A MULTICHANNEL RECORDER FOR HYDROLOGICAL RESEARCH

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ABSTRACT

A new nine-channel recorder, based on a standard Fischer and Porter analog-to-digital recorder, has been developed primarily for hydrological research purposes. It can accept up to nine event inputs or nine analog inputs or combinations of both. The operating speed is relatively slow but should be adequate for hydrological purposes. It is expected that this machine may find use as part of an automatic climate station for remote areas. The principal advantages of this machine are low modification costs and simplicity.

INTRODUCTION

The Fischer and Porter analog-to-digital water-level recorder uses a 16-channel paper tape as its recording medium. Each digit occupies four channels across the tape.

The tape is punched according to the position of two code discs behind a punch block. A die-cast ridge pattern on each disc causes a code to be punched on the tape according to the position of each code disc. A disc can impress 100 different hole combinations on the tape, representing the numbers 0 to 99. Normally the discs are linked by a 1-to-100 gear train, thus giving a range of 0 to 9999 when the low-order disc is rotated. These machines usually record water level at fixed time intervals.

If the code discs are mechanically separated we now have a much more flexible machine capable of recording more variables at lower resolution. Measures can, however, be taken to restore this lost resolution (Chandler and Patterson, 1970).

One of the most promising machines with separated code discs is the multichannel event recorder. One disc registers time while the other records channel number whenever an event occurs in that channel.

It is not difficult to construct a machine capable of registering nine inputs unambiguously on paper tape. Once a basic two-channel

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machine has been constructed, only six electronic components need be added for each additional channel. A 20-channel machine is technically possible.

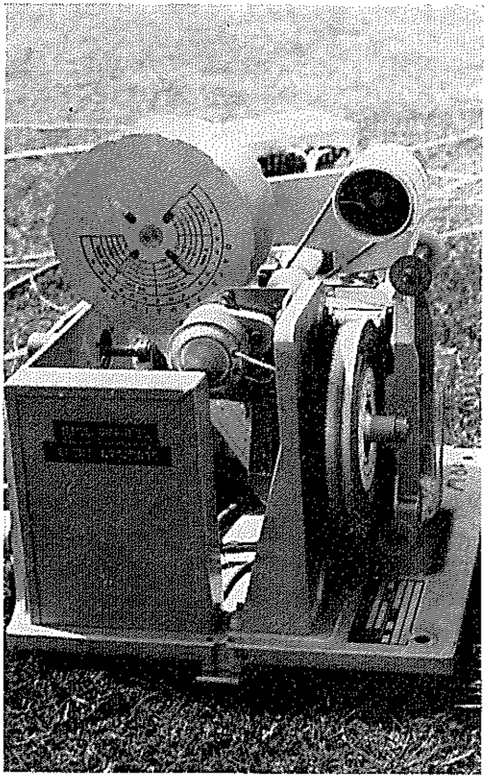

FIG. 1 — The recorder showing the circuit cover, the punch motor and the high-order (channel) code disc.

THE NINE-CHANNEL RECORDER

The nine-channel recorder (Fig. 1) is very similar to the single-channel recorder described by Chandler and Patterson (1970). In fact, present event recorders could be converted to multichannel recording at little extra cost. The main difference between the recorders is that the high-order disc now records channel number instead of time. The low-order disc still registers time. Operation is as follows:

1) A channel input is activated when an event occurs.
2) The high-order code disc scans for the correct channel number.

3) The machine punches time with the low-order disc, and channel number with the high-order disc.

If several channels are activated at the same time, then the events are stored until the machine clears itself by punching all events on the tape. Up to nine inputs can be memorized at the same time in different channels.

If one channel input dominates, then the scanning action of the high-order disc is omitted, unless some other input intervenes.

Since time is recorded by only one disc to two significant figures it becomes necessary to regard one complete revolution as an event to be recorded. The disc revolves at one revolution per hour or day, depending on the clock used, and when it reaches 99 the machine records this event in channel 9, thus punching the code 9099. This distinctive number is easily recognized on the tape as a time mark and divides the record into blocks of one hour or one day. This feature could be of value even on single-channel machines when the record is checked manually, as a particular period of interest could be easily located on the tape.

