A PRINTING COUNTER FOR THE FIELD RECORDING OF EVENTS

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ABSTRACT

A novel low cost housing for a single channel Swiss printing counter mechanism allows recording of some hydrological and meteorological variables under a variety of field conditions. A range of accessories has been developed for recording solar radiation, soil moisture and average temperatures. Variables such as rainfall, wind run, water flow, etc. may be recorded by using the appropriate transducer.

INTRODUCTION

A combined event and fixed time recorder has been described previously (Patterson 1971) based on a Swiss Printing Counter (Sodeco model PL 103 with 24 volt coils). Field testing of the original unit led to the development of a new robust housing, a better take–up mechanism, standard battery holders, a locking handle, a printed circuit, a new chassis and mounting for the counter, spacers for permanent mounting on a concrete pad and a range of accessories for recording such variables as solar radiation, average temperatures and soil moisture.

More than thirty units are now being used and have performed reliably under a variety of conditions from southern New Zealand to tropical Malaysia. Improvements not considered necessary at this stage include the use of plastic based paper and inks for very low temperatures.

Workshop drawings (MC 322/38, WS 114 in 7 sheets) have been prepared by the Ministry of Works in Christchurch.

MECHANICAL CONSTRUCTION

The original housing fabricated from mild steel was abandoned because of cost. A new configuration (Fig. 1) was adopted consisting of a chassis carrying the printer, circuit, clock, batteries, switches and other components, attached by spacers and rods to an aluminium base and covered with a modified 305 x 305 mm stainless steel kitchen sink. The kitchen sink is a standard unit with the edges modified to take a rubber seal. Two raised holes in the top of the cover allow two rods to pass through so that it can be tightened down onto the base by means of two large cover retaining nuts. The assembly is secured by means of a locking bar (g. Fig.1) which takes a standard padlock. The bar also serves as a carrying handle.

The use of the kitchen sink as a cover offers a low cost, mass produced solution

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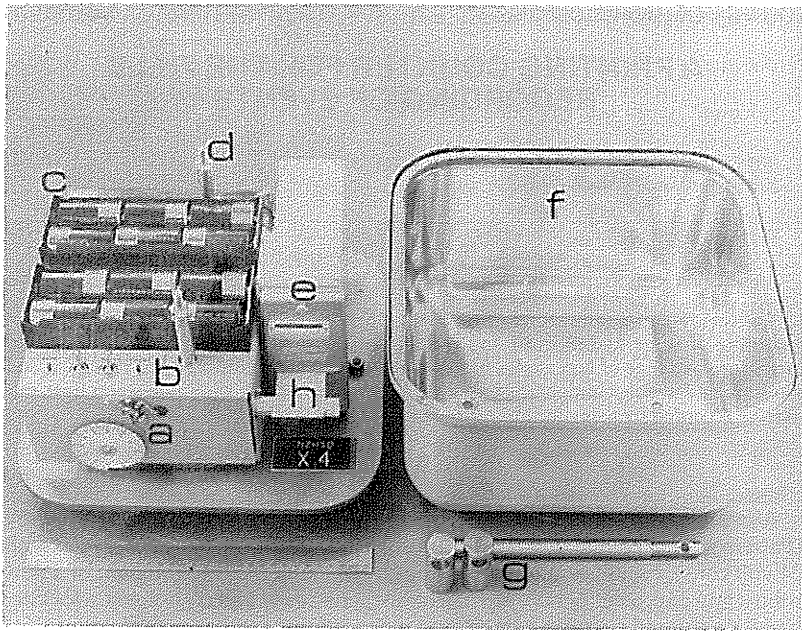

FIG.1 — NZHSD Printing Counter showing: a. Clock cam and microswitch assembly. b. Control panel. c. Battery holders. d. Threaded rods to accept the cover retaining nuts. e. The Sodeco PL103 printing counter. f. 305 x 305 mm kitchen sink. g. Locking bar and cover retaining nuts. h. Paper take up spool.

to the housing of instrumentation under field conditions with the added benefit of stainless steel's strength and corrosion resistance. Other stainless steel pressings have been used as housings for accessories.

