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AN AUTOMATIC PUNCHING COUNTER

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AN AUTOMATIC PUNCHING COUNTER

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SUMMARY

An automatic punching counter was constructed to enable numerical values associated with plant growth experiments to be counted and stored on paper tape in a format for computer input. By choosing the appropriate input device, counts, coded assessments and certain quantifiable factors, such as units of water supplied, can be recorded on paper tape as 3-digit integers.

Space, carriage return and line feed symbols are inserted automatically. Uniselector stepping switches are used to form the primary and line length counters, and digital indicators display their contents. Electromechanical circuitry is used throughout to allow reliable operation despite poorly regulated mains supplies and spurious impulses from other equipment.

The equipment consists of a 3-decade counter coupled to a paper tape punch via an encode matrix. A motorised sequence switch serialises the data, and circuitry is provided to insert the correct line termination characters, to allow the punching of dummy values in place of missing observations and to reset the counters. Slow real-time working allows the use of fairly simple counters and punch, with a consequent reduction in cost.

The instrument has been used extensively in the laboratory and has also been tested with a portable generator in the field. Remote operation is possible, and remote lead lengths can be long without loss of accuracy or spurious operation.

INTRODUCTION

Much numerical information is collected during each herbicide evaluation experiment and so a study was made of the methods by which this information was collected, and an attempt was made to improve the efficiency of the process. Previously, numerical assessments and counts of plant features such as shoots were recorded with pencil and paper, and if the data were to be subjected to computer analysis, were punched at a later date. The object of designing the equipment described here was to eliminate the intermediate pencil and paper stage by transferring as many assessment features as possible directly to paper tape. Most of the non-destructive assessments involve counting, so the equipment was constructed around a decade counter. Visual assessments are coded as single digit numbers, so to enter scores of herbicide damage a telephone dial is used to generate impulse trains to step the counter round to the correct value. A water metering device was also devised to dispense fixed increments of water and to record a count for each increment. By using this device to water the plants a record of their water usage can be built up.

The aim of using the punching counter is to save labour by removing the need for re-punching, and to save time, since punching is more rapid than writing. Eliminating one step in the process also eliminates a source of error, so that accuracy should be improved.

The equipment has a potentially wide application whenever replicated experiments are performed, and the basic design is adaptable to record a variety of numerically expressed factors. A fuller description of its use together with an experimental example is given elsewhere (Simmons and Caseley 1972).

FORMAT

Each entry on the tape is in the form of a space character followed by a 3-digit integer. Ten such entries form the normal 'line', which is terminated by a further space followed by the characters 'CARRIAGE RETURN' (CR) and 'LINE FEED' (LF). A shorter line can be pre-set inside the machine if necessary, down to a minimum of two entries per line, but all lines on the same tape must have the same length. The structuring of sequentially collected data into a series of lines of fixed length is a common requirement for computer input, particularly where the input device treats the paper tape as though it were a series of cards or where a data line file is created from the punched data. Heading and trailer characters must be added to the tapes before despatch, to meet the requirements of the computer department paper tape input routine. This is normally done by copying the tape on a teletype machine and typing in the appropriate characters.

To transmit the data to the computer via an on-line teletype machine, the punching counter must be modified to permit the punching of five line termination characters.

Manual reset keys are provided for both counters, and function keys are also provided to enable a special symbol to be punched to indicate missing values, when a plant has to be omitted from the assessment. This is done by causing the sequence switch to scan a preset character code instead of the decade counters.

