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OPERATING EXPERIENCES WITH A MODULAR INSTRUMENTATION SYSTEM FOR MEASURING CURRENT SPEED, DIRECTION AND TEMPERATURE

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SUMMARY

The paper describes the design and some operational experiences that have been made with an oceanographic instrumentation system based on small modules for data acquisition and on personal computers for processing.

A modern recording instrument for in situ measurement of variables like current speed, direction and sea temperature will in general consist of:

1. A set of sensors.
2. Electronic circuits that scan the sensors at programmable intervals and transfer their information to a recording medium.
3. A reservoir of electric energy (Battery).
4. A mechanical carrier for 1-3.
5. A system for readout and processing information from the instrument memory.

For several years the Institute of Marine Research has been involved in developing a new generation of oceanographic instruments that combine low cost and ease of use with a reasonably high data quality.

DESIGN GUIDELINES FOR THE NEW INSTRUMENT SYSTEM

When making instruments for oceanography the designer must define both mechanical and electronic design targets.

The mechanical carrier was defined to be non corrosive, easy to handle and strong enough to absorb the numerous mechanical shocks it will experience in the field. In addition its physical shape should distort the local current velocity field as little as possible.

The key to fulfill these demands was to give the instrument carrier both low weight and small size.

Compactness reduces transportation costs, mooring line costs and material costs. A small carrier also minimises the drag forces and the distortion of the current velocity field.

The target for the electronic design was to fill the mechanical carrier with electronic circuits that would process the sensor information as precisely as possible and store as much of it as possible in its memory using as little energy as possible.

THE MODULAR DESIGN PHILOSOPHY

Technological breakthroughs in batteries, optoelectronics, static memories, microprocessors and personal computers have made the electronic design both easier and worse.

The design has become easier because of increased component performance and quality. The design work has become worse because of the fast rate of new and better components available to the designer.

When the designer "freezes" a design, he often realises that it is already obsolete because of new components that were not available som months ago.

The answer to this problem has been a modular design philosophy. The electronic parts of the instrument are designed to a standard mechanical shape that correspond to the space available in the mechanical carrier.

New electronic units with new components and/or different sensors can then easily replace "old" electronic units without need for modifying the mechanical parts of the instrument.

Fig. 1 shows the modular system in detail. The standard carrier is a 350 mm long transparent plexiglass tube of inner diameter 40 mm. This carrier leaves a free volume of approx. 1700 cm3 for the electronic circuits.

The electronic modules are built on encapsulated printed circuit boards of size approx. 300x39 mm. The upper end of the card is attached to a circular end cap with O-ring seals that fit to the carrier bore. Thus the carrier is automatically sealed as soon as an electronic module is plugged into it.

COMMUNICATION WITH THE ELECTRONIC MODULE

When the electronic unit is in the instrument, communication with it is made via magnetic and optical signals.

The electronic circuits are commanded to start measuring or to present their results when a magnet is held outside fixed positions on the carrier.

The electronics respond by switching on light emitting diodes that transmit binary coded serial data through the transparent end cap of the module to a photodetector outside, or by displaying data on a numeric display, which is easily readable through the transparent carrier wall.

SENSOR EQUIPMENT

The modular system has sensors for current speed, current direction and temperature. The sensor for current speed is a Savonius type rotor made by Aanderaa Instruments, Bergen.

The rotor stem contains a magnet which activates a magnet sensitive switch in the electronic module when the current speed makes the rotor to move.

The compass has a magnetic needle which makes contact with on out of 24 conducting sectors when given a "clamping" signal.

The temperature is measured with a thermistor which controls the frequensy of a resistor controlled oscillator. On signal from the electronic unit the thermistor dependent frequensy f_T is loaded into the instrument memory. To obtain self calibration, the system at fixed intervals records the frequensy f_C as obtained when the thermistor is temporarily replaced with a known resistance R_C.

DATA RECORDING

The data are recorded into a static C MOS RAM-memory. The present data capasity is 32 000 bits which are used for 1024 corresponding data sets for current speed, direction and temperature. By using a new generation of memeory chips the data capasity can be easily expanded to say 16 000 data sets.

DATA READOUT AND PROCESSING

Fig. 2 shows how data are transferred from instrument to readout device when the instrument is still unopened. A readout head with photodetectors is snapped over the electronic module end cap. In a few seconds data are flashed from the instrument into the readout device selected.