Referring to Fig.1; the base is an 8 mm thick aluminium plate. Three hollow spacers keep the unit clear from the ground and may be used for permanent siting with bolts set in a concrete pad on the ground. Three rods, two of which have slip–over spacers and nylon locking nuts (d), support the chassis above the base. These two rods extend through the cover to take the cover retaining nuts (g). A close fitting hole in the base allows connection of the transducer cable to the recorder. On one side of the chassis a bracket holds the printer (e) securely. The battery holders cover the top and back of the chassis (c). Near the front of the chassis a control panel (b) comprising four switches allows the unit to be turned on and off, the counter to be reset, a manual input and the choice of fixed time or event recording. An Ergas hourly clock, fitted with a cam, is located on the front panel of the chassis (a). A microswitch and cam follower supply timing pulses at a rate dependent on the clock cam chosen.

The printed circuit is mounted on spacers underneath the chassis (b, Fig.2). A seventeen way terminal block allows removal of items like the clock and battery holders with the aid of a screwdriver. A two way terminal block accepts the transducer cable. Soldered wire terminations would simplify the design by allowing a direct point to point wiring scheme to be used. Direct mounting of switches onto the printed circuit board could also be desirable.

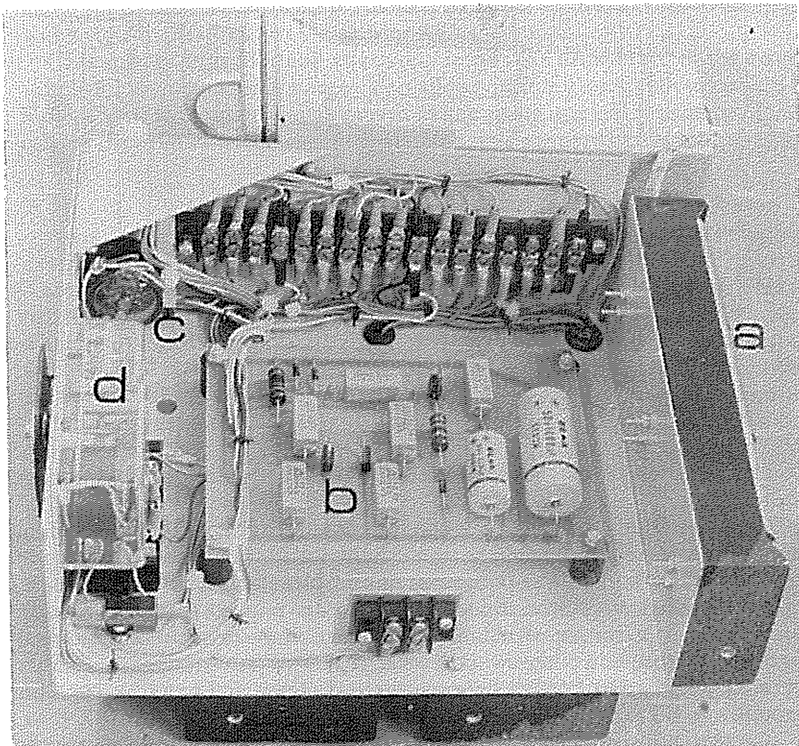

FIG.2 – Under chassis view showing: a. Rear battery holder. b. The printed circuit. c. Take–up spool motor. d. The Ergas timer.

A take–up mechanism is mounted through the chassis in front of the printer (h, Fig.1). It consists of a motor (c, Fig.2), identical to that used to wind the clock, and a spool assembly designed to allow easier removal of accumulated tape. The spool is springloaded and will flex away when pushed. This allows one end to be unsupported without the danger of bending the motor shaft. A hairpin spring with one leg running in a nylon groove on the spool assembly prevents the unwinding of accumulated paper. The recorder design uses S.I. units throughout.

CIRCUIT

The circuit (Fig.3) has a variety of functions, namely: control of the print, count and reset functions, operation of the take–up mechanism and winding the clock.

The power supply consists of eighteen size D cells fitted in three battery holders. Operation of the recorder is possible with the power supply ranging from 27 volts to less than 20 volts. The power drain is intermittent and of short duration under normal circumstances. This means that battery life is long, e.g. several months for event recording of rainfall. It should be noted that 27 volts can be dangerous to handle under some circumstances, (for example in moist

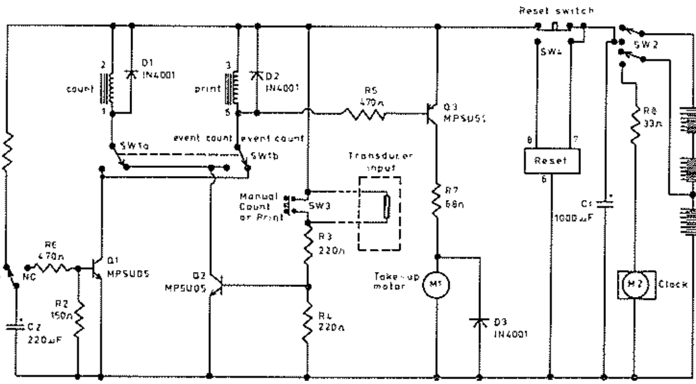

FIG.3 – NZHSD Printing Counter circuit.

conditions) so any electrical connections should be carried out with the recorder switched off.

