Chapter II

Data Acquisition and Processing

by

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Foreward

This chapter is based on "The Belgian Automatic Oceanographic and Meteorological Data Station" by G. Pichot, A. De Haen and J. C. J. Nihoul, Symposium on Offshore Data Acquisition Systems, Southampton, Sept. 16-18, 1974. The author is endebted to the Belgian Navy for the help he received in collecting the data for the preparation of this report.

1.- Ships survey

The Belgian Navy provided five ships whose characteristics and activities are summarized in table 2.1. The main cruises consisted in the study

- of 25 points distributed on rectangular or radial networks (see fig. 1.1) and surveyed regularly, at least every season. Particularly, the important cruise of September-October 1973 was one of our contributions to the JONSDAP 73 (Joint North Sea Data Acquisition Programme) exercise in collaboration with the United Kingdom and the Netherlands.
- of some characteristic points of open sea and coastal waters (see fig. 1.1), considered as fixed stations and continuously surveyed during a week, in 1973.

Table 2.1

Name of the ship	Type	Length (m)	Crew	Scientists	Number of effective working days at sea			Total
					1971	1972	1973	
MECHELEN	M.S.C.	44	28	11	74	76	78	228
ZENOBE GRAMME	Ketch	28	13	3	26	32	42	100
HASSELT or HERSTAL or KORTRIJK	M.S.I.	34	12	1	37	125	80	242
Total					137	233	200	570

- of 1200 points for a unic sedimentological survey.

The results of all these cruises and their discussion are the subject of all the following chapters.

2.- Currentmeter stations

Our Plessey MO21, NBA DNC2A and VACM-AMF currentmeters were only received since August 1973 and used for the first time during Jonsdap 73.

Figure 2.1 shows the deployment of automatic stations during this exercise. Our programme assured two stations at 51°14' N 2°28' E and 51°31' N 2°25' E and contributed to the rigs of instruments intercalibration and of spatial coherency check with the KNMI (De Bilt).

The schema of the used mooring is reported on figure 2.2.

For example, the results of the bottom meter of the station (51°31' N , 2°25' E) is given, after decoding and translating its magnetic tape, fig. 2.3 where the upper and lower diagrams represent the phase and the amplitude of the current. One identifies :

- an oscillation of 12.4 h period which is the principal lunar tide M_2 .
- an about 14 days modulation which is the beating between M_2 and the principal polar S_2 .

