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A GENERAL SYSTEM FOR LOGGING INFORMATION FROM
INSTRUMENTS IN THE SEA.

by

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Summary

The paper describes a logging system which aims at integrating various forms for primary data recording into a common standard that can be handled by the same reading and data processing equipment. Some illustrative examples of both magnetic tape and solid state logging systems are presented.

INTRODUCTION

Representative measurements of physical or biological processes in the sea normally requires a succession of observations taken during a specified time interval. Sometimes the measurement and recording of one single variable is adequate, but in general a repeated sequence of measurements from several sensors are required.

Most instruments designed for field purposes hence must include a unit for temporary or permanent logging of the measured information.

The information to be logged originates from either an analogue or a digital sensor system. Analogue sensor systems normally consist of a sensor arrangement followed by a scaling and level adjusting amplifier which generate a continuous output signal within a standard range, like f. ex. $\pm 5V$. Figure 1 shows a typical example of an analogue sensor arrangement consisting of a thermistor bridge and an instrumentation amplifier presenting an electrical voltage signal proportional to the temperature.

Fig. 2 shows a typical digital sensor system consisting of a propeller which presents electrical impulses to a counter during a specified integration period T_1 . In a digital sensor the output is usually a parallel N bit digital word, which changes discontinuously in steps of the least significant bit. The most common digital representation form for digital information in the binary code.

At the Institute of Marine Research information is collected from fixed, moored instruments in the sea, from instruments hanging from a cable and from hand made notes based on visually observed information. The instruments used differ greatly in sophistication. Common for most of the information, however, is that it sooner or later will be presented to a computer for organized storing or for further processing.

In order to make data aquisition easier and to avoid time consuming data format changing like f. ex. punching, work is being done to develop a general data logging system suited for storing field acquired information.

In general such a system must consist of:

1. A primary storing medium. This ought to be an integral part of the instrument and must be designed to meet the demands set by storing capacity, recording speed, space, power, shape etc. It must also be able to survive the expected environmental conditions.
2. A control system for the primary storing medium. This should make it possible for the user to control that the logging system is working without having to open the instrument in the field.
3. A programable timer which can be programmed by the user to sample the variables at the required rate.
4. A readout system for the primary storing medium. The readout system must be able to convert the recorded information to a standard digital format. This has been chosen as a standard 12 bit binary code. It must also be able to convert the data to analogue information and to a computer compatible 9 track tape.

Recording media.

A range of different recording media are presently available. The most used are:

- Chart-recording on paper
- Printing on paper
- Frequency modulation on continuous running tape
- Digital information written into a stepping recorder
- Digital information written into a solid state random access memory.

Analogue recording on paper by ink or by radiation on photo or heat-sensitive paper is still used in simple recording instruments. Due to mechanical problems, low information density and difficulty of automatic readout, this is not recommended in modern recording systems.

Digital printing on paper is slightly better than ink-recording, but still not adequate in terms of reliability, information density and ease of automatic reading.

Presently logging on magnetic tape cassettes offer the best technical and economic solution.

Logging on tape cassettes can be done by frequency skift modulating a continuously running tape (used when maximum recording speed is needed) or by writing the information bit by bit into a stepping type tape recorder which moves the tape a fraction of a mm for each recorded bit.

Fig. 3 illustrates the frequency skift method.

The data to be logged are put on a serial shift register which is clocked at a rate of say 1000 Hz. The data output controls a switch which lets through 1 oscillation of 1 kHz (logical 1) or two oscillations of 2 kHz (logical 0) for each bit period. The audio tape receives a continuous stream of information which consists of a 24 bit synchronisation code followed by $N \times 12$ bit data words with no interruptions between.

This method is recommended when continuous recordings of fast changing events lasting from 5 to 30 minutes are needed. An application of the principle is described by GYTRE (1977).

Discontinuous logging of information is done on stepping type tape recorders.

Presently two systems dominate - The NRZ - (Non-return to zero) - system and the phase encoding (P.E.) system.

Fig. 4 illustrates the NRZ-system.

Two recording heads and two tape tracks are used. The data - usually coming from a serial shift register - are organised to generate a flux change on record head 1 for each logical 1 and a flux change on record head 2 for each logical 0.

After each clock pulse, the tape is advanced one step. The maximum number of steps possible with the NRZ-system is between 800 and 1000 per inch of tape. One typical cassette can store appr. 2,2 million bits.

In the phase encoding system only one track is needed. Data are transferred to the tape at a fixed distance of f.ex. 1/800 inch between each bit. For each bit interval a positive flux change is generated for logical 1. If the bit represents a logical 0, a negative flux change is generated. When data change, it is necessary to put in an extra flux change between the data points. This is later ignored by the readout system. Phase encoding systems can store up to 10 million bits on one standard C-type cassette.

Fig. 5 illustrates the P.E - system.

Solid state recording is presently most easily done using low energy random access memories. Fig. 6 illustrates the principle.

The information to be recorded must be available as a parallel, digital word before recording.