Realising the fact that personal computers will soon be available everywhere at a very low cost, the instrument design has been adapted for easy readout via personal computer. The personal computer can easily be programmed to compute and present raw data and to compute simple statistical properties with the data material.

Advanced processing and storing of the data in a central data base system is obtained by transferring the data from personal computer to a large computer via a modem connection.

OPERATING EXPERIENCES WITH THE SYSTEM

The modular system has been tested in the field for about two years. The most important experiences have been:

1. <u>The mechanical carrier</u>.

The general impression has been good. The carrier stays vertically in the sea and directs itself into the current direction when the current speed is more than 2-3 cm/s. A few of the transparent pressure tubes have fractured due to mechanical shocks. Carriers made from plexiglass can be used to 600 meters. For use at larger depths, metal tubes must be employed.

2. Communication with the instrument.

The use of magnets for giving start and read commands and the use of photoemitters for transferring data from unopened instrument has been very successful. When the user follows the instructions for use, no data have been reported lost or distorted.

CURRENT SPEED SENSOR

In all instruments that have been made the current sensor has reliably transferred its rotational data to the electronic module without problems. The correspondence between current speed and number of rotor revolutions per minute follows the rules that have been experienced with the Savonius type rotor in general. For use in the wave zone an ultrasonic type current sensor would no doubt be better, but at the cost of much more complicated electronics and power supply.

COMPASS

The compass has till now been the most unreliable sensor in the system. In some earlier designs the compass could fail up to 20-30%. Improved contact plating and better control when making it has reduced the failure rate to less than 1%. Still a non contact type compass like a flux gate compass may be a better choise for the future.

The experienced precision of the present compass is approx. $\pm 10^{\circ}$.

TEMPERATURE

The thermistor type used (Fenwall GB32JM19) has proved to be very stable. The readout processor first calculates the thermistor resistance at the moment of measurement. Then it converts the resistance to temperature by using the general thermistor equation

$$\frac{1}{T} = A + B \ln R_T + C (\ln R_T)^2 \quad \cdots \quad (1)$$

where T = temperature (°K)

R_T = resistance of thermistor

A,B,C are calibration constants

When inserting individual calibration constants, the calculated temperature error will be less than 5/100°C over the temperature range -2 - +22°C.

PROCESSING

Processing on personal computer is simple to perform. The programs for processing are loaded on PROM card or on a floppy disc.

Fig. 3 shows an example of a raw data listing.

Fig. 4 shows how the personal computer makes a simple statistical analysis of current speed and direction distribution from one batch (1024 observations) of data.

CONCLUSION

The modular system for measuring current speed, direction and temperature is about to become a simple and reliable instrument for acquisition of small or moderate amounts of data.

New electronic modules which are planned will have larger memory and contain microprocessors that can in situ process the observed data to a high level of sophistication whithout increasing their present carrier volume. The next generation of modular instruments will probably be able to compete with large tape recorder based instruments in both performance and data capasity.