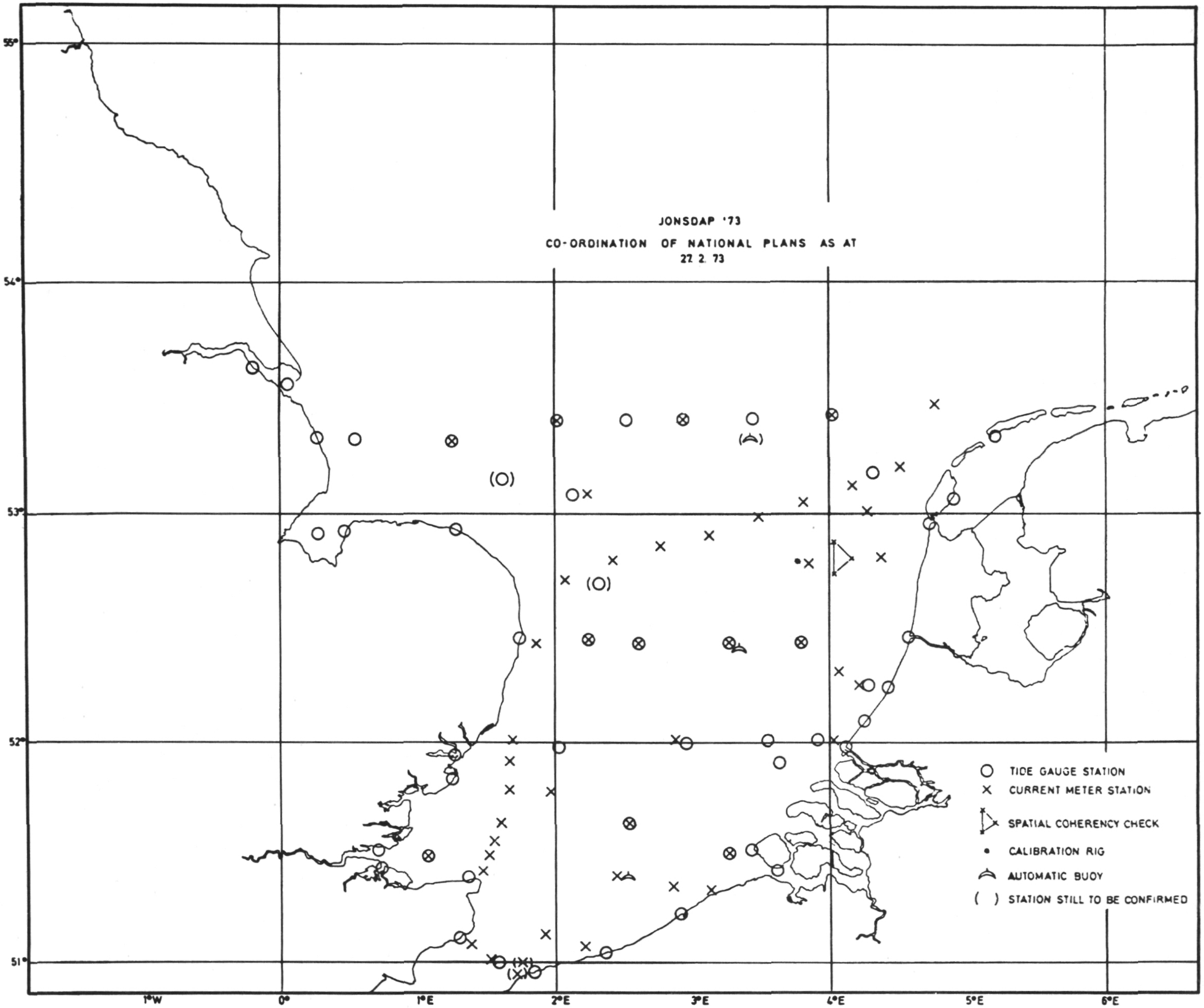
JONSDAP '73
CO-ORDINATION OF NATIONAL PLANS AS AT
27. 2. 73
55°
54°
53°
52°
51°
1°W
0°
1°E
2°E
3°E
4°E
5°E
6°E
TIDE GAUGE STATION
CURRENT METER STATION
SPATIAL COHERENCY CHECK
CALIBRATION RIG
AUTOMATIC BUOY
( ) STATION STILL TO BE CONFIRMED

fig. 2.1.