FORMAT

Coding on the tape is in binary coded decimal representing four digits: d_1 d_2 d_3 d_4.

d_1 is the channel number from 1 to 9. Zero is avoided because of the possibility of the stop command, 0000, for the translator being punched.

d_2 is always zero because the punches representing this digit have been removed from the punch block to allow less precise positioning of the high-order disc.

d_3 and d_4 represent time. When $d_3d_4 = 99$ the code 9099 is automatically punched, thus recording the fact that the time disc has completed one revolution.

ANALOG RECORDING

Since the clock rotates the low-order disc, a number sequence is generated, i.e. 0, 1, 2, ... 99, 0, 1, 2 . . . . . Selected numbers are punched when events occur, thus giving the time of the event. If a linear potentiometer is coupled to the clock drive its resistance must have a 1:1 relationship to the above sequence at any time. This potentiometer (Fig. 2) becomes part of a wheatstone bridge containing an unknown resistance, e.g. a thermistor. The bridge is adjusted so that the balance point can be found by rotating the potentiometer. The balance point is therefore obtained once for each revolution of the clock drive. This is an event and is applied to one of the event inputs of the recorder. Channel number and time are punched; this 'time' is numerically equivalent to the value of the unknown resistance in the bridge. Thus three different variables can be represented without ambiguity during one punch-out. Rapidly fluctuating temperatures may cause several punch-outs to occur, but a built-in hysteresis minimizes this effect.

CIRCUIT

The circuit is simple in design. The punch and scan motors are controlled by two-stage transistor switching circuits. The scan motor (Fig. 2) has automatic braking, achieved by electronically shorting the motor windings when the correct channel is located. This is necessary for positive positioning of the high-order disc. To help, the 100s punches have been removed, making positioning less critical and ensuring correct punching.

Inputs are memorized by silicon-controlled rectifiers and are cleared by reed switches behind the high-order code disc (Fig. 3).

No power is consumed during periods of inactivity. Battery life is clearly dependent on activity, but No. 6 dry cells should last at least six months in temperate climates. The battery may be made from cells totalling from 7.5 to 18 volts. The increased voltage makes for faster operation.

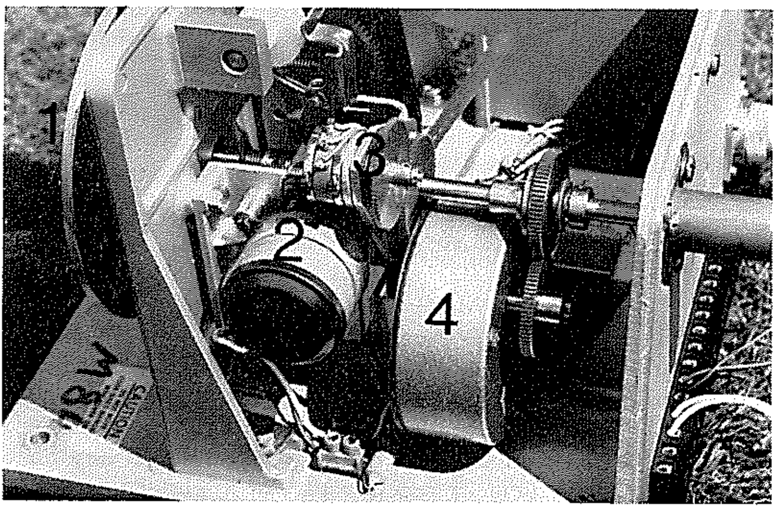

FIG. 2 — The recorder showing: (1) the low-order (time) code disc; (2) the scan motor driving the high-order (channel) code disc through existing gearing; (3) the reference potentiometer; (4) the battery-activated clock.