On a given clock signal the data are written into the location as specified by the address. When changing level on the read/write control, the information can later be brought to the output.

Solid state memories can be loaded and read at very high speeds but the capacity is presently practically limited to appr. 100 000 bits in one instrument. The expected magnetic bubble memories which are now being developed may dramatically increase the capacity of solid state memories.

Control systems.

During field conditions all opening of sealed instruments represents a leak hazard and a chance for introducing moisture into electronic components. A signal telling what is going on inside should thus be available on the outside of a recording field instrument. The simplest solution,

which was described by Gytre and Sundby (1977) is to seal the recording instrument with a transparent housing through which the information can be read from standard LED-displays inside on command from a magnet being held outside.

The most practical solution for controlling systems using tape recorders is to transfer the information which is impressed on the tape recording head to the outside via optical feed through windows.

By means of read LED-lamps, the user can - with his own eyes only - both see that a recording takes place - and very roughly control that the data seem reasonable. By connecting a photo detector combined with a succeeding display and readout circuit, exact readout of the data which are simultaneously recorded can be obtained. Fig. 7 shows the principle.

Timing.

The necessary sampling rate which is needed to reveal the dynamic behaviour of a variable depends on its highest significant frequency component.

If this frequency component is f , sampling must take place at a repetition rate of at least $2 f$. An efficient way of obtaining representative logging both in time and frequency is to use the burst sampling technique. Fig. 8 shows the principle.

A crystal controlled oscillator generates high precision time intervals f.ex. for each $1/10$ sec. By programming the succeeding circuits, combinations of the basic time interval may be generated.

In general a specified number of impulses (N) at a repetition rate f_2 is made to occur for each T_1 minutes by setting appropriate program switches on a program card in the instrument.

Each impulse initiates the sampling and recording of all sensors connected to the logging system.

Readout system.

In the readout system 12 bit words have been chosen as standard. Data belonging to one set of information, f.ex. simultaneous measurements of N data input channels from a multiplexer, are arranged to form a $N \times 12$ bit word. The word starts with a recognisable start code and usually ends with a stop-code. Fig. 9 shows the recording format.

Fig. 10 shows the principle for the readout system.

If the data have been recorded on different media they are first fed to individual readers which convert them to a stream of continuous data and clock signals.

The data stream is then fed into a formatter which divides the data stream into individual 12 bit words. The words from the same sensors are converted to analogue signals and fed into individual output sample and hold units which are updated each time new data from the same channel number are converted.

Each decoded word is presented in parallel for on line computer processing. It also appears on LED-lamps for direct visual reading in binary code. Also control signals for re-recording of the data into a 9 track tape recorder are generated.

Examples on data logging instruments used at the Institute of Marine Research.

Oceanographic data logging system.

Fig. 11 shows a self contained data acquisition instrument. This instrument is presently equipped with a 3 axis ultrasonic current sensor, a compass and a thermometer. The organisation of the instrument is shown in Fig. 12. A timer can be programmed to start a measurement cyclus for every T_1 minutes. T_1 can be adjusted in steps of 1 minute from 1 - 256. For each T_1 N scans ($1 \leq N \leq 15$ or $N = \infty$) can be made to take place in intervals from 1 - 15 seconds. For each scan all analogue data (max. 16 channels) are sequentially converted to 12 bit digital words.

Any number of 12 bit digital words may be added to the data chain. Finally all data are clocked into a NRZ-type cassette tape recorder. Two optical feed through plugs A and B are used to control the recording process. A flash of light in A indicates the recording of a logical 1, while a flash in B indicates a logical zero.

A control unit which has both printer and analogue output can be snapped on to the optical plug to show the exact value of the logged information during recording. This unit has proved very valuable during calibration of the instrument.

Recording of fish length.

Fig. 13 shows a logging fish length measurement board. The board contains 120 sealed magnetic switches which are placed at a distance of 1 cm between each switch. During use the fish is placed on the board as usual. A manget is held over the fish tail end for a brief moment, thus activating magnetic switch no. N, where N represents the fish length in cm. The number N is then automatically logged into a connected tape recorder. Additional information like species, catching field, fishing vessel identification, date, etc. which has been preset prior to the length measurement are also logged in the standard 12 bit format. For control the recorded number also appears on a 3 digit display during magnet activation.

Automatic logging of coastal water properties.

Fig. 14 shows the principle for automatic logging of the surface coastal waters properties.

A temperature and salinity sensor combined with a position detector and a clock is mounted in contact with a ship's engine cooling water intake. At a fixed rate, ex. for each 10 minute, the ship's position, speed, direction and the sea water temperature and salinity is recorded. The tape cassette is changed after each cruise typically lasting from 2-3 weeks.

Solid state recording current meter.

Fig. 15 shows the principle for a miniature, solid state current meter.

Controlled by a timer, the current speed and current direction is measured for each T_1 minute. The information is loaded into a solid state RAM - memory until 1024 measurements have been made.

Readout is initiated with a magnet being held outside the closed instrument.