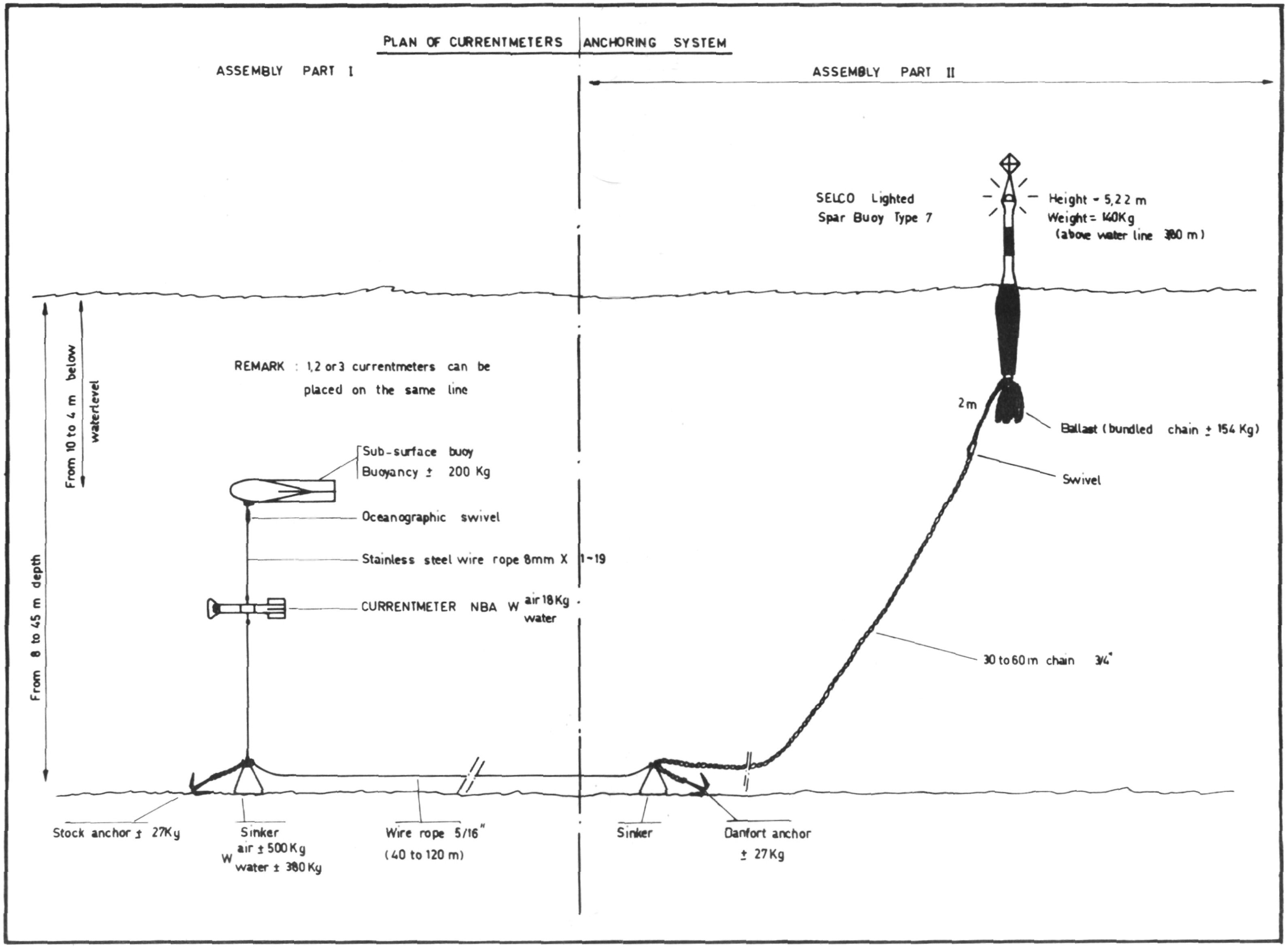
PLAN OF CURRENTMETERS ANCHORING SYSTEM
ASSEMBLY PART I
ASSEMBLY PART II
SELCO Lighted
Spar Buoy Type 7
Height = 5,22 m
Weight = 140Kg
(above water line 3,80 m)
From 10 to 4 m below waterlevel
From 8 to 45 m depth
REMARK : 1,2 or 3 currentmeters can be placed on the same line
Sub-surface buoy
Buoyancy ± 200 Kg
Oceanographic swivel
Stainless steel wire rope 8mm X 1-19
CURRENTMETER NBA W air 18Kg water
2 m
Ballast (bundled chain ± 154 Kg)
Swivel
30 to 60 m chain 3/4"
Stock anchor ± 27Kg
Sinker
W air ± 500 Kg water ± 380 Kg
Wire rope 5/16"
(40 to 120 m)
Sinker
Danfort anchor
± 27Kg

fig. 2.2.