The negative side of the supply is connected to the chassis via the clock winding motor, so care has to be taken to avoid shorts via the input leads. Turning the recorder off during setting up prevents this problem.

The connection of accessories or transducers requires care. Transducers incorporating a simple switching mechanism may be connected directly provided neither side of the switch is grounded. This prevents the possibility of an electrical current flowing between the transducer and recorder via damp ground.

Accessories incorporating electronic circuitry should be isolated by means of a reed relay. For example, a DC leakage path could upset the operation of the electrical soil moisture accessory for gypsum blocks. All accessories will have a reed relay or an optical coupler built in. Insulation of the clock from the chassis is an alternative solution, or preferably another type of clock could be used. For example a quartz crystal type which would also improve timekeeping.

The clock is wound at hourly intervals by a motor driven off the rear battery pack via a small dropping resistor R8. As the power drain is very low, this practice means that this battery pack is not discharged well before the other two.

Circuit operation is as follows (Fig.3): The switch SW5 is actuated periodically by the clock driven cam. With SW5 in the normally open (N.O.) position, C2 charges up via R1. When SW5 changes over to the normally closed (N.C.) position, the charge on C2 is fed, via R6, into R2 and the base–emitter circuit of Q1. This current turns Q1 on, thus driving the "count" or "print" coils depending on the position of SW1 a and b.

Inputs to the recorder are connected in parallel with SW3. An event, or momentary operation of SW3, connects R3 to the positive supply. Current flowing through R3 turns Q2 on, thus driving the "print" or "count" coils depending on the position of SW1 a and b.

Protection of Q1 and Q2 from high voltage turn off transients is provided by diodes D1 and D2.

When the print coil operates, Q3 turns on, causing the take–up motor to operate. The reset switch SW4 triggers an electrical reset function incorporated in the Sodeco printer. Switch SW2, when turned on, applies 27 volts to the circuit and 9 volts to the clock via the resistor R8.

C1 is a large capacitor and effectively lowers the impedance of the battery supply for momentary discharges. This allows ordinary torch cells to be used for long periods without problems caused by the rising internal resistance of these cells as they run down. Manganese alkaline cells are used at low temperatures.

ACCESSORIES

An integrator (Fig.4) using low cost integrated operational amplifiers has been designed for use with high output solar radiation transducers. The integrator has a sensitivity of one output pulse per minute for a 50 millivolt input. Errors are usually less than 2 or 3 counts per 24 hours for moderate temperature changes. The circuit board must be clean and should be protected with polyurethane spray if reliable operation in the field is to be obtained. Transducers having sensitivities of about 0.40 mV mW^{-1} cm^{-2} are suitable. Low output transducers are less suitable, as integrator errors may dominate the record under low output conditions. More sophisticated integrators are available commercially*. Better operational amplifiers such as the LM 308 could be substituted in the existing circuit with minor modifications.

Civit and Bracho (1971) have published circuits for voltage to frequency convertors. The present design is based on these circuits with appropriate changes in time constants and the addition of a monostable circuit to assist in the discharge of each cycle. A current drain of about 1.5mA gives good battery life.

Briefly, operation is as follows: the integrator's input is connected to a solar radiation transducer. The integrator's output rises at a rate proportional to the voltage at the input, (i.e. the voltage is integrated). When the output equals that of a 3 Volt reference supply, a comparison circuit switches on momentarily, causing the discharge of the integrating capacitor. The cycle then repeats. The

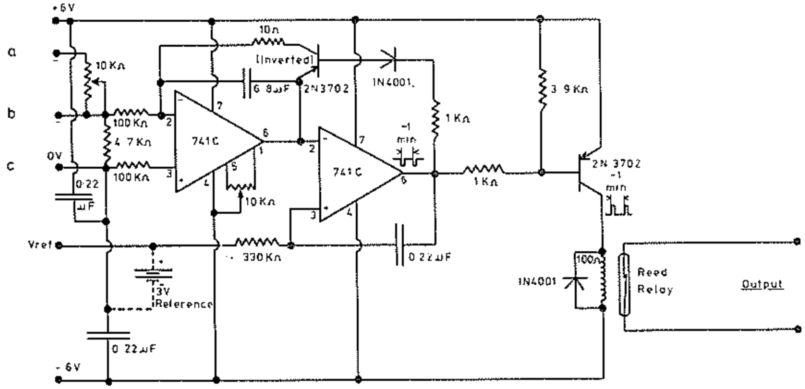

FIG.4 – Standard Integrator–50 mV input for 1 contact/minute output. a. -50 mV transducer input. b. Temperature accessory input (negative). c. Common terminal 0 Volts.