THE BASIC MODULES FOR ACQUISITION OF DATA FROM THE SEA

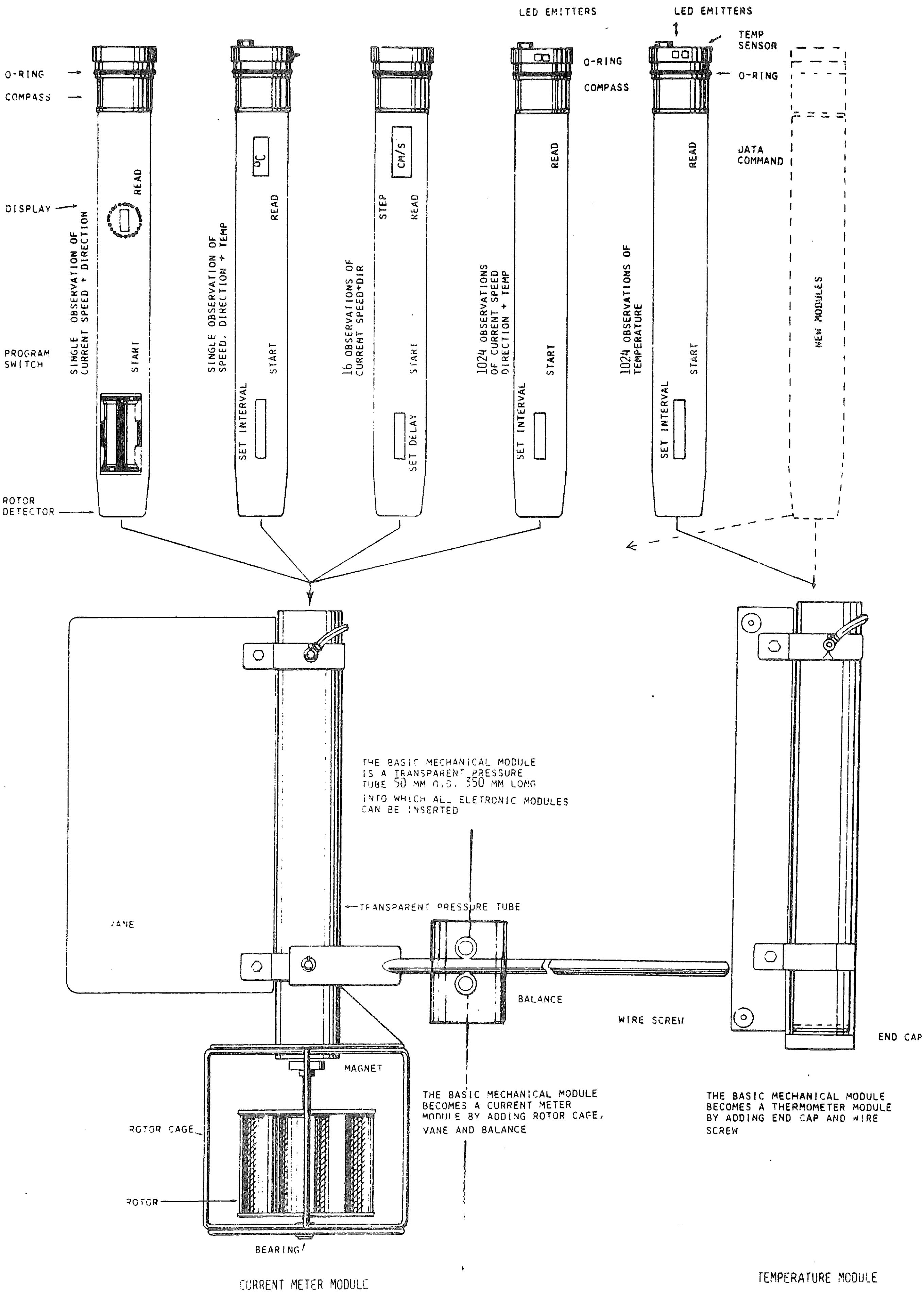
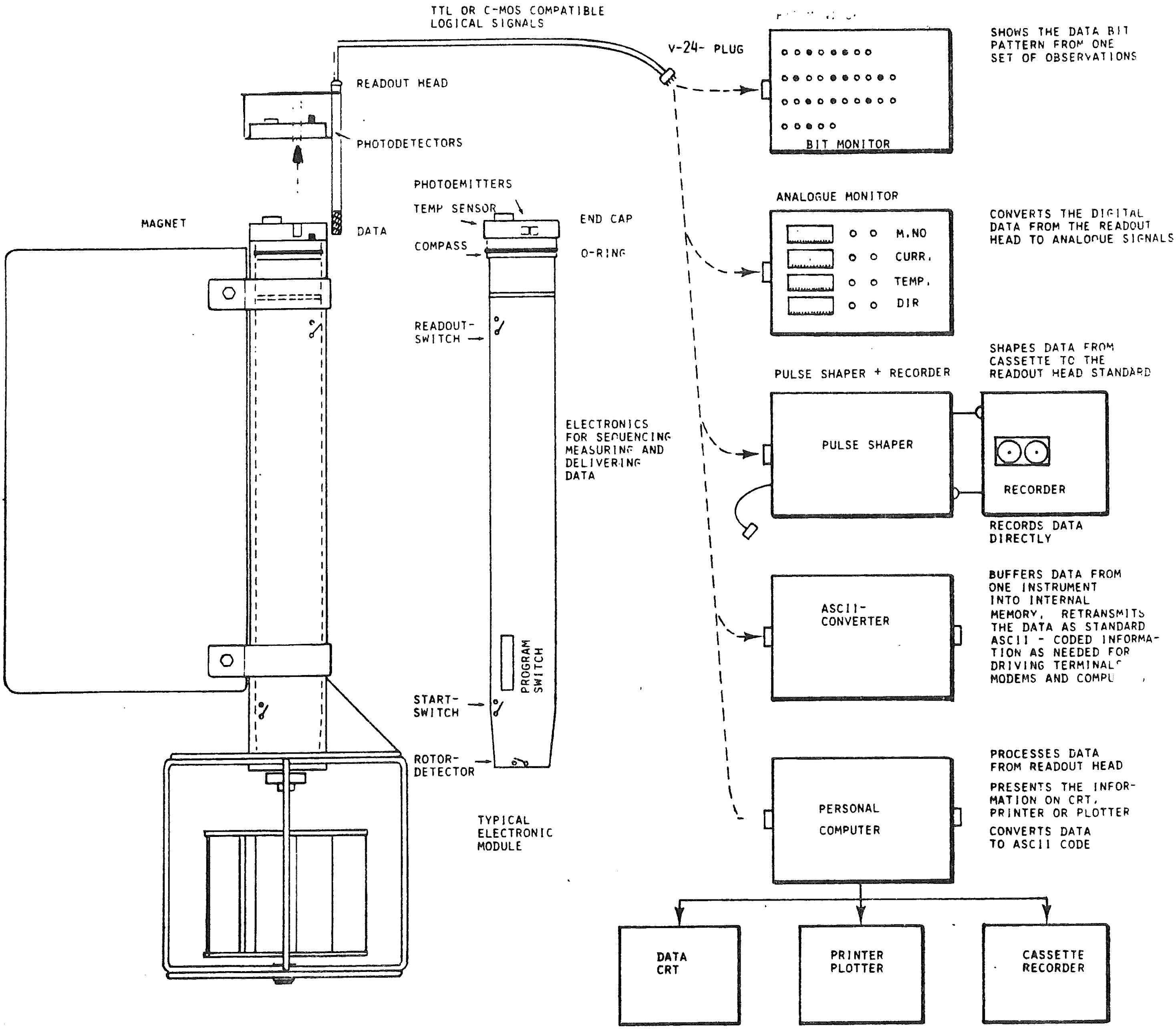