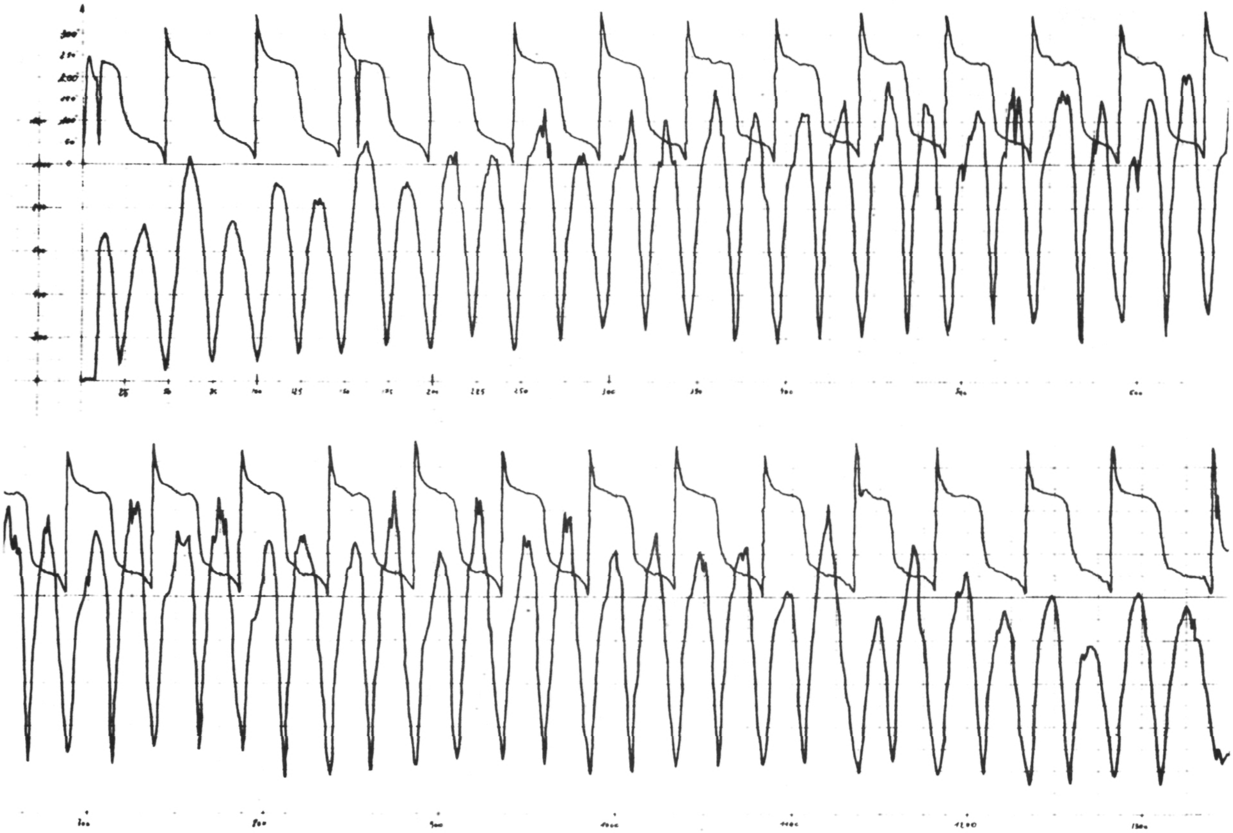

fig. 2.3.

- a daily maximum of speed due to the principal lunar diurnal tides O_1 .

- the difference between two successive maxima which is decreasing with an increasing amplitude probably due to an interaction of M_2 , S_2 and O_1 .

- the speed maximum of neap waters in opposition direction of these of spring waters due to the topography of this area.

3.- Automatic oceanographic and meteorological data stations

Because the model requires continuous knowledge of the boundary conditions, the acquisition of automatic and meteorological data stations was decided.

An *ad hoc* working group was set up to conduct a market survey. It considered the following buoys : Comex (Telem 150, HSB/1 and Borem), Sysna, Selco (type 6,7,12 and 17), Simrad (SBI, MET and satellite commanded), Hagenuk (UBA and Stamob), LCT (L55), Dornier, General Dynamics, Saclantcen and came to the following main conclusions :

1. The scarce, irregular and geographically scattered demand in this new field led to a lack of industry involvement, real competition and normal market conditions.