During readout the memory is automatically scanned word by word. Each word is copied into an output register. This is connected to two LED lamps which flash impulses of light into two transparent windows. An optical data detector detects the signals and converts them to analogue and digital words. It also converts the information into 12 bit words for NRZ- tape recording.

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ICES CM 1977/C: 24. Hydrography Committee.
- GYTRE, T., SUNDBY, S. A new instrument for simple observations of current speed and direction in the field.
ICES CM 1977/C: 23. Hydrography Committee.

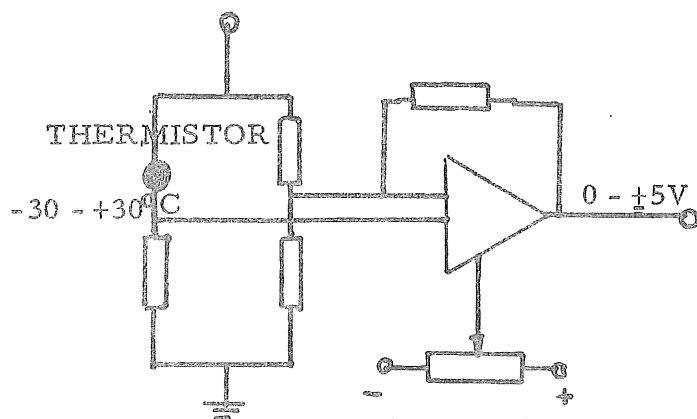


Fig.1. Example of an analogue sensor system.

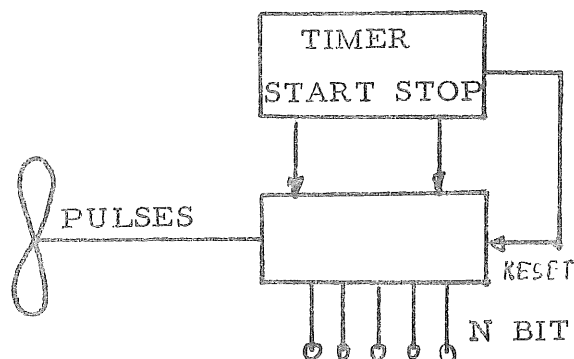


Fig.2. Example of a digital sensor system.

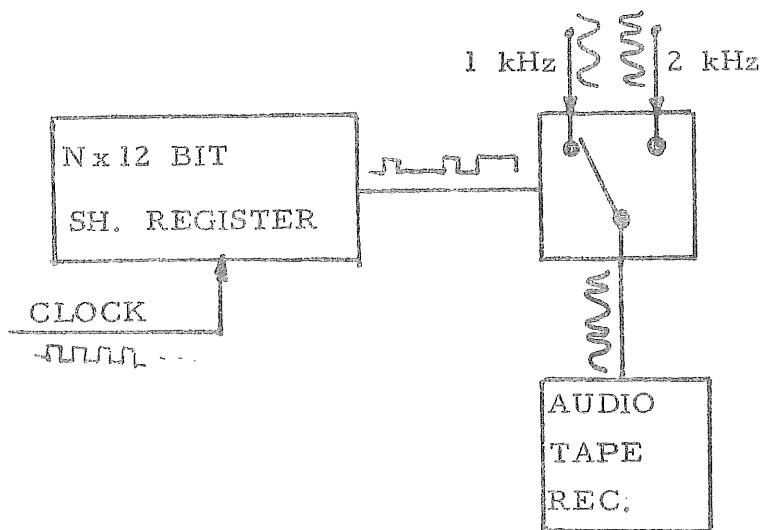


Fig.3. Principle of frequency shift modulation.

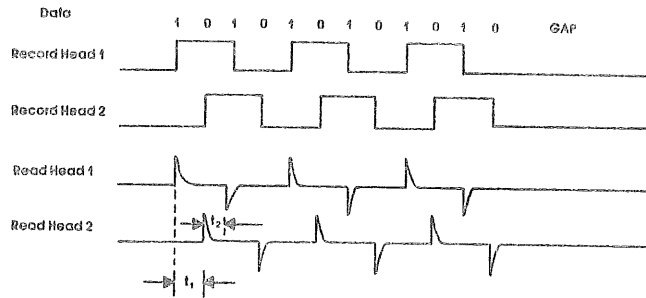


Fig. 4. Recording in NRZ data format.

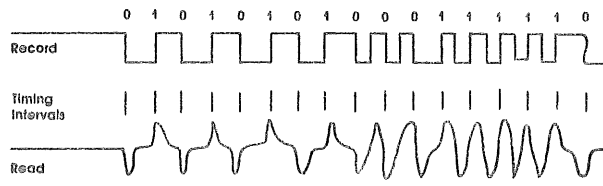


Fig. 5. Recording in phase encoding (P.E) data format.

