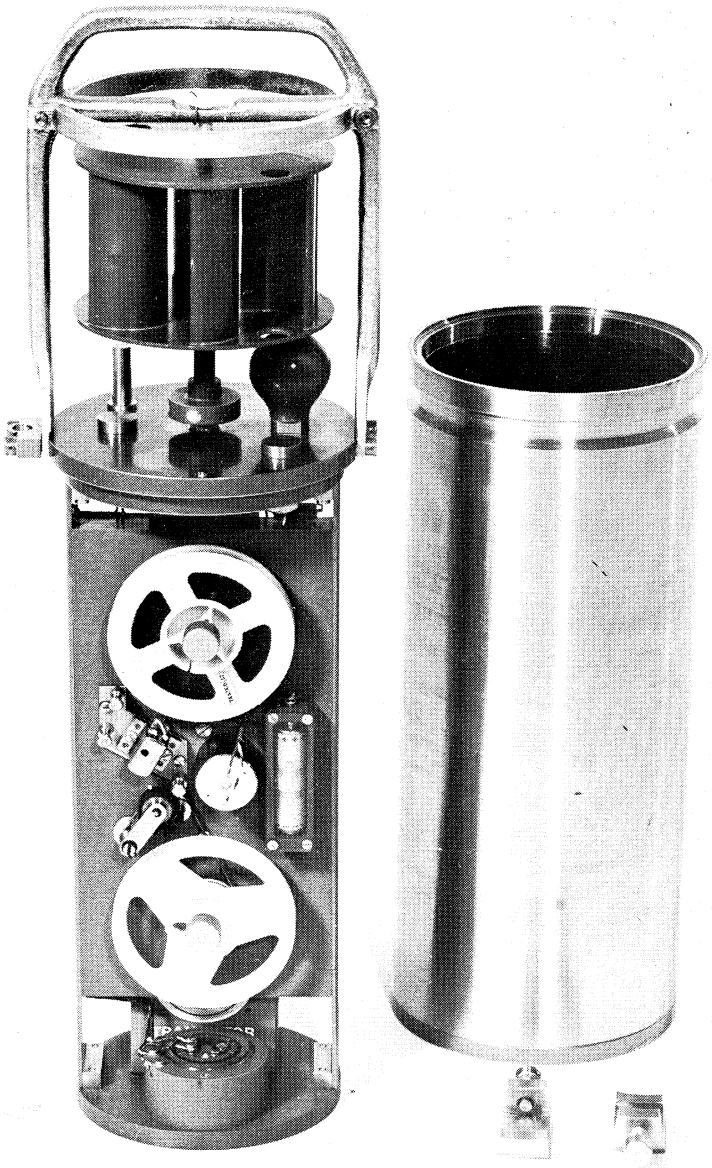
FIGURE 6

HYDROPHONE RECEIVER 14-18 Khz



ENCODER SIDE
of
Recording unit
Recording current meter model 4

FIGURE 7



TAPE RECORDER SIDE
of
Recording unit
Recording current meter model 4

FIGURE 8

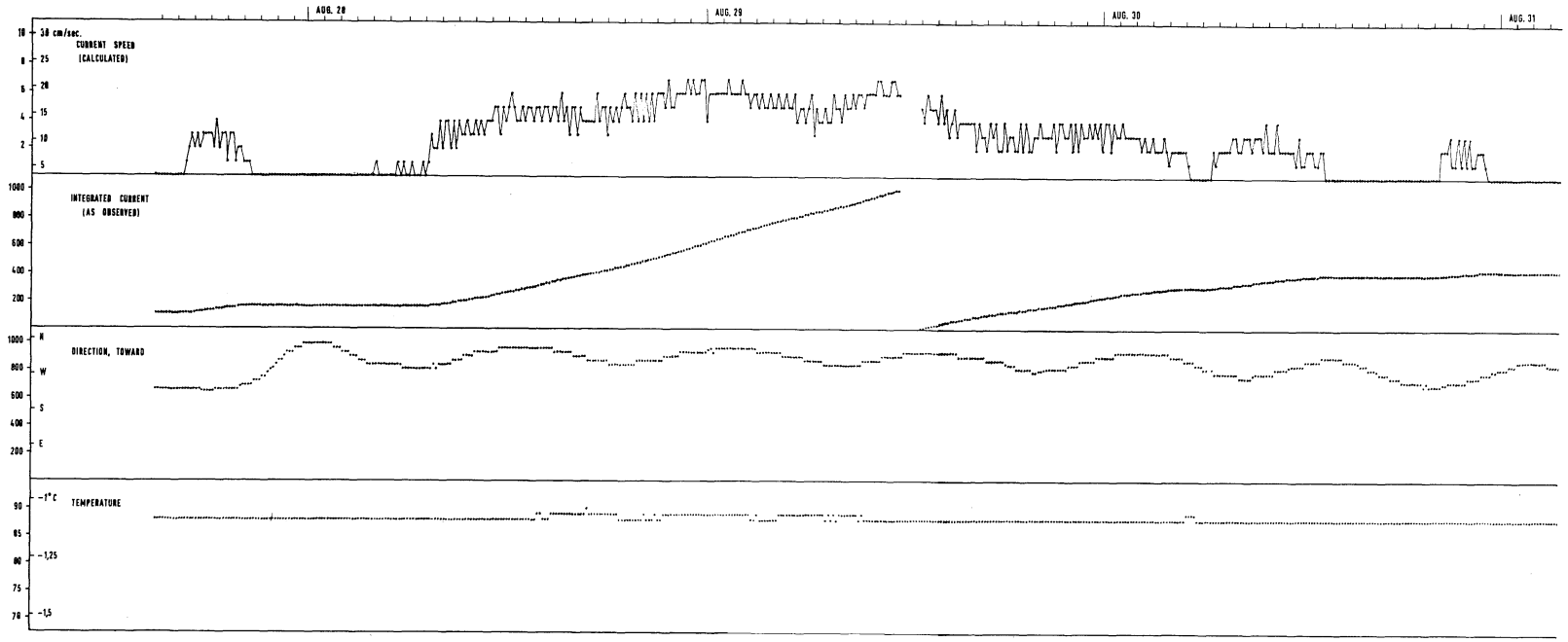
TEMPERATURE PROFILE RECORDER TR-1

FIGURE 9

MEASUREMENT NO.	REF.	TEMP.	NOT USED		COMPASS	CURRENT
0001	390	829	1023	1023	380	492
0002	390	841	1023	1023	410	492
0003	390	841	1023	1023	410	492
0004	390	845	1023	511 *	350 o	492
0005	390	850	1023	1023	380	492
0006	390	833	1023	1023	32	497
0007	390	469	1023	1023	186	527
0008	390	463	1023	1023	0	550
0009	390	462	1023	1023	62	573
0010	390	464	1023	1023	92	599
0011	390	464	1023	1023	998	626
0012	390	463	1023	1023	123	655
0013	390	463	1023	1023	154	684
0014	390	462	1023	1023	154	716
0015	390	463	1023	1023	452	749
0016	390	462	1023	1023	154	785
0017	390	462	1023	1023	154	827
0018	390	461	1023	1023	155	866
0019	390	465	1023	1023	185	911
0020	390	466	1023	1023	155	959
0021	390	467	1023	1023	185	1004
0022	390	463	1023	1023	154	0
0023	390	463	1023	1023	185	45
0024	390	463	1023	1023	154	86
0025	390	464	1023	1023	154	125
0026	390	466	1023	1023	154	163
0027	390	464	1023	1023	185	199
0028	390	464	1023	1023	185	234
0029	390	464	1023	1023	185	267
0030	390	461	1023	1023	215	297
0031	390	461	1023	1023	246	325
0032	390	464	1023	1023	216	351
0033	390	463	1023	1023	246	362
0034	390	462	1023	1023	241	378
0035	390	460	1023	1023	271	403
0036	390	461	1023	1023	211	432