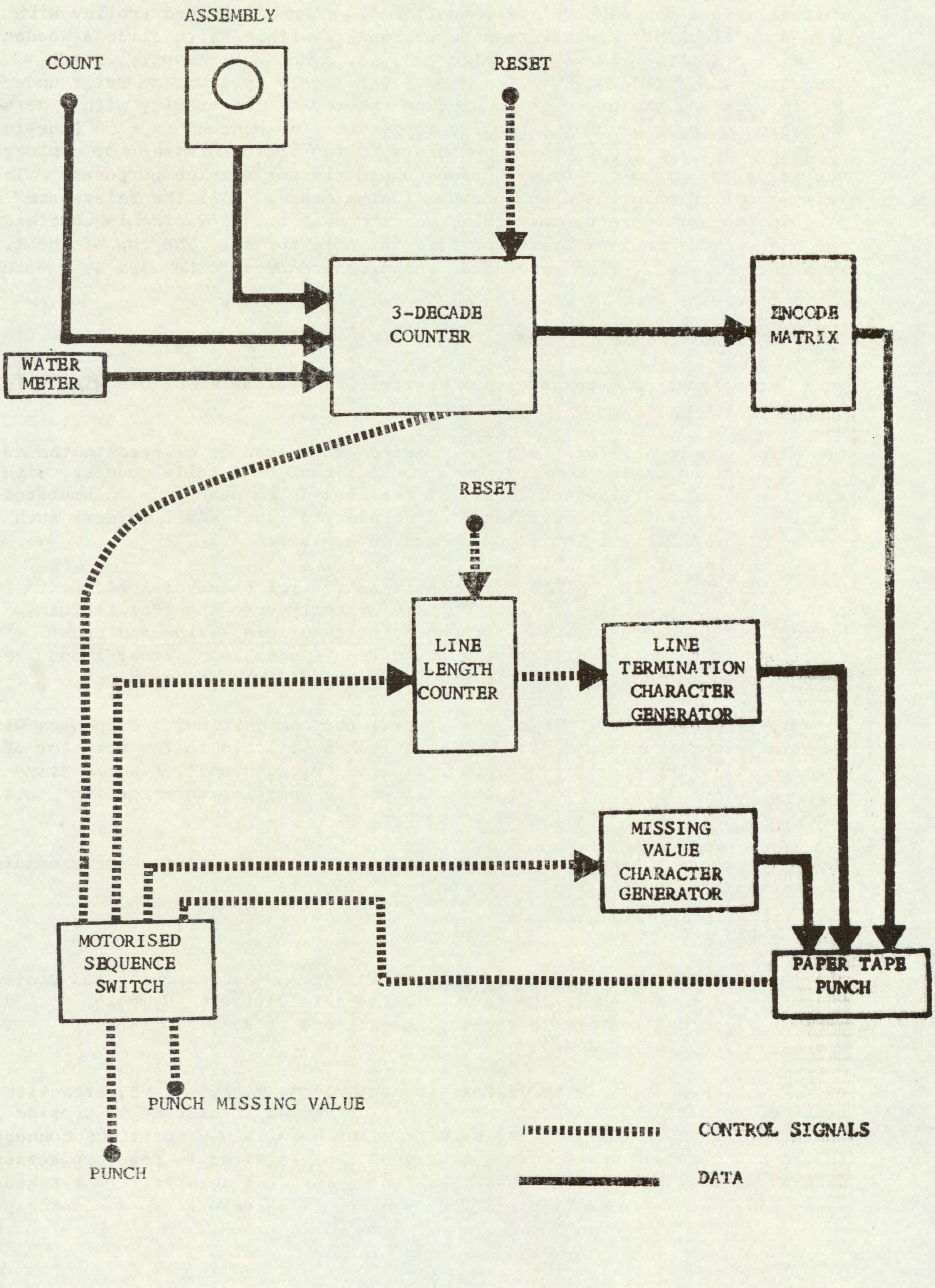
CONSTRUCTION

The basic elements are shown in Fig. 1. Sources of supply of principal components are given in an Appendix. All except the punch operate from +24v DC supplied by a post-office "LT. supply unit type 19". The punch has its own 48v DC supply. (Fig. 4)

The machine is constructed from post office type uniselectors, telephone dials, relays and power supplies, as these are readily available on the surplus market and will carry sufficient current to operate the punch solenoids directly. This type of circuit element also has the advantage that the status of the current count and line length counters is retained if the power supply is interrupted.

The use of electromechanical circuitry also obviates many of the problems associated with using electronic counters with external switching devices, where contact bounce can cause false operation of the counter, and long lead lengths can degrade the pulse shape. Neither of these problems occur with the electromechanical units employed, nor does the equipment require elaborate power supplies, being tolerant of variations in mains supply voltage of ± 30v AC. By replacing the AC motors used for the punch sequence switch and reset/runout generators by DC operated equivalents, the instrument could be redesigned to operate from storage batteries such as vehicle batteries. The prototype instrument has also been tested using a portable petrol-driven generator as

Fig. 1. AUTOMATIC PUNCHING COUNTER. SIMPLIFIED BLOCK DIAGRAM



the power source. Such a combination can be mounted on a vehicle for field use.

The method of construction was chosen in order to give maximum accessibility to the component parts so that repairs and modifications are simple. This is of great importance in prototype equipment which rarely survives the initial trials period completely unaltered. A metal framed trolley with drop-down sides has central transverse runners within which slide a wooden frame carrying the relays, uniselectors, 48v punch power supply, reset generator and encode mesh. The main power supply is slung on rails under the chassis and the punch is mounted on the top of the trolley with a detachable bin on the side of the trolley to collect the punched tape. Plug-in leads connect the front panel components to the central frame; by unplugging the leads the frame can be withdrawn completely for service purposes. The relay panel is mounted in an aperture in the frame. All the relays are plug-in types to permit easy replacement. Most of the wiring is confined to one side of the central frame and tied in cable forms. The top of the trolley is a perspex sheet, also removable, and strong enough to be used as a work surface.