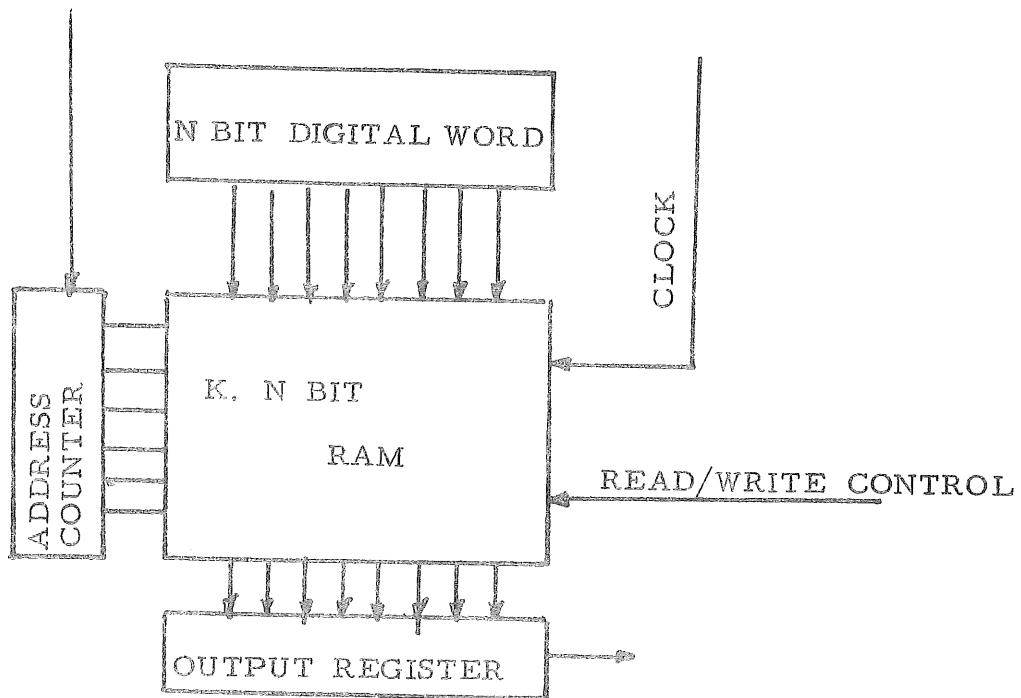


Fig. 6. Principle for recording in a static random access memory.

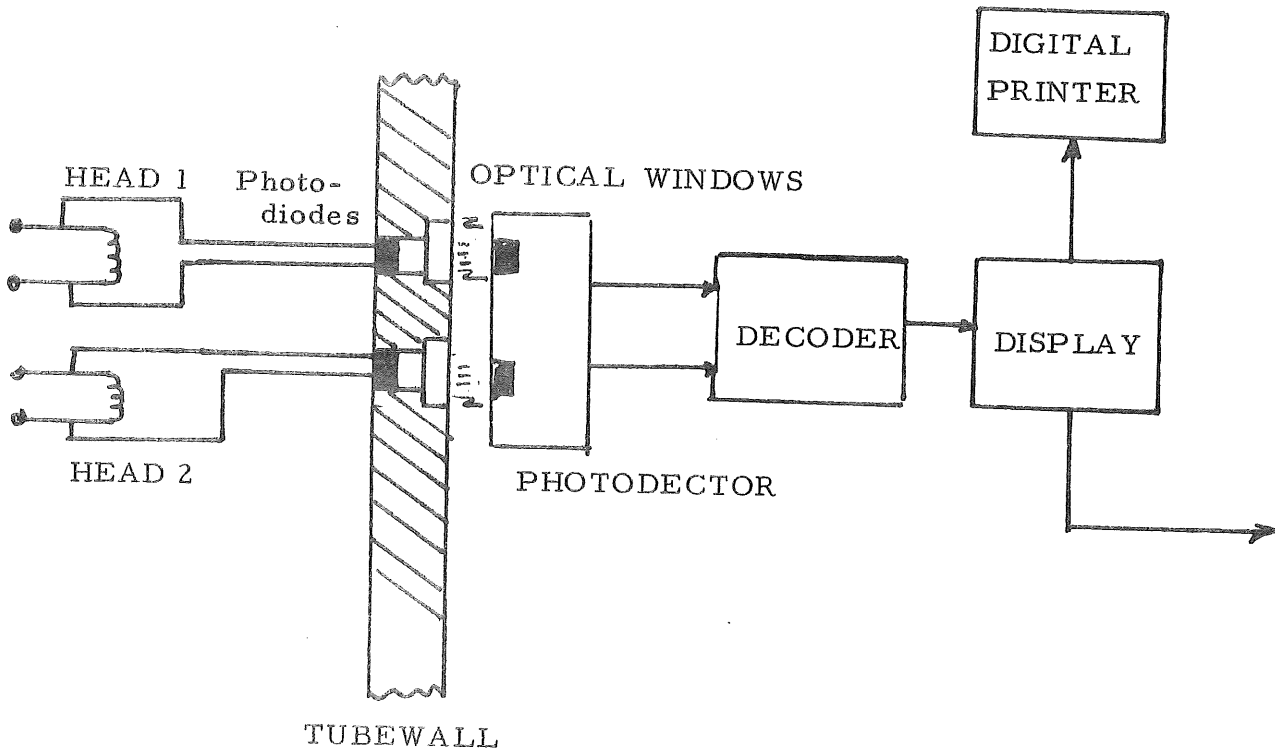


Fig.7. Principle for the optical field control unit. A portable detector can read the value of the data being logged without opening the instrument.