2. In spite of large publicity statements, most of the systems had at our own knowlegde not thoroughly, if ever, been experimented.

The buoy was required to be big and robust enough to carry safely a great amount of all kinds of sensors, to be easily noticeable by ships and to survive long periods of unattended operation in all seasons. The French Sysna buoy appeared to be the best compromise between our programme's requirements and its financial possibilities.

The electronics was designed and developed by ourselves. It is quite sophisticated so that it can receive and treat nearly any form of sensor signal, operate a certain level of pre-processing (numerical integration, vectorial projections, sums, etc.) and monitor the buoy itself (energy levels, movements, safety, etc.).

General Description of the SYSNA Buoy

The float of the Sysna buoy is a disc of 3 meters in diameter and 1.5 meters thick. Its important own stability is further increased by a 900 kg fixed ballast contained in the short elliptic stream-lined tail and also by a 1500 kg mobile ballast suspended at 8 meters below the buoy at the end of a V-shaped synthetic fibre line. This mooring chain is attached underneath this ballast.

Four hatches are symmetrically disposed on the flat deck of the buoy, around the center. They cover the cylindrical wells which contain the battery racks. A fifth hatchway gives access to the inner space of the buoy. Two easily accessible, 1 meter high, standard 19 inch instrument racks are mounted on each side of this compartment. Although they support the complete electronics, the transmitter, the control and distribution panel and some dry batteries packs, abundant space is provided for additional equipment. In addition, several smaller, completely sealed-off compartments can keep the platform buoyant in case of flooding of the main chamber.

The central, 8 meters long, tubular mast is guyed by four stainless steel cables. It supports a tubular structure to which are fixed the flashlight, the radar reflector, the antenna system and the meteorological sensors. Two wind generators are symmetrically attached to the mast, halfway up, in order not to disturb the meteorological measurements. Under normal conditions only one of them can keep the batteries fully charged.

The buoy and its mooring are shown in figure 2.4 and table 2.2 summarises its characteristics. The buoy and the mast are made of sea water resistant aluminium alloy. All precautions have been taken in order to avoid galvanic corrosion of the submerged parts.

Table 2.2

The SYSNA Buoy

Mechanical characteristics	
Overall diameter of the float	3,021 mm
Height of the float (including small ballast tail)	2,180 mm
Maximum height inside	1,580 mm
Mast length	8,100 mm
Mast diameter	150 mm
Displacement	2,000 kg
Float volume	10 m^3
Stability	2 t.m
Rolling period	2.8 s
Heave period	1 s
Spare buoyancy (with 1 ton of batteries and equipment)	7 tons
Materials used	
Buoys : AG4MC aluminium alloy, specially resistant to marine corrosion. Tubes : AG3 . Cast parts : AS 13 74 . Guys and guy fixings : stainless steel 316 (18/12 Mo).	