INPUT DEVICES

Three types of external input devices are available for use with this instrument.

a) Hand counter. This is a small switch which can be clipped to the hand, and is operated in the same way as a conventional hand tally counter, with the addition of an extra switch to signal the machine to punch the accumulated total. An operator can use the hand counter to count small objects such as seeds or the number of leaves or shoots on a plant.

b) Dial entry unit. This unit consists of a telephone dial mechanism to permit the entry of single digit numbers directly onto the tape. Push-buttons are provided to allow the punch, punch missing value and count functions to be called directly from the remote unit, and signal lamps are incoproraed to indicate the clear and busy conditions of the punch.

c) Water meter unit. This is a special purpose unit which dispenses water to plants in fixed increments. Microswitches attached to the actuator of the control valve generate one count impulse for each unit of water dispensed. A punch button attached to the unit allows the operator to record the total number of water units delivered to each plant.

Any other device which produces a pulse or switch closure corresponding to a count or a unit quantity can be used with the machine.

CIRCUIT DETAILS

A complete circuit diagram is given in Fig. 2, and component and contact identifications quoted in the text refer to this figure. Symbols used in Figs. 2-5 conform to the recommendations of B.S. 530 (British Standards Institution 1948).

a) Counting unit. Three 11 position uniselectors, PF1, 2, 3, each with three banks of contacts plus a homing bank, are connected in cascade to provide three decades of count. One bank of each selector has its 0-9 positions connected to the punch encode mesh, while the second bank is wired to rear projection digital display units to indicate the contents of the counter. The third bank is not used except at the tenth position which is wired to the homing bank. The wiper of the homing bank is connected to the appropriate reset relay D, E or F so that on reaching the tenth position, the uniselector resets to zero, moving over the eleventh position. The tenth position on the first and second decades is also connected to the coil of the next selector so that as it reaches 10, a carry impulse advances the next selector by one.

b) Encode mesh. The encode mesh is a conventional diode matrix with input lines from the selectors and output lines to the eight punch solenoids. Diodes connect each input line to the output lines appropriate for that particular character. Consideration of the action of such a matrix shows that it is in fact equivalent to a set of inclusive OR gates, since any particular punch solenoid line is energised when any one or more than one of the input lines which energise that particular solenoid is at 24v.

As well as the numerals 0-9 , lines for the symbols 'SPACE', 'CARRIAGE RETURN', 'LINE FEED' and '*' are provided. Two spare input lines for other characters are incorporated into the mesh for possible future requirements. The output code used is ISO 8 hole code, but the code can of course be changed by rearranging the diodes.

c) Punch sequence switch. This is a motorised switch with the switch units operated by cams on the shaft of a geared synchronous motor operating at one revolution per second. The cams are arranged to perform the sequence of operations necessary to punch the number onto the tape and reset the counters.

The order of operations is as follows:

1. Punch SPACE /Advance total operations counter by 1
2. Advance tape / punch sprocket hole
3. Punch 100's digit
4. Advance tape /punch sprocket hole
5. Punch 10's digit
6. Advance tape /punch sprocket hole
7. Punch 1's digit
8. Advance tape /punch sprocket hole
9. Reset main counter / advance line length counter by 1
10. Stop sequence switch motor

Operations 2, 4, 6 and 8 are carried out by one cam, each of the other operations has its own cam and switch contacts.

d) Reset generator. The reset generator provides pulses at a frequency of 8Hz to reset the uniselectors, and also to make rapid punch calls to produce runout, which is blank sprocketed tape necessary to facilitate threading of the tape into readers. It is energised via a relay S which is called by the RUNOUT switch and also by the reset relays of the uniselectors.

A motor driven wheel revolving once per second carries eight magnets which operate a reed switch to produce the basic 8Hz pulse repetition frequency. The reed switch drives a relay R. The contacts R1 supply 24v pulses via the reset relay contacts D3, E3 and F3 to the uniselector solenoids. When the reset relays are closed, either by the master reset relay A or via the selector bank 3 contact 10, they latch and allow reset impulses to step the selectors round to the zero position, where a break in the homing bank contact disconnects the supply to the reset relay concerned, which opens, disconnecting the selector solenoid from the reset line and reverting it to the count condition. Relay C performs a similar function to the reset relays for the line length counter uniselector PF4, but is energised only by the front panel switch reset group.

e) Line length counter and control character relays. The line length counter is a uniselector similar to those used for the main count, but it is advanced by a signal from the punch sequence switch '5' contact. Hence it keeps a record of the number of punching operations completed, and after ten punching operations have been performed the tenth set of contacts on the selector will be energised and will cause the control character relay CRLF to operate. The 48v lines to the counter uniselectors are routed through CRLF 1, 2 and 3 contacts and operation of this relay disconnects them and routes the first two directly to the encode mesh lines CR and LF. CRLF 4 disconnects the total operation counter and CRLF 5 causes a punch call. During this punch cycle the characters SPACE, CARRIAGE RETURN and LINE FEED are punched onto the tape, and at the end of the cycle the line length counter is once more advanced. The contact immediately after the one which called the control cycle is connected to the reset relay to step the selector round to zero again. (In fact in the case of a 10 entry line this is not necessary because the selector will already stand at zero).

f) Tape punch. The tape punch is an Eichner unit with directly driven 48v solenoids. External tape advance impulses are required but the unit has an optional sprocket punch switch operated by the advance solenoid plunger allowing the use of blank or pre-sprocketed tape as desired.