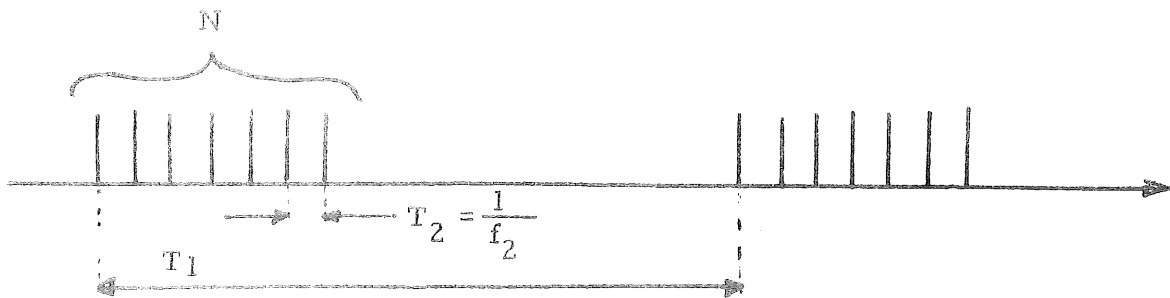


Fig.8. Principle of burst sampling. For each T_1 minute N measurements of all sensor channels are made at a repetition rate $f = 1/T_2$.

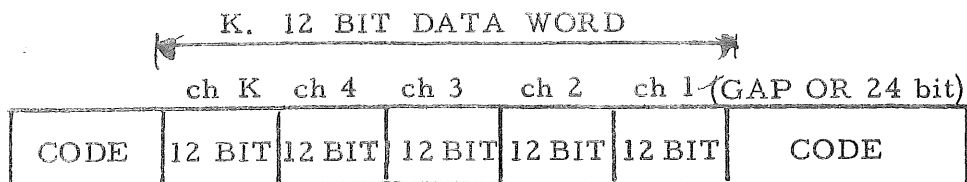


Fig.9. Standard data word format. All data that belong to one simultaneous observation are gathered into one "big" K.12 bit data word. The data words are separated by a synchronisation code of 24 bit or by a word gap. After each 64 data word (typically) a file gap may be generated. The file gap is useful for discontinuous computerassisted readout as the computer will load in the information from one file at a time.