SYSNA BUOY

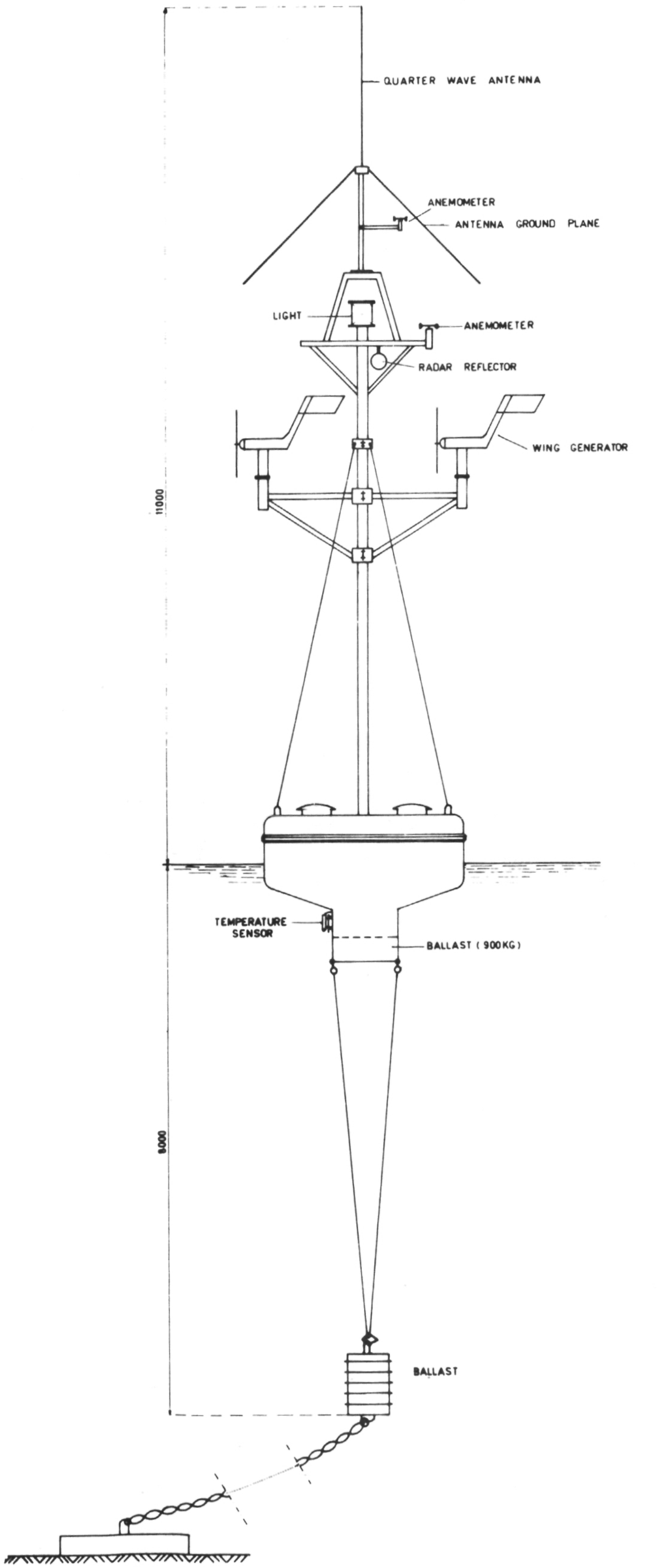

fig. 2.4.

Power Supply

Because of the general use of "COSMOS" type integrated circuits in the "Data Acquisition System", its power drain has been kept very low and is of the order of 3 watts. The used voltages are + 24 volts and - 18 volts for the D.A.S. and + 24 volts for the radio transmitter, the sensors and the light.

1) Wind generators

Two AEROWATT type 24FP7 wind generators are the buoy's main energy source. Under normal conditions, the battery buffered output of only one of them is sufficient to maintain the whole buoy system including the powerful flashing light in operation.

Their main characteristics are :

a) Electrical

- direct drive permanent magnet two phase alternator. The output is converted to DC by two built-in diode bridges;
- rated power output : 24 watts (for a 7 m/s wind speed);
- rated voltage : 24 volts.

b) Mechanical

- propeller : directly mounted on alternator shaft;
- two lightweight specially treated wooden propeller blades;
- variable pitch automatically controlled by wind pressure;
- average starting wind velocity : 3 m/s ;
- maximum rotation speed : 1200 rev/m ;
- overall length : 1530 mm ;
- propeller diameter : 1000 mm ;
- total weight : 20 kg ;
- wind drag at 30 m/s : 26 kg .

2) Rechargeable batteries

The inconvenience of wind generators is their irregular output. This is why they are buffered by 24 V , 195 A hours lead acid batteries. This set gives the buoy system an endurance of 7 days at full performance in the complete absence of wind by total generator breakdown.

3) Expendable batteries

A small set of dry Mallory Duracell alkaline manganese batteries provides a negative 18 volts, 20 A hours power supply for operational amplifiers and various other circuits requiring a negative polarisation. As a simplification this negative voltage will be provided in the future directly from the mains 24 volts by a solid-state DC-DC converter.