SUMMARY OF MANUAL CONTROL FUNCTIONS

a) Count. PF1 operates when the count switch is operated or the external count contacts are closed. If selector 1 reaches 10 by this operation relay D closes and the reset generator resets it to 0, generating a carry impulse as it steps past position 10. Similarly if selector 2 then reaches 10 a reset and carry operation to selector 3 occurs.

b) Reset (see Fig. 3). Reset switch operates relay B momentarily, disconnecting total counter and energising relay A. A1, 2 or 3 bring in D, E and F which latch via their own 2 contacts. S is energised via the isolation diodes D2 - D4. The reset generator steps PF1, 2 and 3 round to zero, at which point a break in the homing contact allows the reset relays to fall off. When all reset relays are off S is no longer energised and the reset generator stops.

c) Reset group. This switch energises relay C which latches via C2. Relay S is energised as for the reset operation and PF4 is stepped round to zero as above.

d) Runout. One set of contacts of the runout switch energise relay S to start the reset generator motor. The second pair of contacts receive the pulses from the reset relay R2 contacts and directs them to the tape advance/sprocket punch input on the punch causing blank sprocketed tape to be produced at a rate of 8 holes (0.8 in.) per second.

e) Punch. The punch switch operates motor relay M. As soon as the camshaft starts to turn M is held on by sequence contact 6 until cycle is complete.

f) Punch MV. This causes relay MV to pull in. MV4 supplies power to

Relay M and sequence switch motor begins to rotate. Sequence switch 6 then supplies 24v via MV4 to hold the MV relay on till the end of the punch cycle. MV1, 2 and 3 are in the 48v lines to the uniselectors and divert these lines to the encode mesh lines 'SPACE '*' and 'SPACE', these being the characters selected to denote a missing data value. Since the MV branch occurs after the CRLF branch, in the event of the punch MV button being held in over a control cycle, the correct line termination characters will still be punched.

AUTOMATIC CONTROL FUNCTIONS

a) Reset occurs automatically at the end of a punch call. Relay A is called by sequence contact 5 and the reset operation then occurs in the same way as for a manual call.

b) Total count. An electromechanical counter is advanced by the space pulse of each punch cycle. To prevent spurious counts of control cycles the counter is disconnected by CRLF4 during these operations. When an MV punch call occurs there are three space characters in the sequence instead of one, so an isolation diode D1 is fitted to prevent the extra space calls from advancing the counter. Reset of the counter is manual.

c) End of line symbol generation. The sequence of operations has been described in the section on the line length counter. For line lengths other than 10 entries, the CRLF call line must be re-positioned on the appropriate output contact of selector 4, and the following contact wired to the homing bank to reset the line length counter to zero.

USES

The instrument is used for recording water dispensed to plants in pots, and of numerical assessments of plant properties, such as shoot and leaf count. The water is metered by a device working on the positive-displacement principle - dispensing units of water of fixed volume (normally 10 ml). A count is recorded for each unit of water dispensed, by means of microswitches mounted on the activator valve.

Counts of plant properties are recorded by a simple hand or foot operated push-button switch. A small switch can be worn on the hand to allow counting without the need to remove the hands from the plant.

When it is desired to enter numbers, for example a damage score for a plant, a telephone dial assembly is used to generate a train of pulses of the required length. For convenience a remote dial assembly was made containing the telephone dial and duplicate function buttons for 'count', 'punch' and 'enter missing value'. Using this assembly the operator can enter mixed counts and numerical values while remaining remote from the machine. Indicator lamps are provided on the remote unit to indicate when the machine is clear to accept another entry. The electromechanical components used in the counting stages will tolerate remote lead lengths in excess of 1.5 km if suitable cable is used.

The unit is normally used to record one or two pieces of information about each one of a set of plants in an experiment; because the plants are examined in standard order, the position of the item on the tape identifies the plant to which it refers. Several tapes, identical in format but produced at different dates will be generated during the course of one experiment. After the tape, which may contain, for example, watering figures for 400 plants for one day, is made, it must have a brief heading inserted manually before being sent to be inserted on a magnetic disc file at the computer department. The file has a line format analogous to that created on the paper tape, and the information is held in a set of numbered lines in a storage allocation bearing a name given by the user. The file can be edited, added to, or deleted, and can form the data for a FORTRAN programme. A validation programme (Clarke, 1970) is first run on the data to test for correct format and to locate data figures lying outside bounds of size set by the user. In the case of watering pots in the present research project at WRO for example, it is unlikely that any entry would exceed 17, since it is impossible to put more than 170 ml of water in the containers used. The range tested can therefore be set as minimum 0 and maximum 17, and figures outside this range will cause a warning to be printed to an output file together with the line containing the suspect data. The data file can then be edited if necessary from a remote teletype terminal and the corrected file stored on magnetic tape. At the end of the experiment the tapes form the data set for a programme to recover routine statistical information from the data and print a summary of the experimental results.