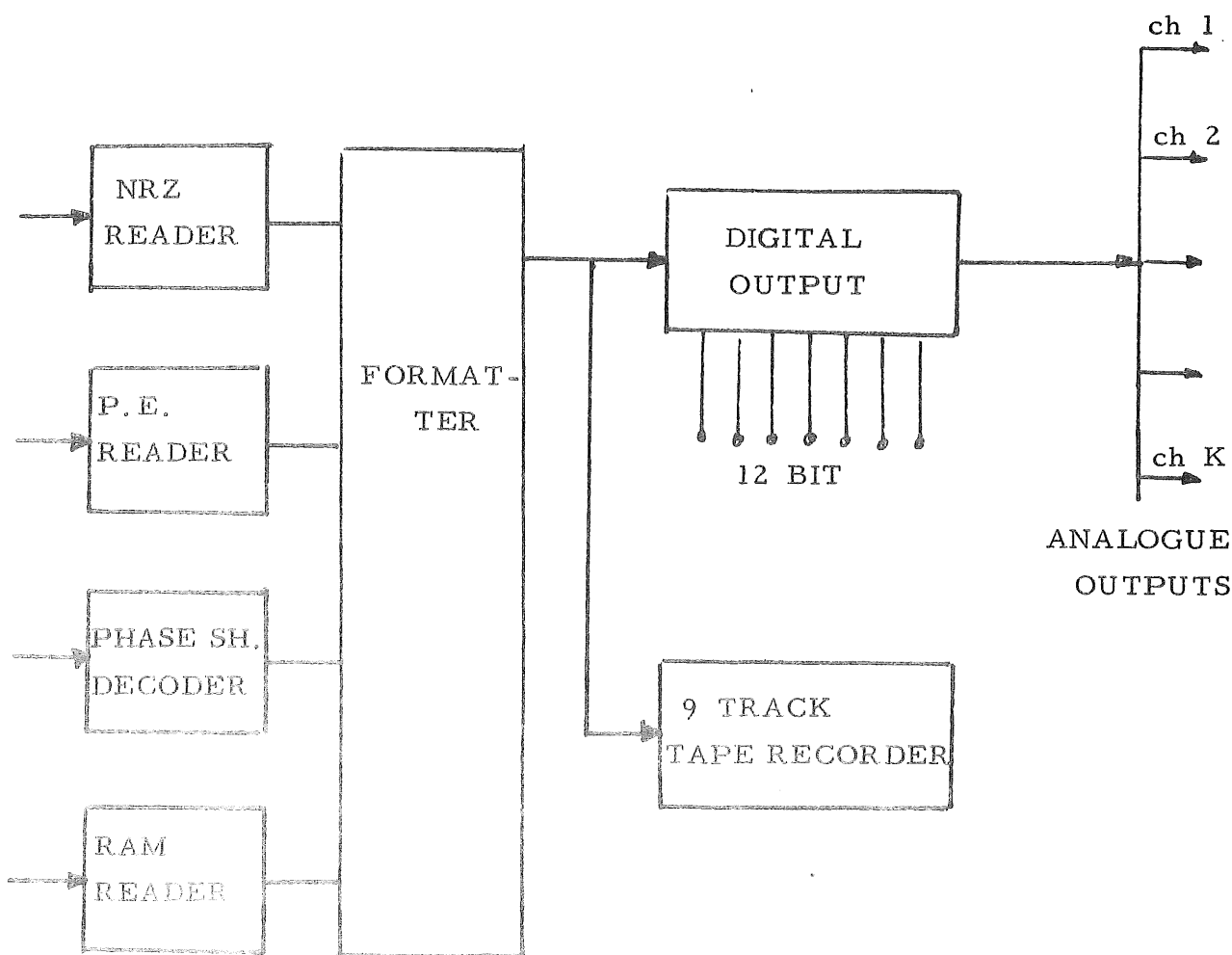


Fig.10. Principle for the general readout system. Data are first decoded to standard serial format according to recording media used. Secondly they are presented both as parallel 12 bit words for LED-display and on line processing, and on separate analogue output lines for analogue recording. Alternatively the data are reconverted and recorded on a 9 track computer compatible tape recorder.

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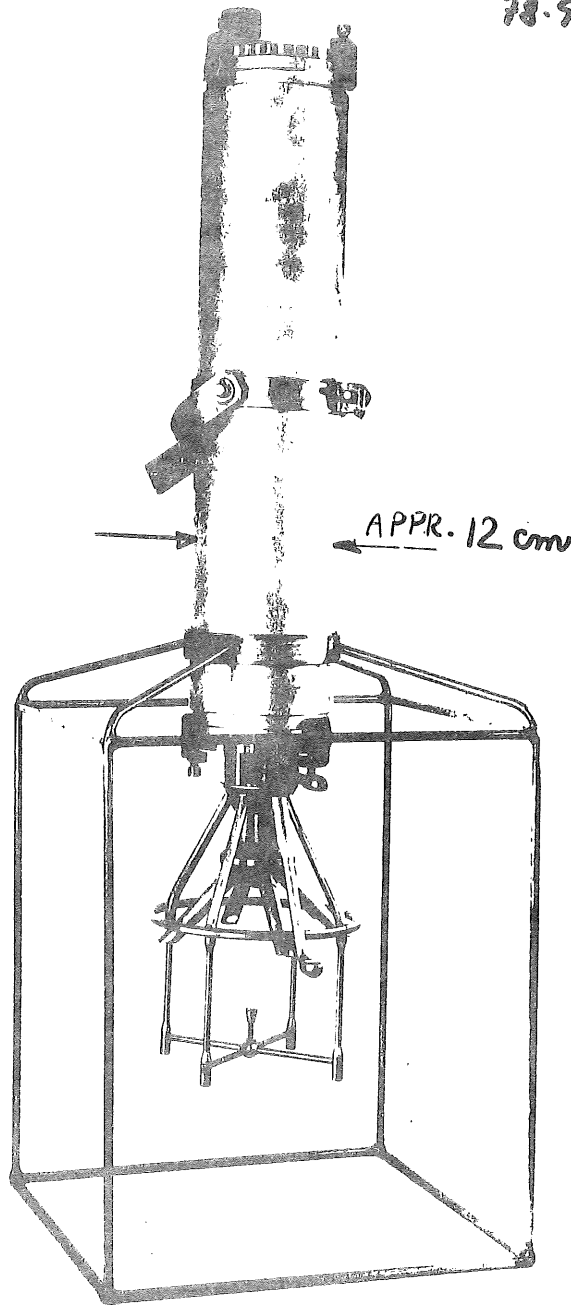


Fig.11. A general logging data acquisition system. The most important part of the instrument is an improved three axis ultrasonic current meter. The current meter has a resolution of 1mm/second, a range of $\pm 2,5$ m/sec. and zero stability within 2mm/sec. for months. The analogue sensor system is expandable to 16 channels. Additional sensors include thermometer and compass. The tape recorder has a capacity of appr. 30 000 6 channel data words. Experience shows that this instrument can work reliably in shallow water during periods of heavy biological growth. Other applications include current measurements close to the sea floor and turbulence studies.