A powerful set of 24 volts 4000 A hours Cipel zinc-oxygen expendable batteries with KOH liquid electrolite previously was the primary energy source of this type of buoy. These batteries have shown to be expensive, cumbersome and unreliable, if not dangerous, when used on a buoy. More compact and safer marine type Nickel-Cadmium rechargeable batteries have been purchased to replace them. They will be connected to the wind generators.

4.- The data acquisition system (D.A.S.)

General description

The basic unit consists of a signal scanner and an A to D converter for analog inputs, and of a code adaptor and a digital multiplexer for the digital inputs. Auxiliary circuits adapt a wide range of input signals, numerically integrate certain parameters, record the time of the measurements, etc. The general use of "COSMOS" integrated circuits lead to high reliability and very reduced power requirements.

1) The analog to digital converter

It is a precision, crystal controlled time interval meter. Its standard *analog input* is a series of frequency modulated pulses. Its *digital output* is in BCD code and is fed to the transmitter's modulator.

2) The scanner

An electronic 32 channel switching device successively interrogates the oceanographic and meteorological sensors. This switching affects not only the sensors output signal but also its power supply in order to reduce power drain, drift due to sensor self-heating and to eliminate possible cross talk on signal cables. Power is provided a certain time before the actual measurement to the integrating channels as well as to the sensors which need warming up.

3) The input adaptors (signal processing)

a) F.M. signals

Each of the scanner's input channels is made to receive a series of frequency modulated pulses. Amplifiers, limiters and pulse shapers allow the processing of any F.M. voltage. In addition, a series of dividers adapt the scale to a wide range of frequencies.

b) D.C. voltages

They are measured by the channels equipped with voltage-to-frequency converters.

c) Digital inputs

By means of buffer memories and under scanner clock control, the system can also directly receive, process and dispatch the information from sensors or sub-systems already equipped with digital outputs.

4) The numerical integrators

For accurate integration over long periods, the F.M. signals are stored in individual digital counters. These operate simultaneously and the integration time is set with precision by the general quartz oscillator clock. The digital output of these counters is then multiplexed under scanner control.

Technical characteristics

1) The analog to digital converter

It is a time interval meter counting the number of reference pulses issued by the precision quartz oscillator between two successive signal pulses. This way it converts the analog F.M. signals from the sensors into a number presented in parallel digital form. This time interval meter, as well as the integration modules, uses the B.C.D. 8.4.2.1. code. Accuracy :

FM signals : 10^{-5} ,

DC voltages : 10^{-3} ,

Full scale resolution : 10^{-6} .

2) The scanner

a) The scanner now has 32 channels. Possible extension up to 64 is provided.

b) A front panel selector limits the number of channels to be interrogated. It adapts the scanner to the actual number of sensors.

c) A "Single Channel Repeat" selector blocks the scanning cycle on any desired channel, excluding all the others. This facility is used for testing or calibrating a given sensor.

d) For easy data processing, prior to the radio transmission the corresponding channel number is added in front of each measurement.

e) The interrogation speed can be adjusted from 1 to 10 seconds per channel. The actual speed of 1 channel per second seems to be a suitable compromise between radio band width considerations on one side and short transmission time and a reasonable simultaneity of the measurements on the other side.

f) The normal sequence of an interrogation cycle is :

Channel N° 1	: Buoy identification number;
2	: Time of the measurement cycle : (day, hour, minute, second);
3	: Control fixed frequency;
4-7	: Digital inputs;
8-11	: Voltages or frequencies to be numerically integrated;
12-22	: Voltages;
23-32	: Frequencies.

Thanks to the modular structure of the system, the sequential order as well as the number of channels of each type can be modified.

g) The interval between cycles is adjustable from "continuous" to one cycle a day. Intervals of half an hour for testing and of three hours for normal operational use seem most adequate.

