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DEPARTMENT OF ENGINEERING AND SCIENCE

A NORWEGIAN METEOROLOGICAL AND OCEANOGRAPHIC DATA COLLECTING SYSTEM

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Introduction

Oceanographers and meteorologists have long been aware of the importance of reliable data from the great open oceans. At present most of the long-term and well-spaced observations has only been solved by expensive multi-ship experiments, but in the future we may hope that unnmanned automatic data collecting buoys will be an important supplement to the research vessels.

The ocean data buoy program discussed in this paper was initiated in 1971, and is sponsored by the Royal Norwegian Council for Scientific and Industrial Research (NTNF). The program has been conducted by the Chr. Michelsen Institute and the Simonsen Radio A/S, in cooperation with a number of Norwegian users institutions.

The first experimental buoy in a prototype data buoy system has been designed and built, and field experiments have been carried out in open waters with long range communication of data to an unmanned shore station. The further plans of the program includes the constructing of a small number of prototype buoys and carrying out field experiments with these in a preoperational mode.

System Description

The buoy system consists of a surface buoy, one or more subsurface oceanographic sensor packages fastened to the anchor line, and a shore station. See Figure 1. The surface buoy, which is of the spar type, carries meterological sensors, HF transmitter and command receiver, digitizing equipment, batteries, acoustic command transmitter, and acoustic receiver.

The underwater package contains oceanographic sensors, digitizing equipment, batteries, acoustic command receiver and acoustic transmitter.

The shore station comprises and HF command transmitter, a receiver and control, decoding and recording equipment.

The block diagram in figure 2 shows the flow of information. The system can operate either controlled by a clock in the buoy or from the shore station. In the first case a high precision crystal clock in the buoy starts the measuring cycle regularly, for instance every 1, 3 or 6 hours. The clock accuracy is better than 1 second pr. day.

The command receiver in the buoy, which is switched on 24 hours a day, responds on a coded interrogation signal from the shore station, and will switch on the electronic circuits onboard in the same way as the crystal clock.

The system is provided with an acoustic data link, in order to have a two way communication between the surface buoy and a number of underwater oceanographic sensor packages. (figure 1).

The data sampling cycle in the sensor package is controlled by a coded acoustic command signal from the buoy, and data are transmitted back to the buoy in a binary code on the acoustic link.

The underwater data picked up by the buoy, together with meteorological data from the buoy itself, are transmitted by the radio link back to the shore station.

Data Formats and Data Handling.

The meteorological and oceanographic sensors in the buoy and the underwater instrument has analog output signals, which are time-multiplexed and digitized in PCM-encoders. Low power CMOS integrated circuits and solid state memories are used.

The digital information is stored for a short time in a temporary memory, until the measuring period is completed. This storing last for 60 seconds in the buoy, after which the data are radio-transmitted. The storing period in the oceanographic sensor package is 2-10 seconds.
As the radio transmission takes place after the measuring period is completed, there will be no distracting effects on the sensor output voltages from the electromagnetic high frequency field from the radio antenna.

The information from an oceanographic sensor package consists of 16 binary words, each of 12 bit with 10 data bit , one parity bit and one spare bit. The data format for the meteorological instrument in the buoy is 32 words, each of 12 bit (10 data bit, one parity bit and one spare bit). The total information every measuring period from a buoy system with one oceanographic sensor package therefore consists of 48 words or 576 bit.

HF Radio Equipment.

The radio communication equipment has been constructed to use the IGOSS-ITU high frequency (HF) channels allocated for ocean data transmission. The first prototype buoy will operate in the 4 MHz band, but any ITU frequency band can be adopted.
Radio transmitter output power is max. 50 watts, and the frequency stability is ± 1 p.p.m. Type of modulation is PCM/FSK. Field experiments have been run with different modulation speeds in the range of 4 to 64 bits pr. second. The antenna onboard the buoy is a 4 m whip, which is switched between the transmitter and command receiver by a coaxial relay.