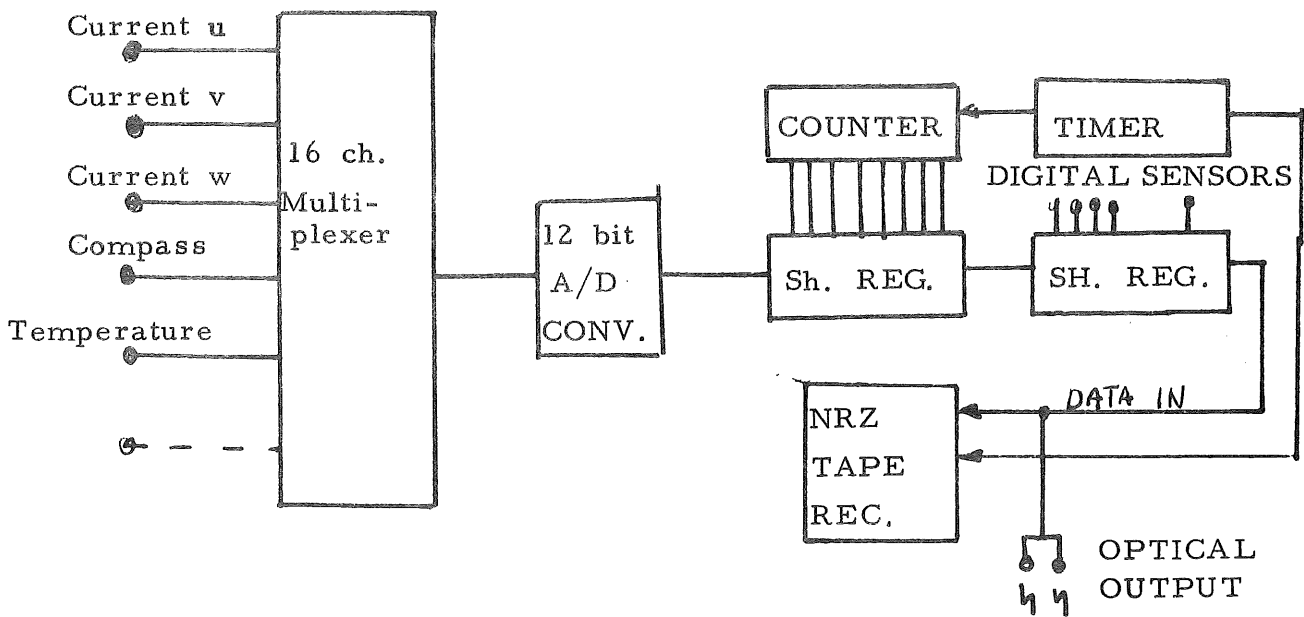


Fig.12. Organisation of the instrument shown on Fig.11.

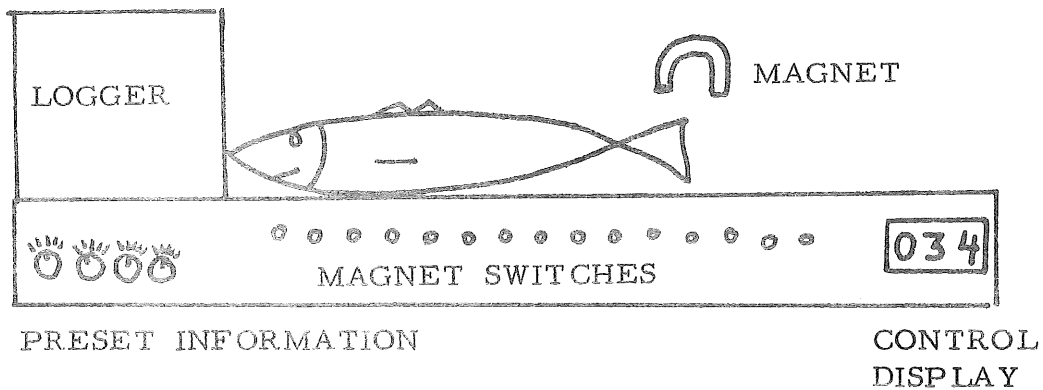


Fig.13. Principle for automatic logging of fish lengths.