3) Timing unit

This general time base is controlled by a 100 kHz crystal oscillator. It delivers the reference pulses for the counters as well as the time of day. It controls the integration periods, the scanning rate, the cycle repetition rate, etc.

4) Input signals

a) Frequency modulated alternating current or pulses. Dividers allow to measure signals over 30 MHz.

b) DC voltages 0-10 mV , 100 mV , 1 V and 10 V ; input impedance : 100 kOhm .

c) Voltages and frequencies to be numerically integrated during 1 , 10 or 30 minutes .

d) B.C.D. coded parallel digital inputs.

5) Output signals

Binary coded decimal "8.4.2.1" code, serial output.

6 measurement digits	24 bits
2 channel number digits	8 bits
channel separation	8 bits
Total	40 bits

To reduce the number of transmission errors due mainly to interference or fading, the self correcting "Hamming" code is used. The additional parity bits needed bring the total length of one measurement to 80 bits.

6) Modulator

This unit transforms the "clock" and "information" pulses delivered on two lines by the D.A.S. into a Pulse Length Coded 2500 Hz modulation subcarrier which is then applied to the transmitter's input.

7) Dimensions and environment

The complete unit can be contained in a 36 cm diameter, 50 cm long cylinder. Operating temperature ranges from - 2 to 40 °C with standard integrated circuits.

5.- Data Transmission

The data are transmitted to Ostend by a 10 watt completely transistorized FM transceiver operating in the lower VHF band (Mobilophone CMT Phillips). A complete transmitter-receiver is used as well on the buoy as at the receiving station for two main reasons :

- equipment standardization and interchangeability;
- possibility of a bi-directional radio link for future remote control and selective interrogation.

The essential characteristics are :

Dimensions : 70 × 235 × 235 mm ;
Weight : 3 kg ;
Power requirements : 24 V DC (21.1 to 31.7 V) ,
transmission 2 A (48 W) ,
receiving 0.12 A ;
Transmitting frequency : 31.850 MHz ;
RF output power : 10 watts;
Modulation : Phase modulation;
Encoding : P.C.M. applied to 2500 Hz subcarrier;
Antenna : Quater wave fiberglass whip and ground plane elements;
Range : 80 km minimum.

6.- Sensors

For the moment, the buoy is only equipped with some sensors which are known as the most reliable at sea. They measure wind speed, wind direction, barometric pressure, waves (Datawell heave sensor), air temperature and water temperature. The two latter ones are built and calibrated by ourselves.

Other sensors, and sometimes the most interesting ones, are still in an experimental phase, not yet miniaturised, cumbersome and energy greedy. Their long term fiability is not warranted in reason of corrosion, fouling and shocks.

Sensors for direct and reflected light, pH, dissolved oxygen, heavy metals by accumulating, phytoplankton activity by autoradiography are at present in research and development.

7.- The data processing computer

A data processing computer is installed in Ostend and linked to the receiving radio station. It is a Hewlett Packard Type 2100 computer with a 32 k words of 16 bits core memory. The various peripherals and input-output devices such as fixed and removable disc, magnetic tapes, teleprinter, fast tape puncher and reader, Tektronix CRT video display, 30 cm and 80 cm Calcomp plotters, Tally line printer, etc. make this relatively small computer specially suitable for receiving large amounts of data in all kinds and to output them after processing in any desired format.

The principal processing phases are :

- transcoding of the received binary data,
- putting in order the digits, the numbers and then the measuring cycles,
- dispatching of the data arriving from different stations,
- synchronisation and introduction or correction of the time scale,
- translation of the received numbers into proper parameters, by means of the calibration equations,

- control of the data : listing, display on video tube, automatic plots, statistical methods,
- editing, after manual or automatic error detection,
- concentration of the data : weighted averages, numerical filters,
- statistics, correlations, power spectra, ...

It is very important that most of these operations can be carried out "on line" and the remaining ones as soon as possible after reception of the data in order to detect any instrumental malfunction immediately and to make them available for a direct, easy and efficient use in our mathematical models.