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A NEW MINIATURE INSTRUMENT FOR IN SITU MEASURING, PROCESSING, RECORDING AND DISPLAY OF OCEANOGRAPHIC PROPERTIES

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ABSTRACT

The paper describes the design philosophy and functions of a new general purpose oceanographic instrument which is presently being tested as a prototype.
The instrument combines established oceanic sensors with modern microprocessor and display technology. The basic idea behind the design is to make a compact and modular "workhorse" instrument that interacts with both humans and computers in a natural way.
The instrument is presently able to measure and to in situ process current speed, direction, temperature, depth and salinity. The processed data may be in recorded in the instrument, visually displayed from the instrument or continously transferred to external processing devices via cable. Other sensors in addition to the already mentioned may be added in the future.

Introduction.

New developments in marine instrumentation can typically be divided into two categories:

1 New instruments based on novel sensor technology.

2 New instruments which use established sensor technology in an more advanced way than previous designs are able to.

Instruments belonging to category 1 are often pioneering instruments which in the hand of the right persons contribute to move scientific barriers.
However, instruments of category 1 are generally expensive and difficult to operate- even when they are successful. .

Instruments belonging to category 2 are in general less expensive and more easy to use. They will not move barriers, but by exploiting years of user's field experience with different measuring principles and sensors, such instruments may significantly contribute to make more efficient field observations.

The instrument which will be described in this paper is a category 2 instrument.

The design idea behind this new instrument is to integrate modern microprocessor technology with known field proven sensors to make a compact ,inexpensive and" intelligent" oceanographic "workhorse" instrument.

Use of microprocessors in marine instrumentation.

An oceanographic instrument is basically a machine that collects and processes information from underwater sensors in a programmed, sequential way .

Traditionally the sequence of operations is conntrolled by the user himself or by a dedicated electronic and/or mechanical device.
In the classical EKMAN current meter, f.inst. a dedicated mechanism makes the motion of the propeller to drop small metal balls into bowls that are positioned by the compass needle. This mechanism is unique and can never be modified to perform other functions.

During the last 10 years designers of instruments have had access to universal , programmable logic units called microprocessors.

Fig. 1 shows the block schematics of a typical microprocessor.

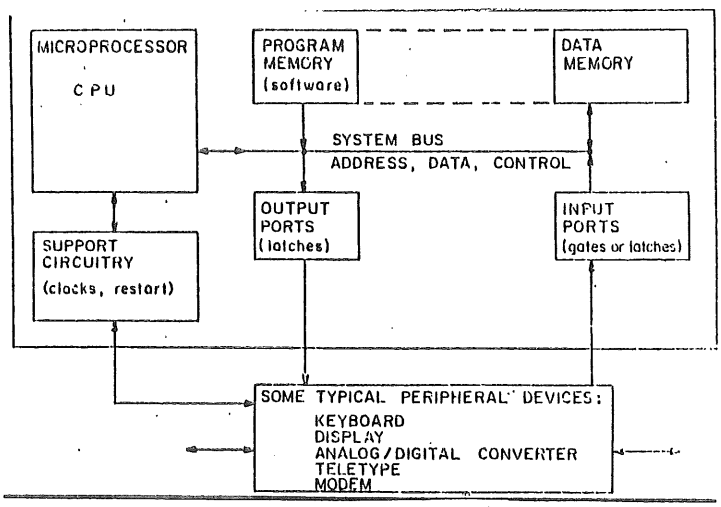

Fig.1

Organization of a typical signal processing system based on a microprocessor

A central processing unit inside an electronic chip is able to fetch sequential commands from a "ROM" type instruction bank.

The commands, which may be fetched and carried out wihin a millionth of a second, will tell the central processing unit (CPU) to collect or process information or to send out information and instructions via its in/out ports. It may also be ordered to modify acquired information according to fixed or adapted formulaes and to store or present information in internal and external devices.
The microprocessor itself is a completely general component. One such component may control signals from a critically ill patient in a hospital,while an identical component may control the operation of an automobile . This generality makes it possible to mass manufacture very complicated chips for a modest unit price.
The individuality of the microprocessor lies solely in the dedicated program that the designer puts into it.

Design strategy for the new instrument.

The design strategy for the instrument described in this paper is simple:

1:Use the mechanical design of the "MINI CURRENT METER which was described in (ref. 1.)
2:Measure current speed with the Savonius type rotor that has been successfully used for years in the Aanderaa model RCM-4 current meter .

3: Measure conductivity with an improved version of the inductive conductivity cell type that is used in the same instrument

4 Measure direction with the field proven clamping type compass design which is used both in the MINI CURRENT METER and the RCM-4

5 Measure pressure with a modern,well documented pressure transducer (Keller model PR-10)

Measure temperature with a , high quality thermistor (Fenwall GB32JM19) which has been used in thousands of oceanographic instruments.