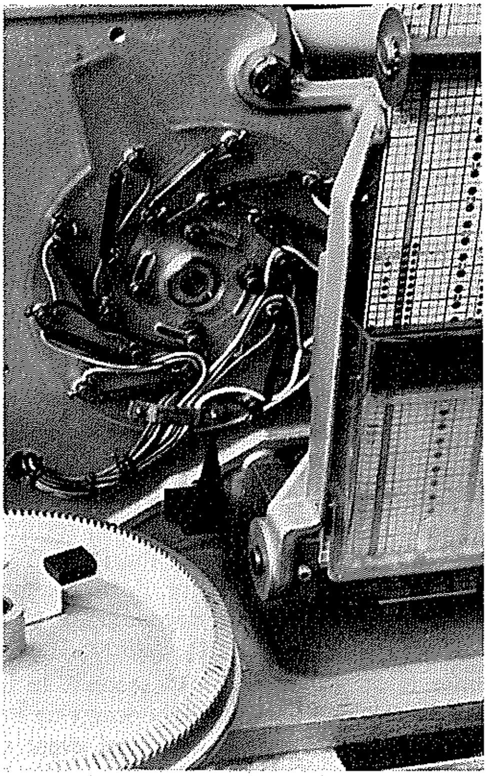

FIG. 3 — The reed switch array behind the high-order (channel) code disc.

COMPONENTS

The components necessary for the conversion of a standard event recorder to nine-channel operation are:

1) A scan motor to drive the high-order disc through existing gearing.
2) A simple electronic circuit on a plug-in board.
3) A reed switch array behind the high-order code disc.
4) For analog measurements, a single-turn 'servo' potentiometer is geared to the time-disc drive, and a bridge circuit is connected to this and to the event inputs.
5) A wiring harness, connectors, plugs, etc.

APPLICATIONS

The prototype recorder has been used to record the following variables at the same time:

1) Rainfall — using a tipping-bucket raingauge.

2) Wind — using a modified cup-counting anemometer giving a contact after every 10 km of wind run.
3) Solar radiation — using a standard solarimeter and a specially developed integrator which generates pulses (events) at a rate proportional to the average intensity of solar radiation.
4) Temperatures — using four Meteorological Office thermistors and a special bridge circuit connected to four of the event inputs. Readings at approximately one-hourly intervals were obtained. A 0.5 deg C change could be resolved.

Other applications are possible providing the slow punch rate of the recorder is taken into account, e.g. soil moisture measurements, using a.c. bridge techniques.

LIMITATIONS

An integrator can generate excessively long lengths of tape if the pulse rate is too high. A compromise must be made between resolution and tape output. An alternative is to record an average hourly value as an analog input during the following hour. This could be done with a modified integrator. Analog sampling is confined to hourly or daily spot readings depending on the clock used. Maxima and minima are not necessarily detected.

The recorder takes about 10 to 15 seconds to complete an average scan and punch cycle, thus rapidly occurring events cannot be sampled without scaling. The multichannel event recorder developed by Goodspeed and Savage (1969) can record at a much faster rate, but specially developed sensors must be used for variables such as temperature. Their type of recorder also has the disadvantage that it punches a time mark every six minutes. For an equivalent time resolution the new recorder need punch only once every 10 hours, as two digits of time are encoded.

A rapid punch cycle would be possible if a faster motor with electronic braking were employed. A punch cycle time of one or two seconds would then be possible.

CONCLUSION

A recorder has been described which is capable of recording some of the parameters required for hydrological research in New Zealand. It is based on a familiar machine and is simple in design. Manual interpretation of the record is not difficult, but a computer program will probably be necessary for long records. A simple "sort-out" program, written by Dr R. P. Ibbitt, Water and Soil Division, Ministry of Works, Wellington (pers. comm.), has been tested and works well, but features such as time corrections need to be added.

It is very tempting, when presented with a nine-channel recorder, to use all nine channels without considering whether the extra data are needed. It is to be hoped, therefore, that the potential value of this machine will not be wasted by mixing necessary data with data that are not necessary.

ACKNOWLEDGMENTS

The prototype machine was constructed at the New Zealand Hydrological Services Depot of the Ministry of Works by Mr Stan McGregor. Mr A. Chandler (Water and Soil Division, Ministry of Works, Wellington) collaborated in developing the original idea.

Permission to publish this paper was given by the Commissioner of Works.

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