MODIFICATIONS

Most of the modifications to the original design were concerned with simplifying the task of the operator and with making the machine more reliable. For example the original design required the simultaneous pressing of two keys to effect a 'missing value' punch. This has been simplified to allow operation by a single key.

The original function buttons have been replaced by illuminated push button switches whose colour changes when the function they control is in progress. This gives the operator a clearer indication of the machine's current state.

Some difficulty was experienced because of arcing due to the heavy inductive load of the punch magnets. Conventional suppression does not entirely eliminate this, and it was necessary to employ heavy duty relays on the reset/runout generator relays to give a reasonable contact life.

At the time of writing of the report, the uniselector mechanisms are being replaced with new uniselectors which have self-interrupting contacts to allow homing to zero without the need for an external reset generator (Fig. 5). They also have integral arc suppression and are less likely to jam than the present type, but naturally are more costly than the secondhand selectors originally used.

Reliability has now reached a satisfactory level though periodic cleaning of exposed contact surfaces is necessary as the machine is used in humid environments. A proprietary contact lubricant, electrolube 2AX has been found to prolong the service life of the selector wiping contacts.

CONCLUSIONS

The instrument described has proved useful in the laboratory for recording directly some parameters associated with herbicide evaluation experiments. It is potentially adaptable to record any factor which can be counted or which can be made to generate a switch closure or impulse to represent a unit quantity. The instrument has been tested using a mobile generator and has possible applications for field recording.

Simple electromechanical circuitry has been employed throughout to simplify the design and decrease the cost, and the equipment has been constructed to allow easy servicing. Because human operators work relatively slowly the use of high speed counters and punches is unnecessary and less expensive devices can be used. Secondhand equipment which may have become unreliable in its original application will perform satisfactorily under the less stringent conditions of slow speed working.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. J.C. Caseley and Miss P. Jones for their assistance in the preparation of this report.

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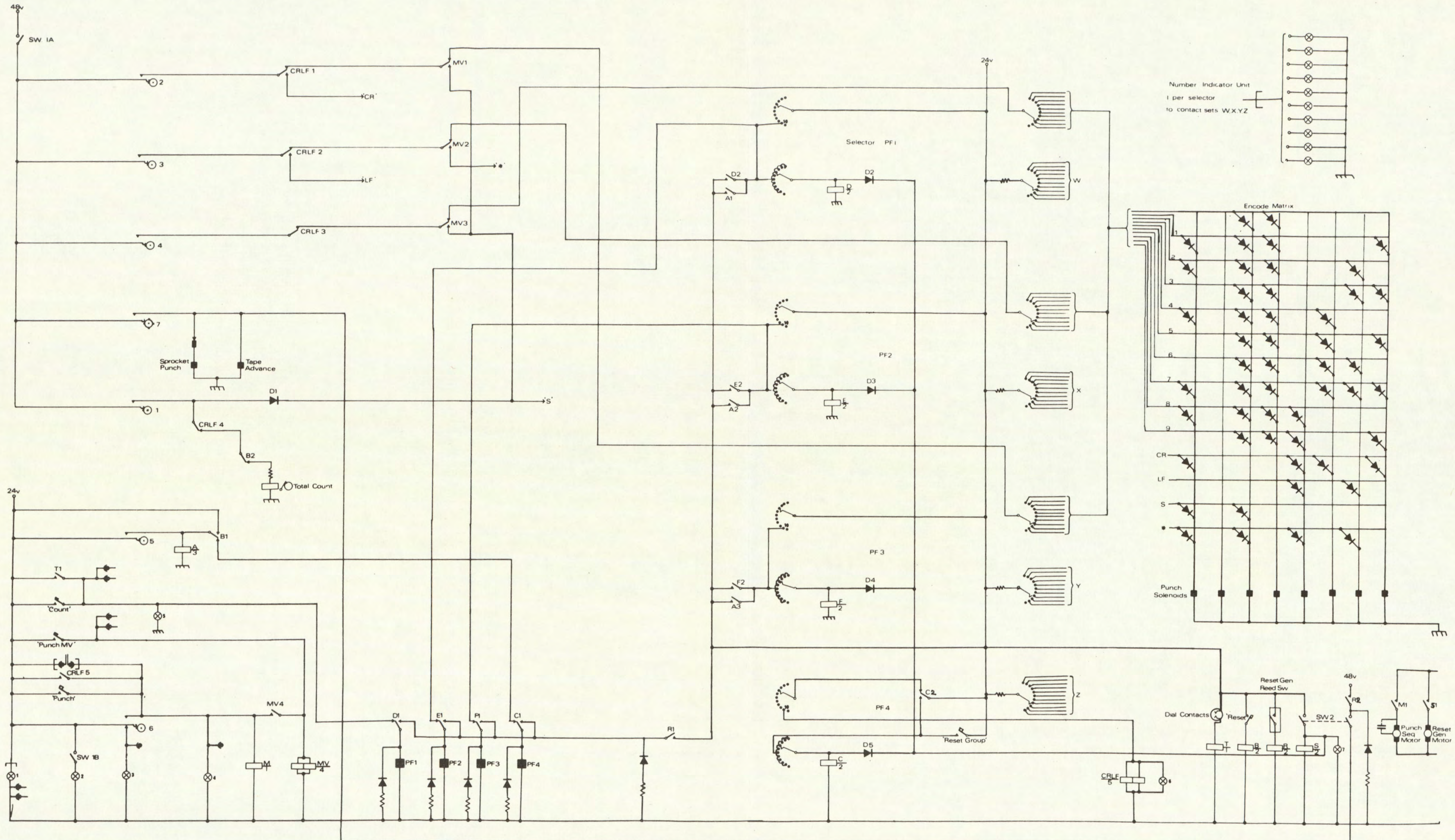
SIMMONS, R.C. and CASELEY, J.C. (1972) An automatic punching counter and metering dispenser. Proc. 11th Br. Weed Control Conf, 1, 123-129.