6 Use a modern C-MOS based microprocessor (Intel 80C31) to scan the sensor information, to correct for their nonlinearity, pressure and temperature dependence .Let the processor compute derived and combined sensor information like vectorial current speed, salinity and sound velocity. Program the processor to store the acquired data in its memory and to display it and/or transfer it to external printer, plotter or computer when the user wants his data.

Also use the processor capabilities to inform the user of what is going on inside the instrument:
Show what intervals that have been programmed. Give signal each time when a measurement takes place. Tell how much battery and memory capacity that is left. Give a selv diagnosis service that warns the user if parts of the instrument fail to work properly.

Fig. 2 shows a block diagram of the new instrument.

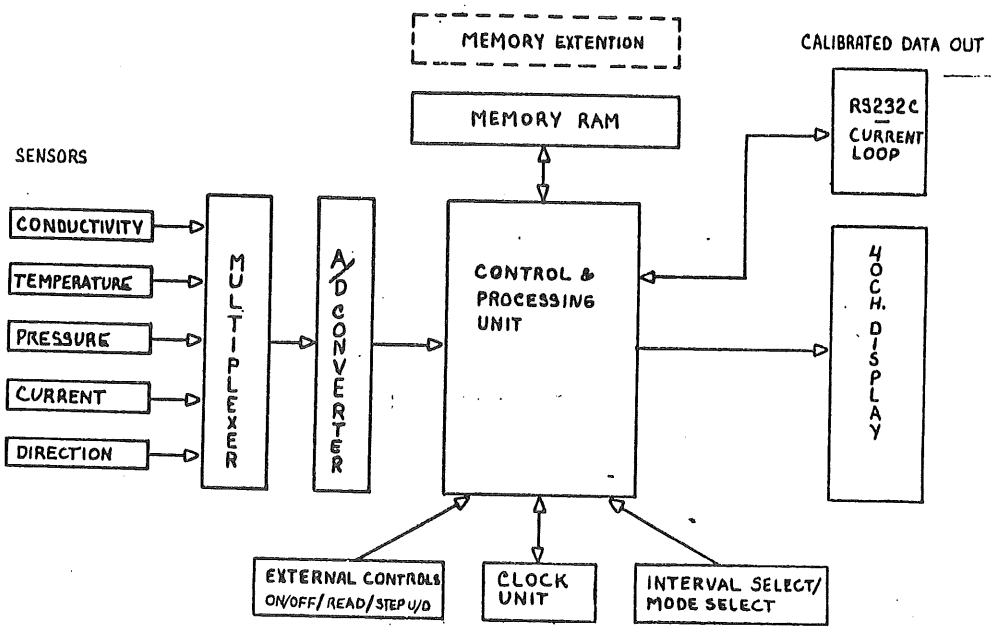

Fig. 2

Functional block diagram for the new instrument. The CPU performs acquisition and processing of information from the sensors after being externally commanded from a magnet which the user holds outside specific command positions on the instrument.

Data are entered into the microprocessor through a common multiplexer.
Via program switches on the instrument (or via external orders from another computer) the instument is programmed to scan and process the sensor information at intervals ranging from 2 seconds to several hours.
The processed data are loaded into a RAM- type memory or sent out from the RS232 interface depending on wether the user needs immediate data via a cable or wants to record data from one or several positions over a time period.

The processed data are simultaneously presented directly in engineering units on a 40 character LCD display.
This display is also used to inform the user of the practical details that were discussed above.

Processing of the sensor signals.

Current speed and direction.

This information can be measured over periods from 30 seconds to 3 hours.
The impulses from the rotor revolutions(2 per revolution) are continuously counted.
10 times during each period the compass direction is measured. The current speed during each 1/10 of the measuring period is split into a NORTH and an EAST component and added to the previous part observation. When the complete period is finished, the mean current speed and direction for all 10 part- observations are recorded in the data memory as one observation.

Temperature

The temperature is measured by measuring the thermistor resistance Rt and then computing the temperature T by inserting Rt into the equation

$$1/T = A + B.\ln Rt + C.(\ln Rt)^3 \quad (1)$$

where A, B and C are thermistor constants that are loaded into the program memory during the calibration.

Depth

The water depth is made with a Keller type PR10 solid state absolute pressure sensor.
To obtain the highest possible precision, the pressure is in situ calculated from a factory made formula that compensates for both temperature and hysteresis effects.
When starting the instrument the atmospheric pressure at this moment is automatically subtracted from the absolute pressure .

Conductivity is measured simultaneously with the temperature and the pressure just after each complete current speed measurement.
The conductivity, temperature and pressure data are immediately fed into the "UNESCO"- formula for calculation of salinity.
The calculasted salinity is recorded in the data memory. It is also used to in situ compute the sound velocity according to the formula made by Chen and Millero(1977)

Calibration.