Platform and Mooring System.

The spar buoy outlined in figure 3 and 4 is made of foam plastic covered with fibreglass reinforced polyester. The substructure is made of steel. The total length is 6.8 m, without antenna, and max. diameter is 0.8 m. The floater, which is hollow and contains the instrument package and the battery bank, has a total buoyancy of appr. 1.9 tons.

The meteorological sensors are placed on the top of the buoy, appr. 2 metres above the surface and are protected by a stainless steel framework. The 4 m whip antenna and a photocell controlled xenon flash light are also included in the buoy top instrumentation.

The sea surface temperature probe is fitted in a small brass case in the bottom of the floater, and the acoustic transducer for the underwater data link is mounted on the substructure, just below the ballast-weight.
The weight of the buoy with complete instrumentation, without the mooring cable, is appr. 700. kg.

This meteorological/oceanographic observation platform is constructed for fixed moored operation in water depths of 2000 - 3000 metres. The mooring system used in water depths of less than 1000-1200 metres consists of heavy galvanized steel wire rope, chain, swivels and a small anchor.
At greather depths plastic rope has to be used.
A number of oceanographic sensor packages can be connected into the mooring line at various depths. As the data transmission from the underwater packages to the surface buoy is by the acoustic data link, there are no electrical conductors or electrical swivels in the mooring line.

Batteries.

The battery bank in the spar buoy consists of a cylindrical container with 92 dry cell elements wired to give three separate voltages. The capacity is sufficient for up to 8 months of operation.

Meteorological Sensors.

The first prototype buoy BS-1 described here, is provided with sensors for measuring these meteorological parameters:

. Air pressure (aneroid barometer),	range	: 950 - 1050 mb.
. Air temperature (thermistor),	"	: ÷ 15 - + 30°C.
. Sea surface temp. (thermistor),	"	: ÷ 3 - + 30°C.
. Wind speed (3-cup anemometer),	"	: 3 - 50 knots
. Wind direction (small wind-vane)	"	: 0 - 360°
. Buoy heading (magnetic compass)	"	: 0 - 360°

Air pressure, wind speed and direction and buoy heading are sampled several times during the 60 seconds measuring period, and an average figure is calculated by the computer ashore.

In addition to the meteorological data a number of housekeeping parameters are also sampled:

. Buoy station reference number.
. Instrument package reference number.
. Instrument package reference number.
. Internal clock data.
. Temperature inside instrument container.
. Battery voltages.

The digitizing and communication system is however provided with spare channels for additional sensors to be installed, both in the surface buoy and in the instrument on the mooring line.

Oceanographic Sensor Package.

The oceanographic sensor package, shown in figure 5, contains oceanographic sensors, digitizing equipment, acoustic command receiver, acoustic data transmitter and batteries. The electronic circuits are housed in a water-tight pressure housing, mounted in a protecting structure. Overall length is 1.2 metres, and the weight (in air) is appr. 50 kg. Maximum operating depth is 2000 metres. The instrument is provided with sensors for:

. Current speed, (two-component ultrasonic current meter)	range:	0.1 to 2 m/s NS- and EW-component
. Package orientation, (magnetic compass)	" :	0 to 360°
. Water temperature, (thermistor),	" :	÷ 3 to + 20°C
. Pressure, (semiconductor strain gauge),	" :	0 to 1000 kg/cm^2

Instrument package reference number, internal clock data and battery voltages are also measured and transmitted.

Alkaline batteries are used with a capasity for 3 months of normal operation.

Shore Station.

The shore station comprises a HF command transmitter, a receiver, a decoding, control and display unit, and recording facilities. For the field experiments this year the shore station is sited at Hjellestad Radio, south of Bergen, and long-wire antennaes are used both for the command transmitter and the data receiver.

The command transmitter is of the same type as the buoy transmitter. The adress code consists of synchronizing bits pluss 8 bits adress, and the command control is either manual or by a digital clock or by an automatic command device, activated by the control unit if a data transmission should be interrupted. The radio receiver has a very high frequency stability, (± 10 Hz over the actual temperature range), which makes it possible to use the shore station in an unmanned mode.