FIGURE 11

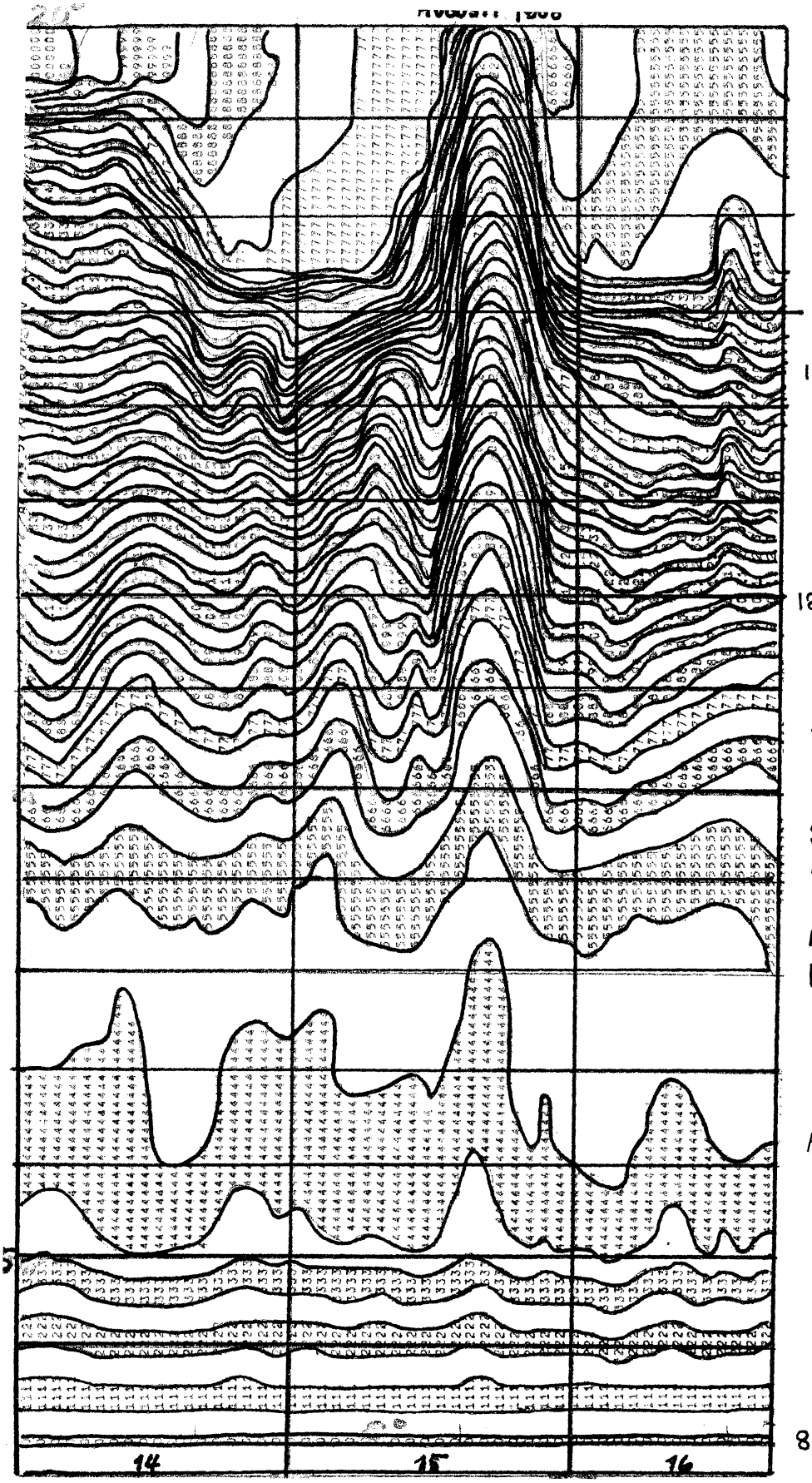
EXAMPLE UPON PRINTED DATA



BOTTOM CURRENT MEASUREMENTS IN NORWEGIAN SEA 1964

INSTR. NO.6. POS. N63°15', W00°05'.

FIGURE 12



ISOPLET DIAGRAM STATION A SWEDISH LAKE VELEN AUGUST 14.15.AN 16, 1968

FIGURE 13