FIG 1

DATA READOUT AND PROCESSING

THE READOUT HEAD IS A GENERAL READ OUT COMMANDER
IT CAN BE SNAPPED ON TOP OF ALL MODULES WHEN IN POSITION
IT COMMANDS THE RAM-MEMORY IN THE ELECTRONIC MODULE TO DELIVER DATA AT A RATE OF 2000 BITS/SECOND TO ONE OF SEVERAL POSSIBLE DATA RECEIVERS



MODULE WITH DATA

DATA PROCESSING ALTERNATIVES

START-TIME OF SD1000:k1.12.00 06.25.83

SIGNATURE: [illegible]

M.NO.:	1	TEMP:		CURR.:	0.0	DIR.	315	TIME:12.12	6.25	1983
M.NO.:	2	TEMP:	10.94	CURR.:	0.0	DIR.	315	TIME:12.24	6.25	1983
M.NO.:	3	TEMP:	10.79	CURR.:	0.0	DIR.	330	TIME:12.36	6.25	1983
M.NO.:	4	TEMP:	10.82	CURR.:	0.0	DIR.	75	TIME:12.48	6.25	1983
M.NO.:	5	TEMP:	10.79	CURR.:	0.0	DIR.	105	TIME:13.00	6.25	1983
M.NO.:	6	TEMP:	10.79	CURR.:	0.4	DIR.	120	TIME:13.12	6.25	1983
M.NO.:	8	TEMP:	10.79	CURR.:	1.2	DIR.	120	TIME:13.36	6.25	1983
M.NO.:	9	TEMP:	10.73	CURR.:	0.0	DIR.	120	TIME:13.48	6.25	1983
M.NO.:	10	TEMP:	10.64	CURR.:	5.0	DIR.	120	TIME:14.00	6.25	1983
M.NO.:	11	TEMP:	10.79	CURR.:	7.9	DIR.	120	TIME:14.12	6.25	1983
M.NO.:	12	TEMP:	10.42	CURR.:	2.9	DIR.	120	TIME:14.24	6.25	1983
M.NO.:	13	TEMP:	10.73	CURR.:	9.5	DIR.	120	TIME:14.36	6.25	1983
M.NO.:	14	TEMP:	10.91	CURR.:	13.3	DIR.	120	TIME:14.48	6.25	1983
M.NO.:	15	TEMP:	10.91	CURR.:	17.5	DIR.	120	TIME:15.00	6.25	1983
M.NO.:	16	TEMP:	10.91	CURR.:	18.3	DIR.	120	TIME:15.12	6.25	1983
M.NO.:	17	TEMP:	10.64	CURR.:	21.2	DIR.	120	TIME:15.24	6.25	1983
M.NO.:	18	TEMP:	10.42	CURR.:	17.5	DIR.	120	TIME:15.36	6.25	1983
M.NO.:	19	TEMP:	10.51	CURR.:	18.7	DIR.	120	TIME:15.48	6.25	1983
M.NO.:	20	TEMP:	10.60	CURR.:	20.8	DIR.	120	TIME:16.00	6.25	1983
M.NO.:	21	TEMP:	10.45	CURR.:	18.7	DIR.	120	TIME:16.12	6.25	1983
M.NO.:	22	TEMP:	10.51	CURR.:	17.0	DIR.	120	TIME:16.24	6.25	1983
M.NO.:	23	TEMP:	10.51	CURR.:	19.1	DIR.	120	TIME:16.36	6.25	1983
M.NO.:	24	TEMP:	10.39	CURR.:	20.0	DIR.	120	TIME:16.48	6.25	1983
M.NO.:	25	TEMP:	10.57	CURR.:	17.0	DIR.	120	TIME:17.00	6.25	1983
M.NO.:	26	TEMP:	10.67	CURR.:	17.0	DIR.	120	TIME:17.12	6.25	1983
M.NO.:	27	TEMP:	10.67	CURR.:	15.8	DIR.	120	TIME:17.24	6.25	1983
M.NO.:	28	TEMP:	10.69	CURR.:	14.5	DIR.	120	TIME:17.36	6.25	1983
M.NO.:	29	TEMP:	10.73	CURR.:	15.8	DIR.	120	TIME:17.48	6.25	1983
M.NO.:	30	TEMP:	10.85	CURR.:	15.0	DIR.	120	TIME:18.00	6.25	1983
M.NO.:	31	TEMP:	10.88	CURR.:	11.[illegible]	DIR.	120	TIME:18.12	6.25	1983

Fig. 3. Parts of raw data listing from a personal computer. The personal computer asks when the instrument was started and what interval time the instrument was programmed with. It then computes temperature, current speed, current direct[illegible]on and measurement time for 1024 succ[illegible]ssive observations.

INSTRUMENT NØ.: 2

STATION NO. 2

DEPTH: 6 METER

PERSON IN CHARGE: ꟊK

START-TIME OF SD1000:kl. 83.07.07

SIGNATURE: [signature]

LISTING OF NUMBERS OF OBSERVATIONS VERSES CURRENT DIRECTION.

GRADES		No.		GRADES		No.
Ø	-	7	!	180	-	11
15	-	5	!	195	-	18
30	-	3	!	210	-	11
45	-	10	!	225	-	6
60	-	4	!	240	-	5
75	-	7	!	255	-	15
90	-	14	!	270	-	106
105	-	32	!	285	-	44
120	-	96	!	300	-	28
135	-	47	!	315	-	296
150	-	19	!	330	-	133
165	-	11	!	345	-	25

NUMBERS OF OBSERVATIONS/CURRENT SPEED.

Ø	-	526	!	100	-	3
5	-	119	!	105	-	2
10	-	80	!	110	-	1
15	-	74	!	115	-	1
20	-	36	!	120	-	Ø
25	-	33	!	125	-	Ø
30	-	22	!	130	-	Ø
35	-	17	!	135	-	Ø
40	-	17	!	140	-	Ø
45	-	11	!	145	-	Ø
50	-	7	!	150	-	Ø
55	-	13	!	155	-	Ø
60	-	14	!	160	-	Ø
65	-	13	!	165	-	Ø
70	-	10	!	170	-	Ø
75	-	8	!	175	-	Ø
80	-	6	!	180	-	Ø
85	-	4	!	185	-	Ø
90	-	3	!	190	-	Ø
95	-	4	!	195	-	Ø

Fig. 4. A simple analysis of the distribution of current speed and direction from one set of data as made by a personal computer.