No sensors are perfectly linear, perfectly independent of other variables or perfectly identical to each other.
However- the output of most useful sensors can be decribed by a polynoma of the form
F(X)= a +b.x +c.x^2 +d.x^3 ...+G(y).F(x) _(1)
where X is a function of the variable sought and x is an electric signal coming from the sensor or its interface.
a,b,c,d....are coefficients which must be determined for each individual sensor. G(y) represents an interaction from other variables (f.inst. temperature to which most sensors are sensitive)

Calibration is done by setting the instrument in the calibration mode.
In this mode the instriment RS232 output must be connected to a small personal computer .The calibrator must know the value of the coeffisients a.b,c,.........p,q,r that he wants to change and f. inst. key in" 0.098 " whem the instrument asks: k=?
The calibration coefficients are stored in the memory until the next partwise or complete recalibration.
Results.
The new instrument is presently being tested as a prototype.

The vectorial current speed program works as planned. The current speed threshold velocity is appr. 2 cm/s and the direction resolution is appr. +/- 7 degrees (limited by the compass resolution presently used.)

The temperature seems to be measured with an absolute accuracy of 0.01-0.02 degrees over the range -2-+30 degrees C.
The salinity is calculated with an absolute accuracy between 0.01-0.02 ppt over the 10-40 ppt. range

The pressure is presented with an accuracy between 0.1-0.2% of full range.
The sound velocity has not been tested yet.
Mechanical design.

Fig. 3 shows the mechanical design.
The design is modular.
The instrument can be used with a transparent pressure tube for depths down to 400 meters or with a metal pressure tube for larger depths.
A transparent pressure tube combined with external start and readout commands via a magnet as described in ref. 1 enables a direct communication between user and instrument. The user may read messages and data directly from the LCD-display without opening the instrument.
By removing the rotor cage and the vane, the instrument may also be used as a miniature STD -instrument.
When being used as a STD, it can be connected to a cable and transmit data to a printer or to a computer above the surface.
It can also be used to take profiles with no extra equipment needed.

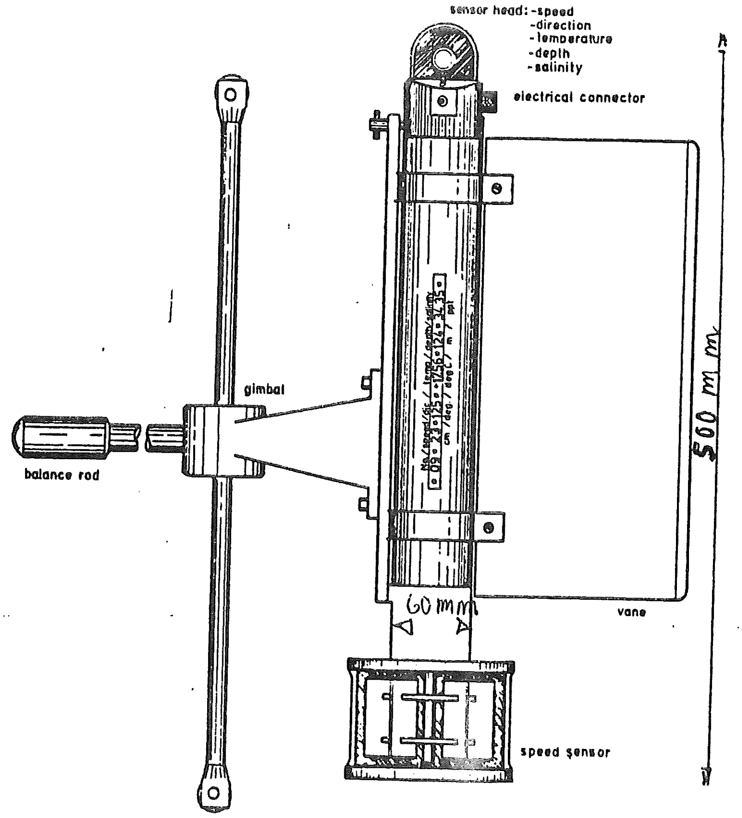

Fig. 3.

Mechanical instrument design. The electronic unit with sensors and microprocessor is plugged into a gimbled pressure tube with attached Savonius-type rotor. The electronic unit in pressure tube without rotor can be used as a self contained STD-unit.

By starting the instrument and then take it down to a wanted depth by a rope , a complete data set can later be read off from the memory via the built in LCD- display. If the data are valuable, they can be written down or transferred to a printer or other computer depending on what technical fascilities that are available.
At the Inst . of Marine Research the new instrument will be used for observing salinity, temperature and current speed at fixed stations , and to monitor temperature and salinity along the Norwegian coast by mounting it on coastal passenger ships.

Ref. 1 T. Gytre "Operating experiences with a modular instrumentation system for measuring current speed, direction and temperature." (C.M. 1983/C:10 Hydrography Committee)