* For example: The Kipp and Zonen Integrators BC1 and CC1 or the Lintronic Agromet Data System Mark V Digital Volt–Time Integrator and hourly average print out system. Various chart recorders offer integrator attachments also.

nett result is an output pulse which occurs at a frequency proportional to the input voltage. This pulse may be used to operate the printing counter, allowing hourly total proportional to solar radiation to be printed out. If necessary the integrator may be calibrated directly in solar radiation units by setting the 10k ohm trimmer connected to input *a* (Fig.4).

Another version of this integrator allows average temperatures to be recorded (Fig.5). A thermistor linearized according to a procedure given by Nordon and Bainbridge (1962) forms part of a bridge circuit (this thermistor is used by the Meterological Office in radiosondes). The output of the bridge forms the input of the integrator. A fraction of the bridge power supply replaces the 3 Volt reference supply. The integrator now gives an output pulse at a frequency proportional to resistance. Since the reference voltage varies in proportion to the bridge supply, the output frequency becomes independent of voltage changes. Over a 40°C range, a linear calibration can be obtained to within 1°C. The circuit is calibrated so that a temperature T degrees above some reference level (0°C or lower) gives a count rate of T counts per hour. Thus if the reference temperature is chosen at 0°C, then the hourly average temperature above 0°C is equal to the difference between the value of successive printouts in the fixed time mode. A 5K ohm trimmer allows for zero adjustments while a 100K ohm trimmer is used for setting the scale factor.

The soil moisture accessory (Fig.6) consists of an oscillator whose frequency is controlled by the resistance of a gypsum block soil moisture sensor. The output frequency is divided by a multistage binary divider to give a pulse rate acceptable to the printing counter. A monostable circuit gives a suitable pulse duration for operating the printer or counter. A stable oscillator and a divider can be designed using RCA COS/MOS integrated circuits giving an output frequency nearly independent of temperature and voltage variations thus offering a potentially reliable field performance. (RCA Solid State 1974.) Since the current through the gypsum block alternates in direction, polarization effects should not give trouble.

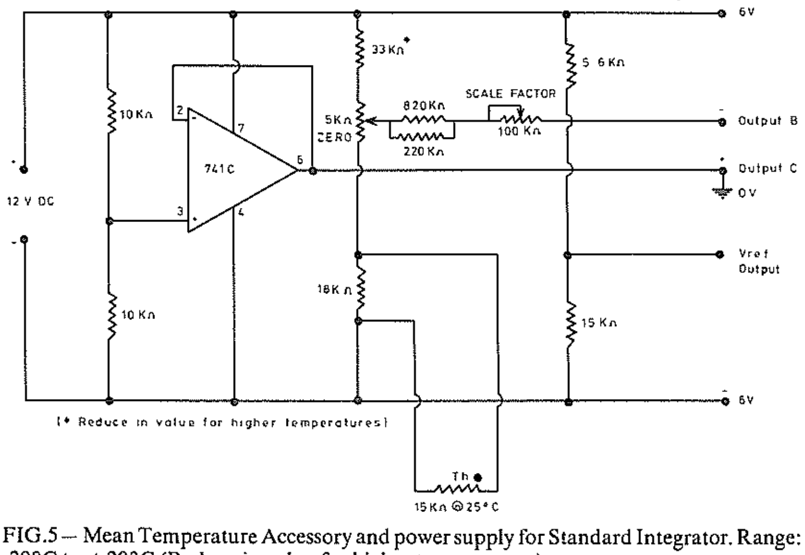

FIG.5 — Mean Temperature Accessory and power supply for Standard Integrator. Range: -20°C to +20°C (Reduce in value for higher temperatures)