The decoding equipment consists of FSK demodulator, bit synchronizer, memory unit, word selector and display unit, and a paper tape recorder, (other types of data recorders can also be used).
This paper tape is computer compatible, and the computer program contains the calibration data for all the sensors in the buoy system. The data print-out sheet contains day, time, meteorological, oceanographic and housekeeping data listed in a well arranged way with headings for each of the parameters.

Field Experiments.

The first field experiment with the prototype buoy and the shore station started early this year. Since that several very valuable long term experimental periods have been carried out, both in the fjords and in open waters, in which the oceanographic sensor package and the buoy have transmitted data in 1 hour regular intervals, 24 hours a day, to the shore station for decoding and interpretation.

From the middle of August this year the experimental buoy BS-1 has been fixed moored in the Shetland-Faroe channel for a one month test period. Meteorological and oceanographic information is transmitted in 1 hour regular intervals to the unmanned shore station, where data are punched on paper-tape. Once a day the tape is fed to the NORD-1 computer for decoding and interpretation.

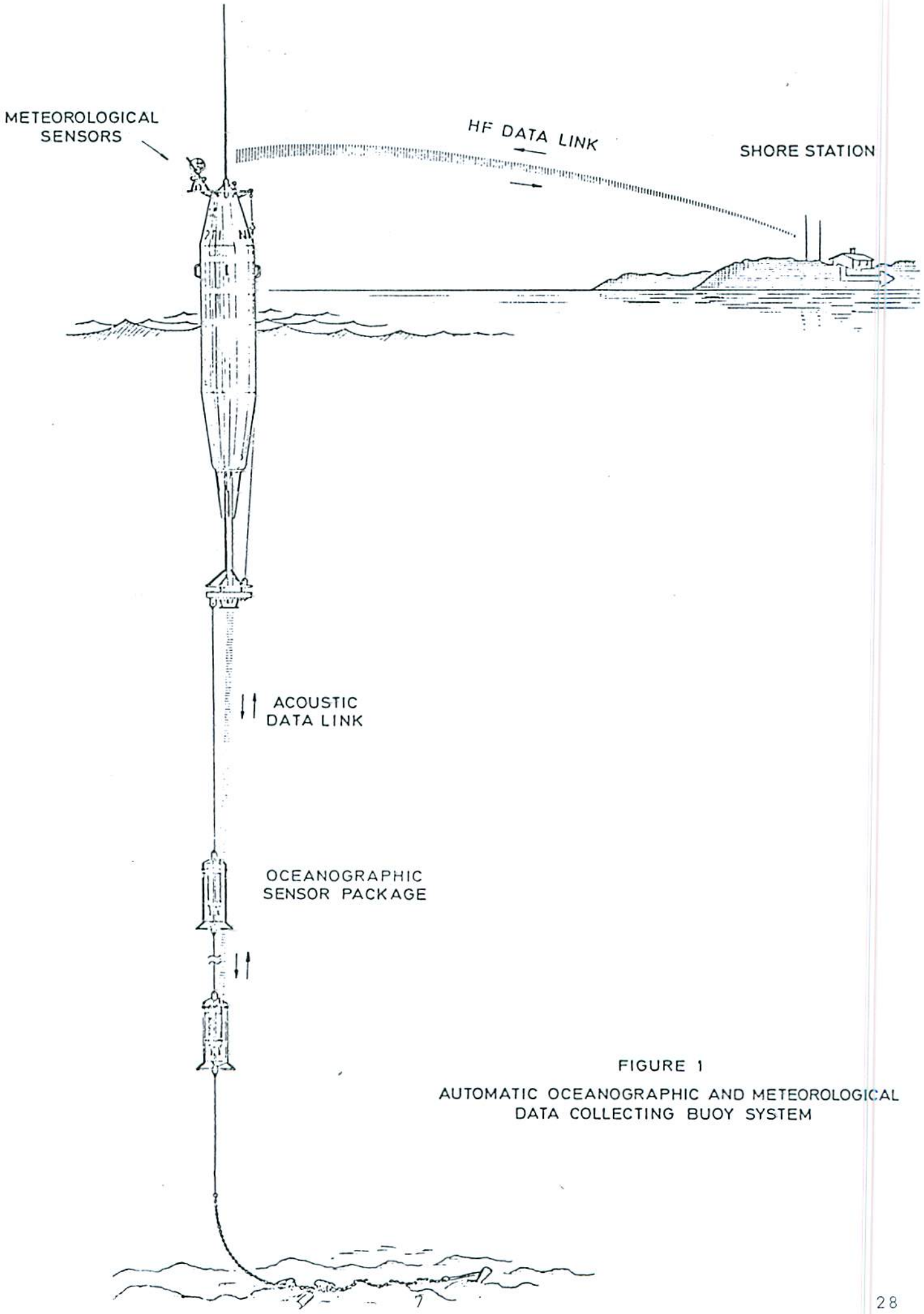


FIGURE 1

AUTOMATIC OCEANOGRAPHIC AND METEOROLOGICAL DATA COLLECTING BUOY SYSTEM

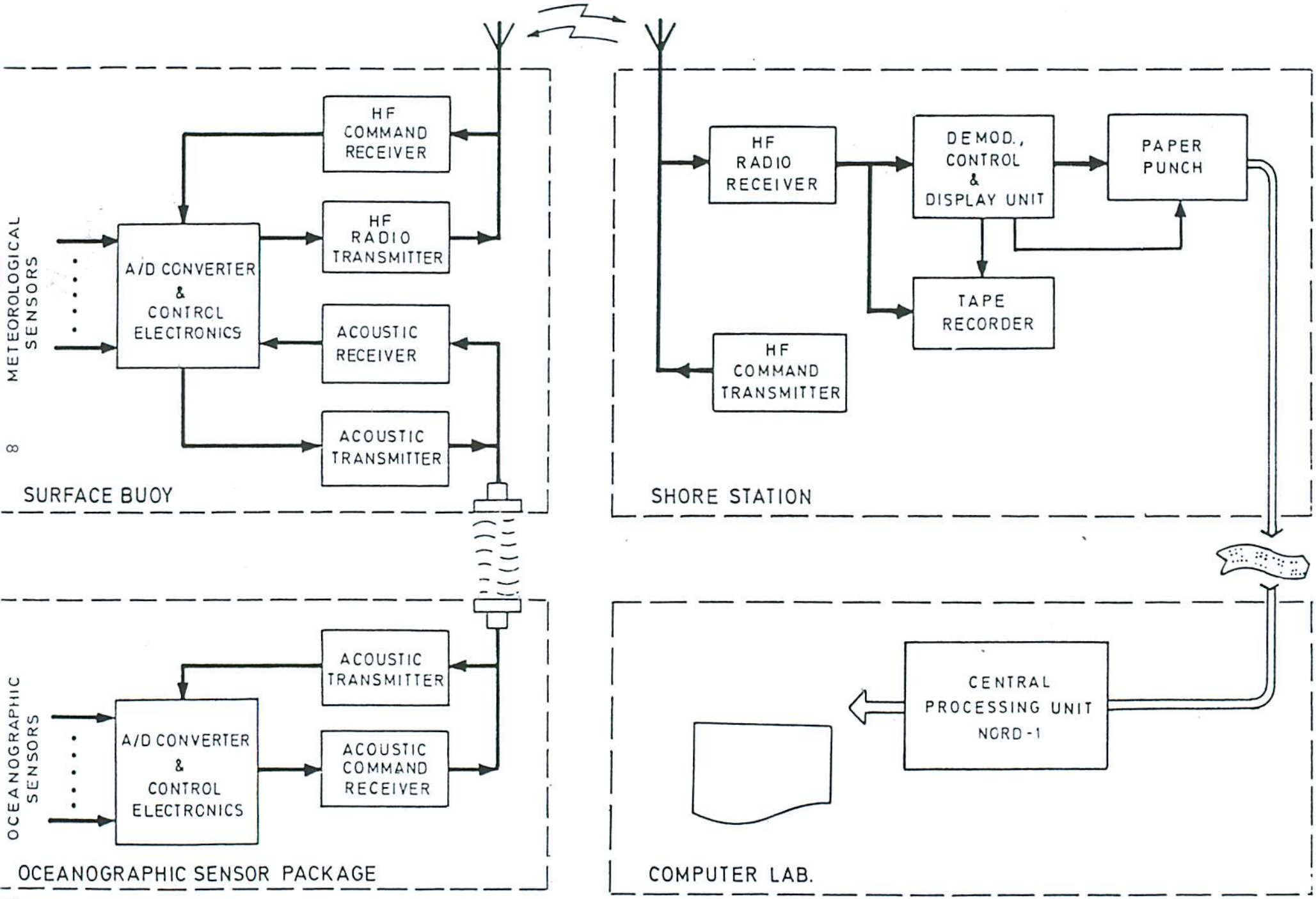


FIGURE 2

BLOCK DIAGRAM

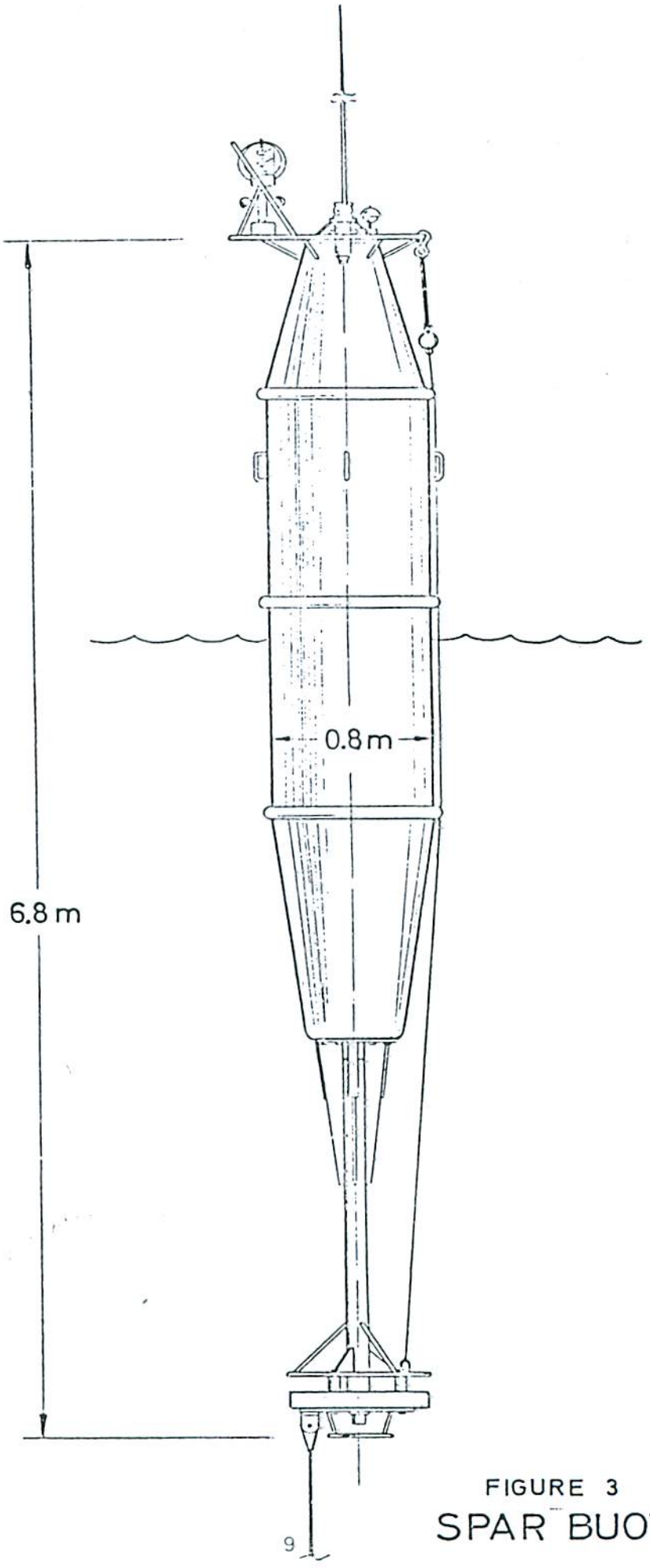


FIGURE 3
SPAR BUOY

FIGURE 4

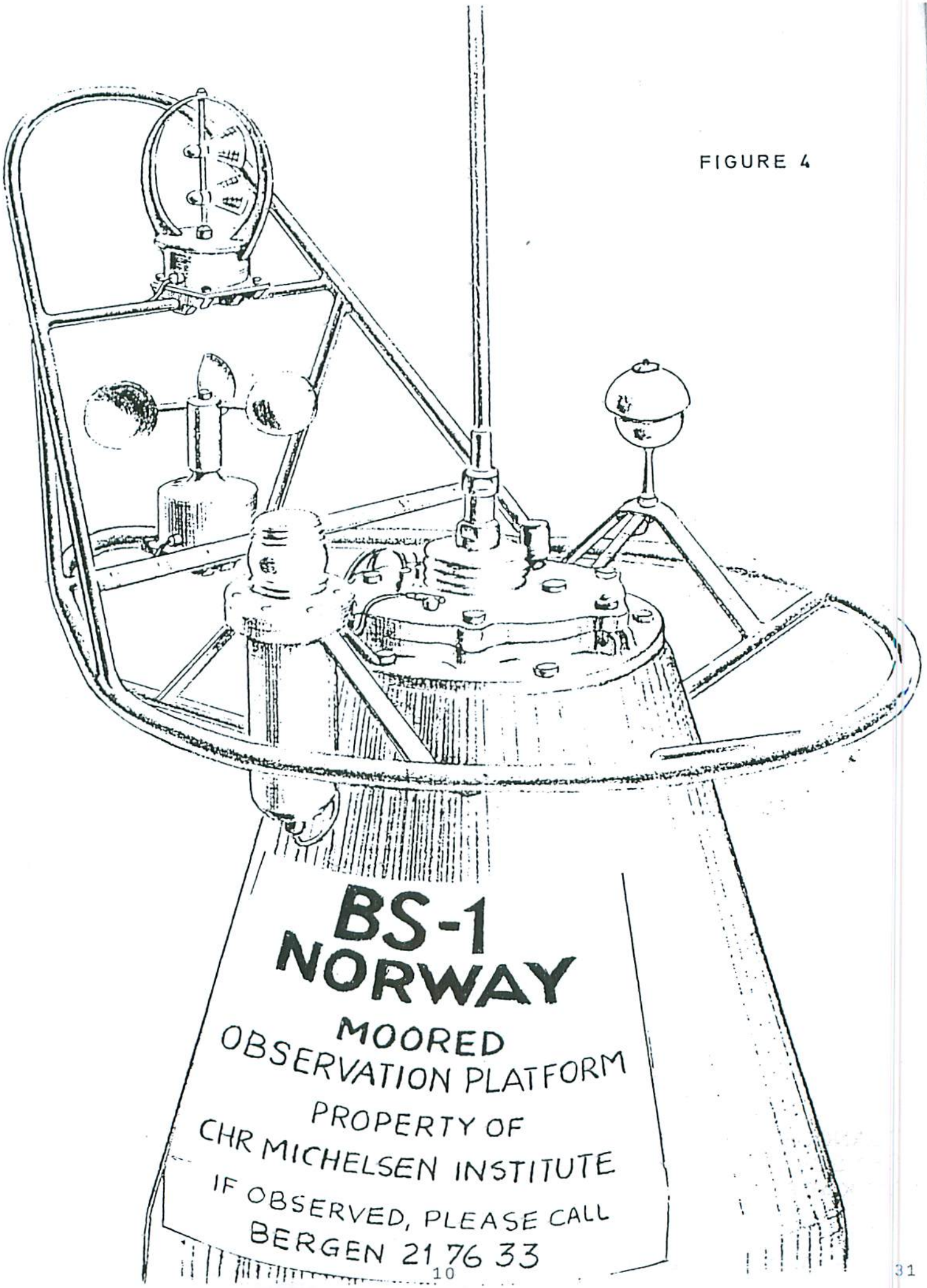
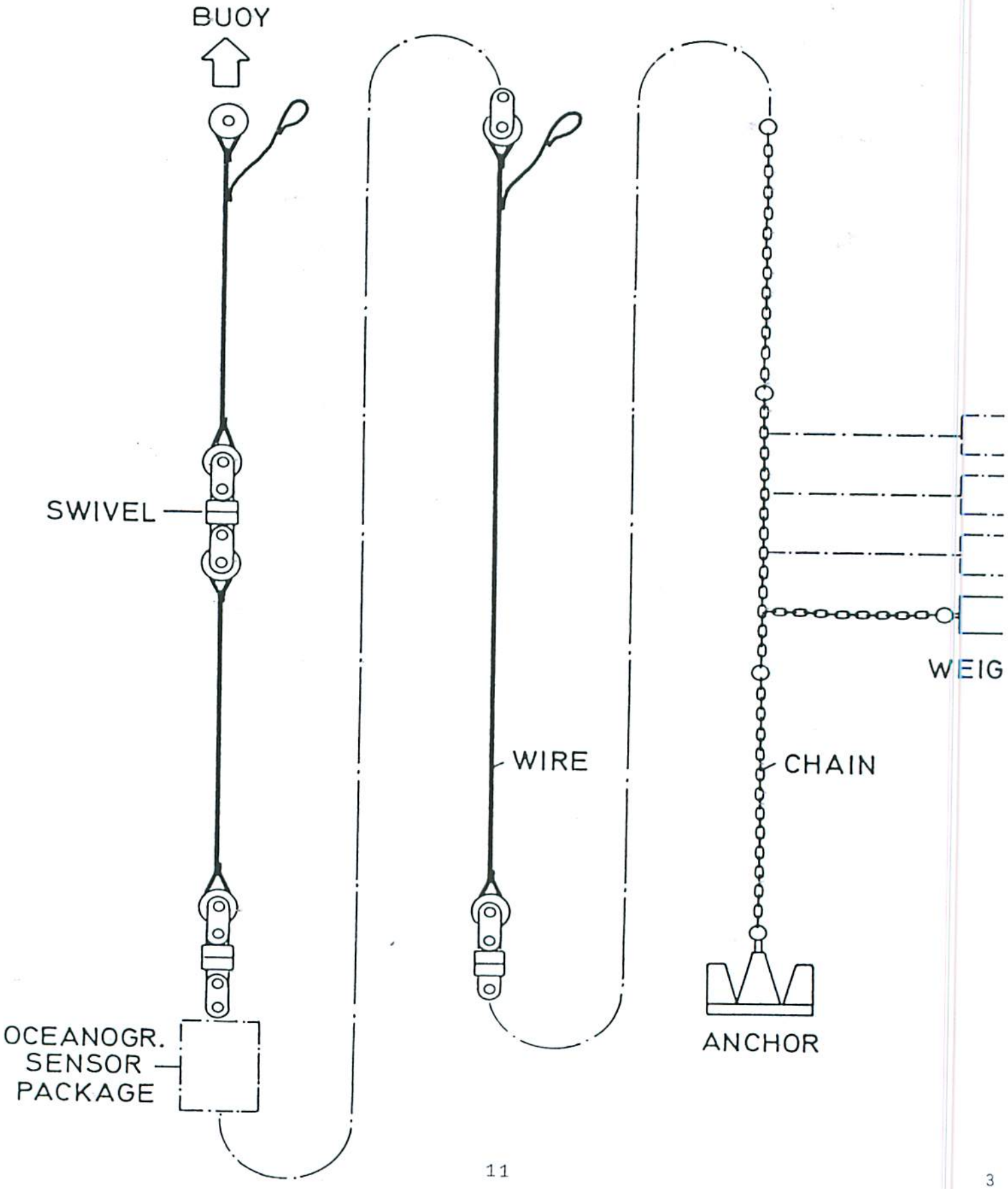