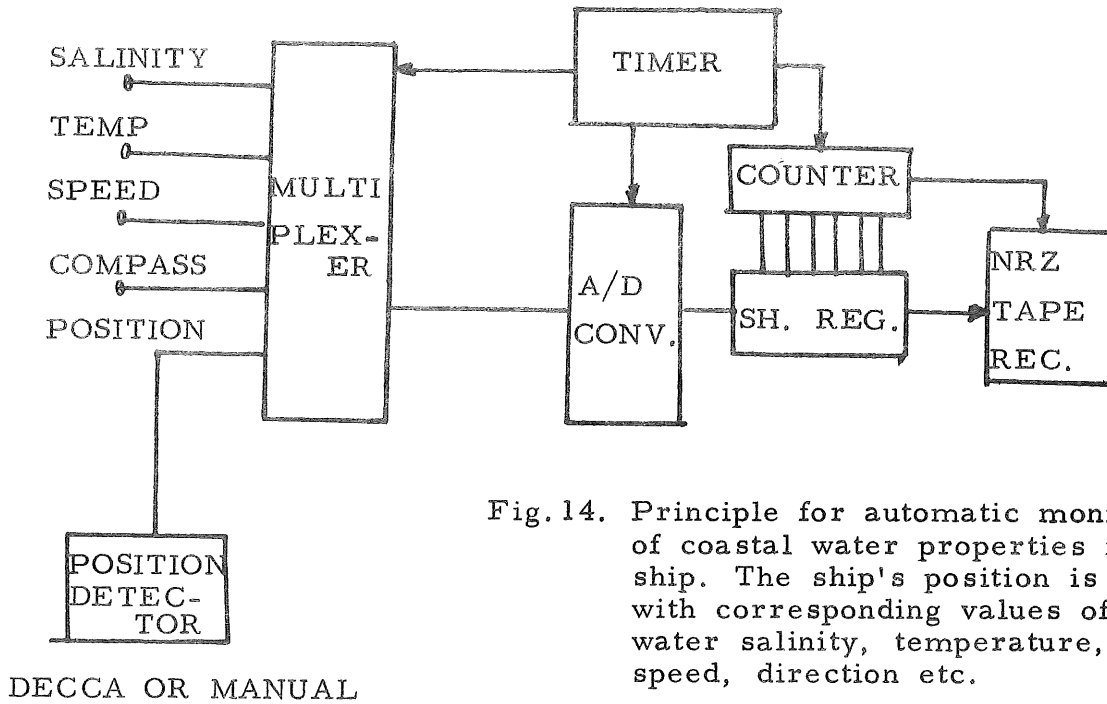


Fig.14. Principle for automatic monitoring of coastal water properties from a ship. The ship's position is logged with corresponding values of sea-water salinity, temperature, ship speed, direction etc.

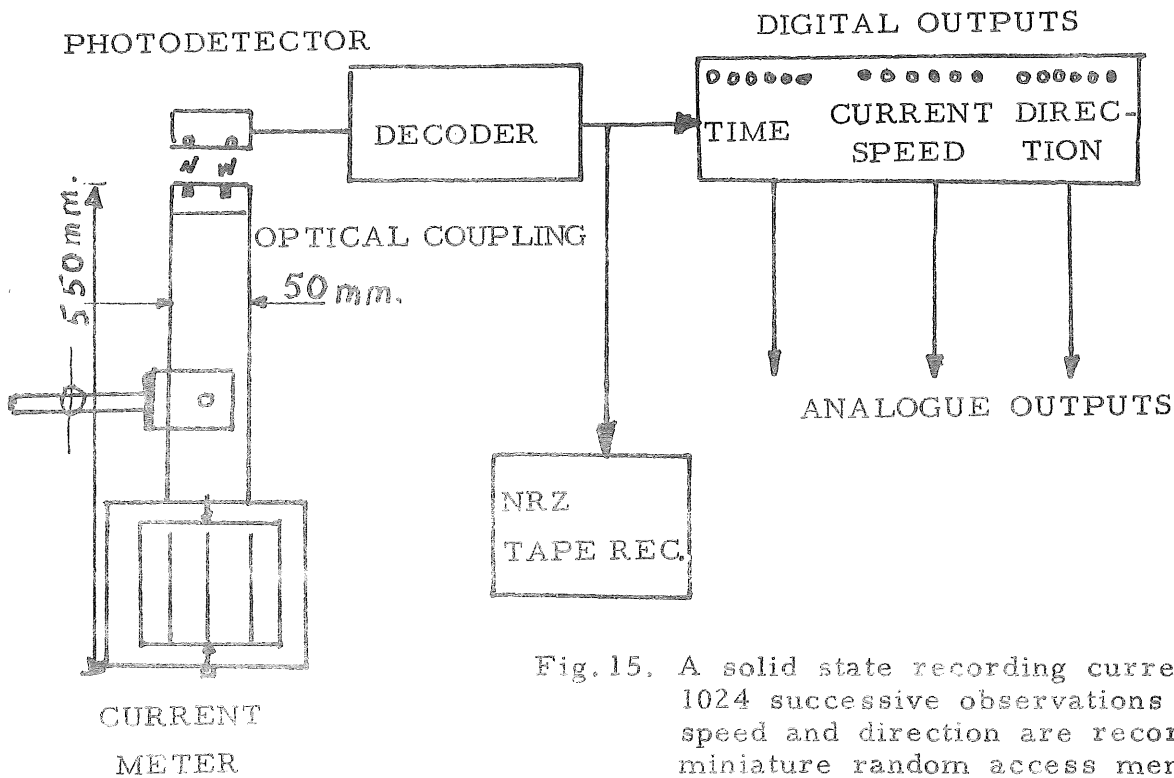


Fig.15. A solid state recording current meter. 1024 successive observations of current speed and direction are recorded in a miniature random access memory.

Initiated by a remote magnetic signal, the memory is automatically made to flash out the recorded information to a readout unit via optical coupling. Data are available as optical and digital LED signals. Alternatively signals from one or several instruments are transferred to a NRZ-tape recorder for readout on the system as shown on Fig.10.