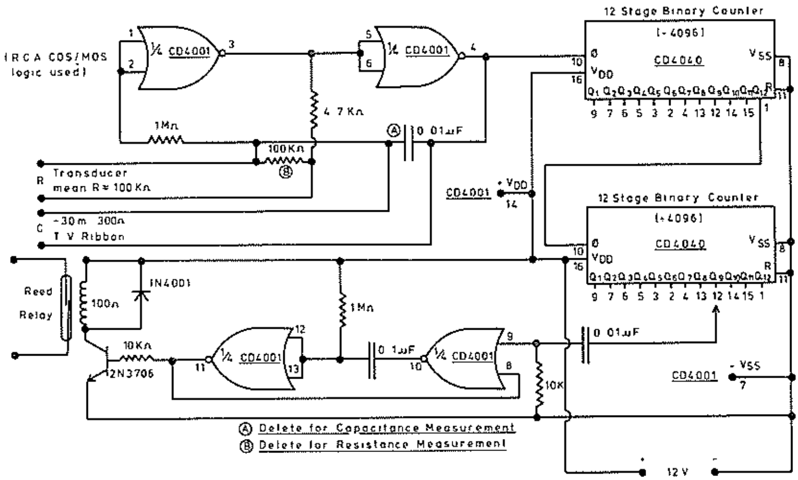

FIG.6 – Resistance (AC) or Capacitance to Frequency Converter.

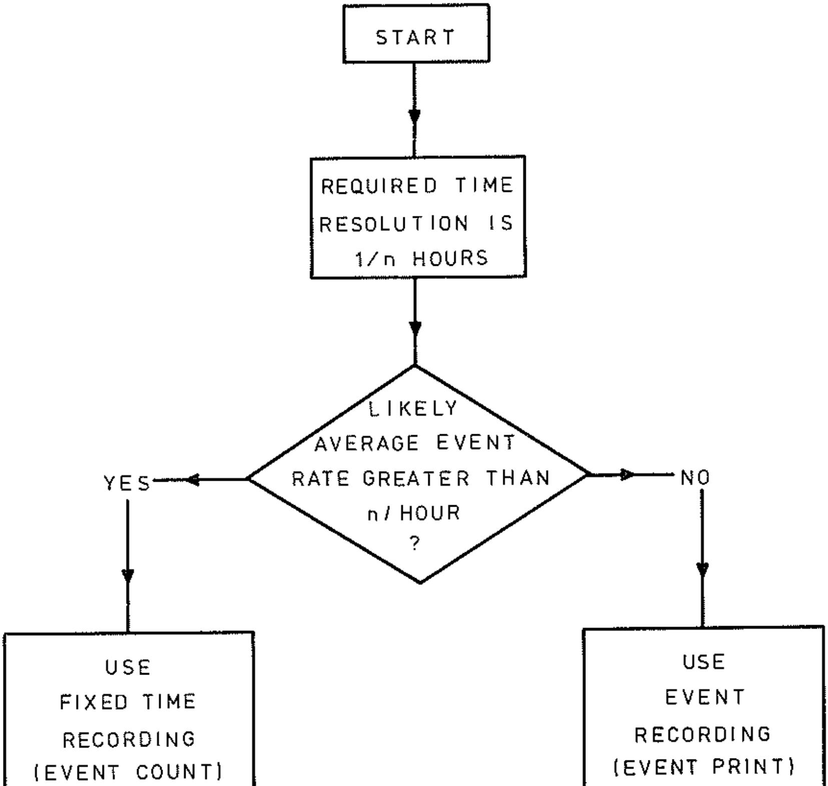

FIG.7 – Minimisation of tape output.

An alternative method suitable for dry soils uses a buried 300 ohm television ribbon, about 30 metres long, as a capacitance transducer. Moisture in the soil increases the capacitance between the insulated conductors of the buried ribbon and lowers the frequency of the oscillator. This technique has not yet been fully developed; significant responses were only obtained in dry soils. The circuit presented (Fig.6) can be used with either capacitance or resistance transducers. The output frequency is inversely proportional to resistance or capacitance and in the event recording mode the difference between successive printouts of time is therefore proportional to the mean resistance or capacitance over that time interval.

The accessories described are compatible with other event recorders (Chandler and Patterson, 1970, Patterson 1972). However the slow speed of those recorders could cause problems with rapidly occurring events. High speed and the choice between event and fixed time recording are the key features of the NZHSD Printing Counter. The latter features allow a manageable length of record to be produced almost regardless of the activity of the input transducer. A guide as to which mode to use is given in Fig.7 which allows tape output to be minimised. Other factors, such as the convenience of the format will affect the choice.

ACKNOWLEDGEMENTS

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