BS-1
NORWAY
MOORED
OBSERVATION PLATFORM
PROPERTY OF
CHR MICHELSEN INSTITUTE
IF OBSERVED, PLEASE CALL
BERGEN 21 76 33

FIGURE 5

SHALLOW WATER MOORING SYSTEM



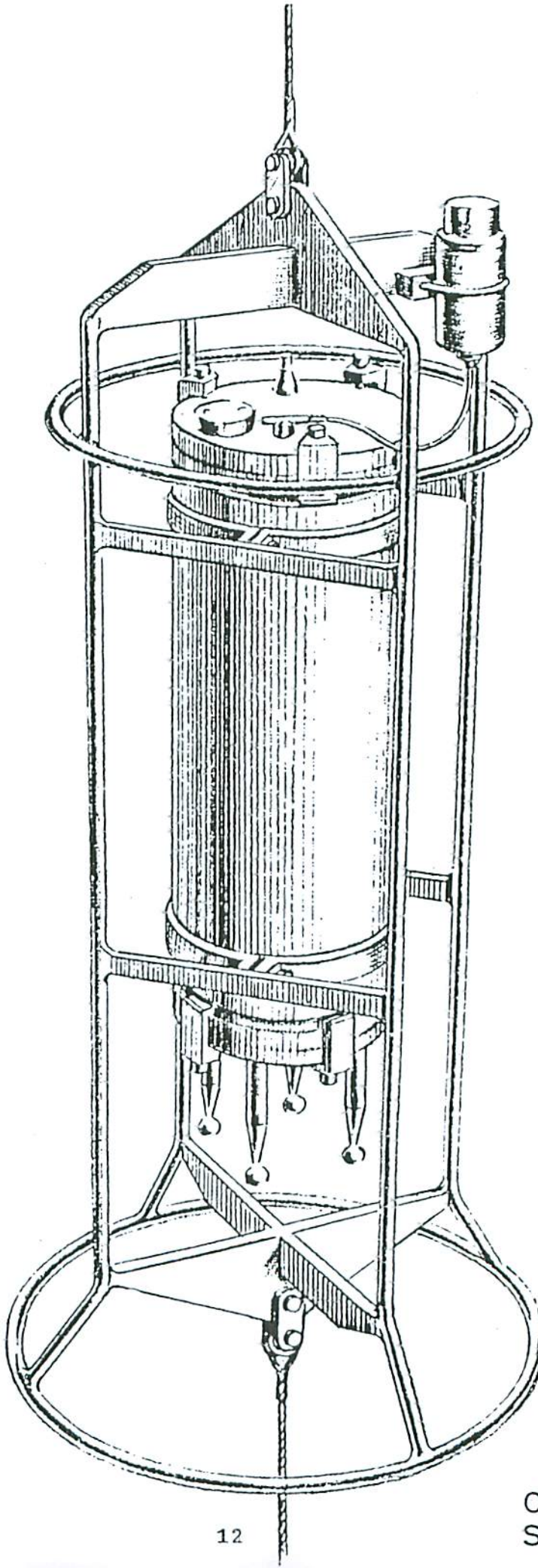


FIGURE 6
OCEANOGRAPHIC
SENSOR PACKAGE