A R C	WEED RESEARCH ORGANISATION	
Item	AUTOMATIC COUNTING PUNCH CIRCUIT	
Drawing	RCB	21 - 9 - 72
Checked		

SW1 - Punch on/off
SW2 Normal/runout

Fig. 2 Circuit Diagram

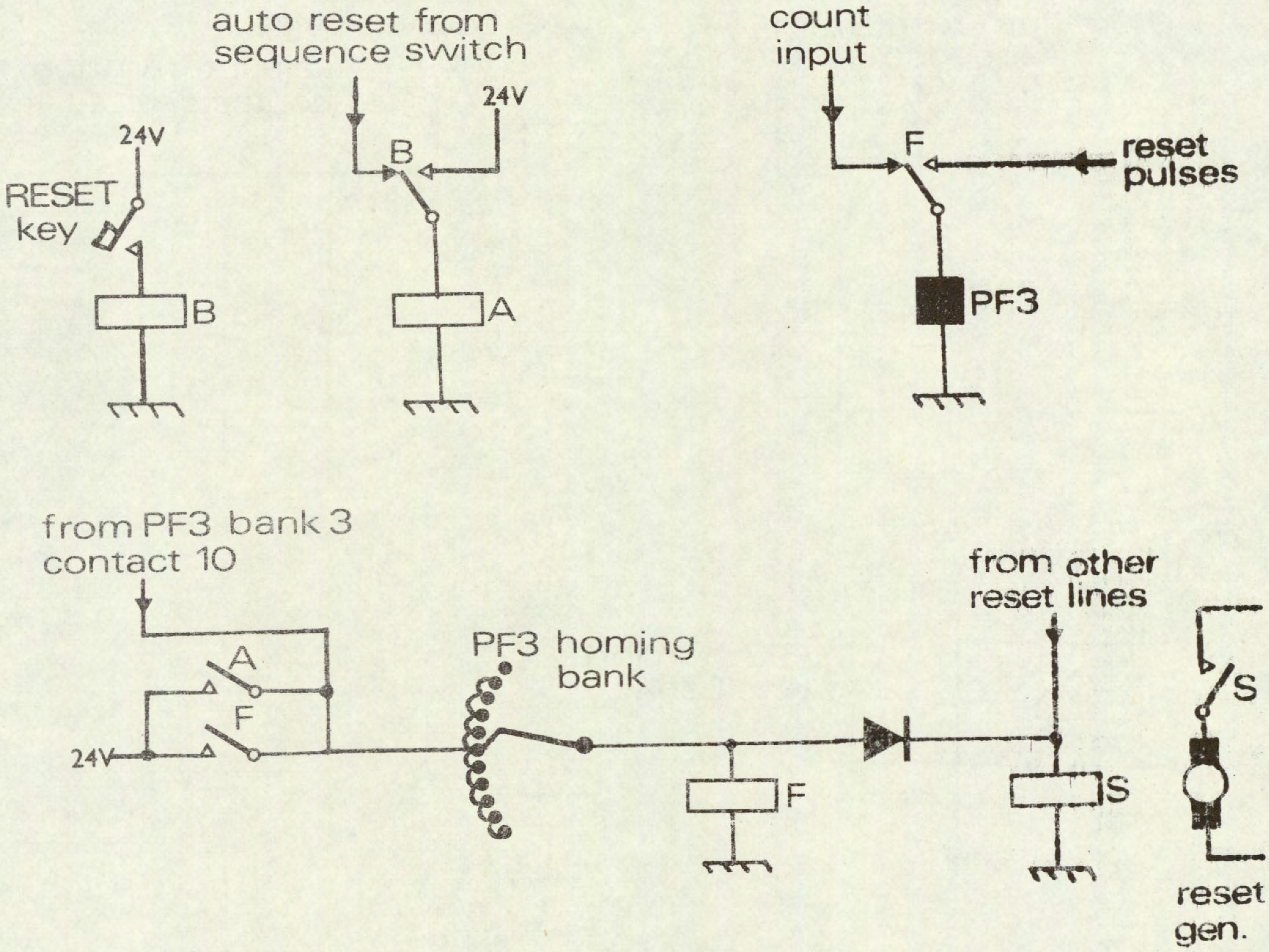


Fig. 3. Simplified diagram of reset circuitry

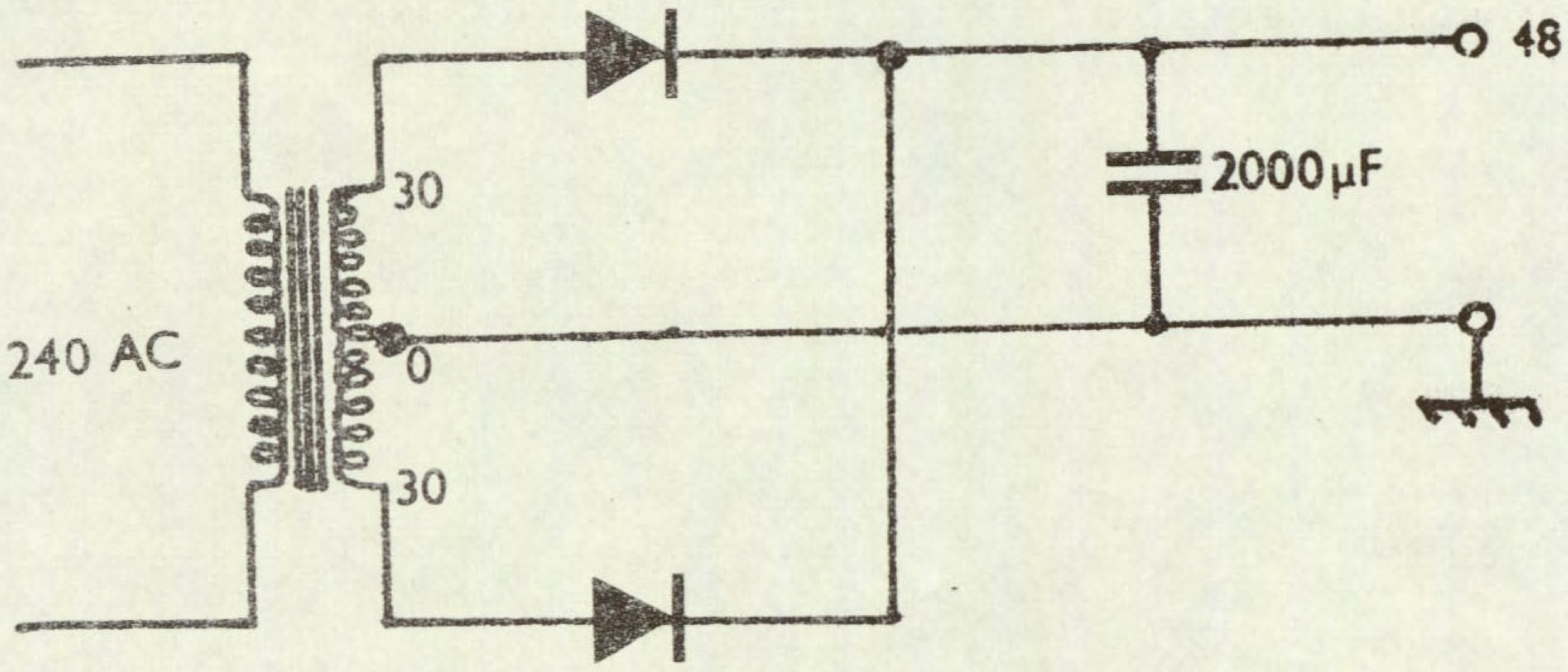


Fig. 4. 48 volt punch power supply

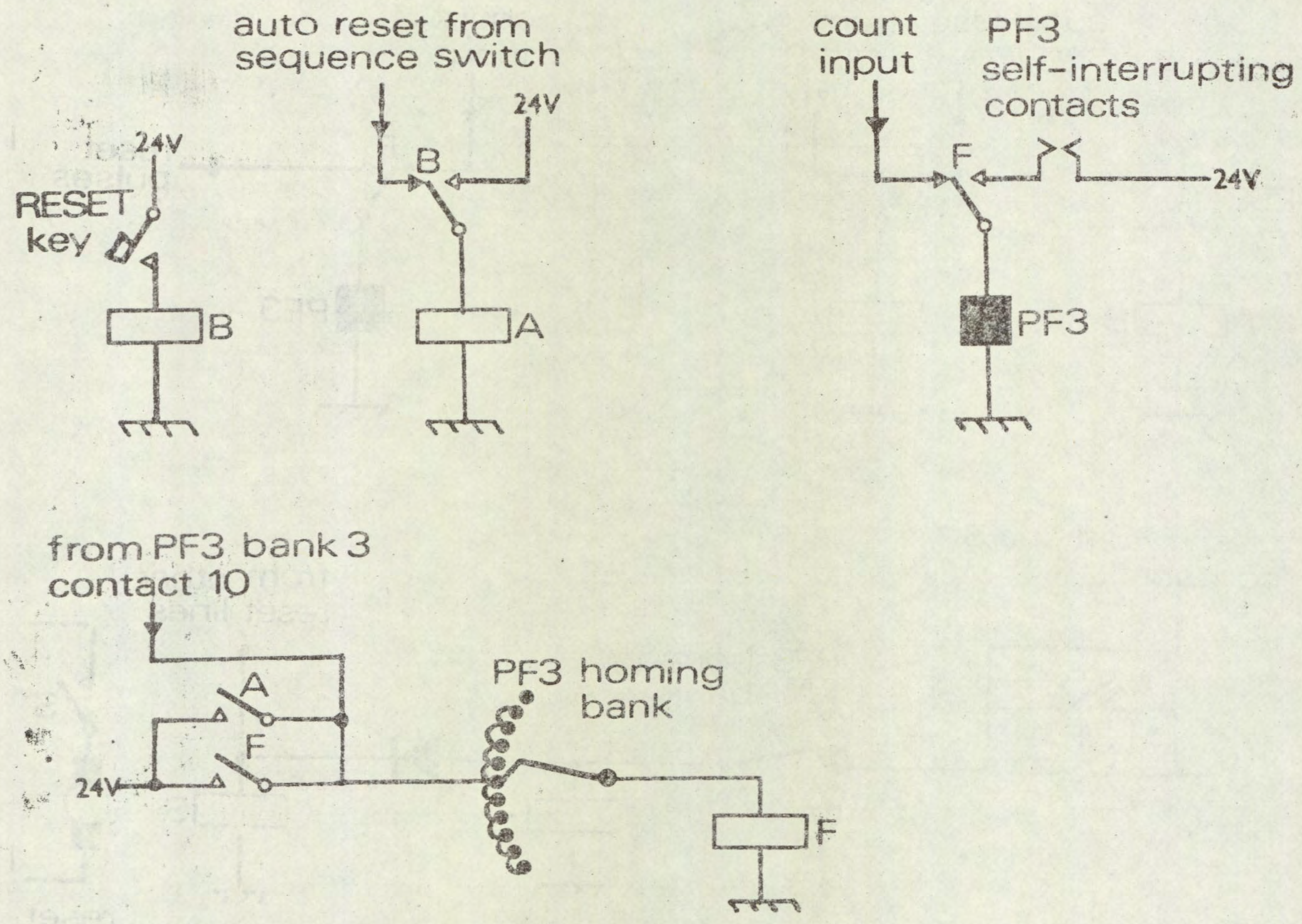


Fig. 5. ALTERATIONS TO RESET CIRCUITRY FOR SELF-INTERRUPTING UNISELECTORS

Comparison with Fig. 3 shows that the line to the next generator from each uniselector is now absent and the reset relays C, D, E and F switch the input to the selector magnets to the supply, via the interrupter springs.

The <u>runout</u> function of the runout/reset generator is retained in the current version of the instrument, but this could be replaced by a self-stepping selector continuously energised via the runout switch if desired.

APPENDIX

Sources of components

*Uniselectors	11 position 3 bank plus Homing bank 24-36v D.C.	Service Trading Co., 57 Bridgeman Road, London W45BB
New self-interrupting selectors	Automatic Electric Type 44	Keyswitch Relays, Garratt Lane, London SW18.
*24v Power Supply	Post office type 19	Samsons Electronics, 9 Chapel Street, London, N.W.1
Punch Sequence Switch	7 cam timer 1 Rev/second. supplied with 6 adjustable cams and one blank cam (for 4-lobed tape advance cam).	P.S.B. Instruments Ltd., Palmerston Road, Harrow, Middlesex, HA3 7RL.
*Tape Punch	Eichner 8 hole paper tape punch	Computer Sales and Service, 49-53 Pancras Road, London, N.W.1.
*Digital Displays	1" rear projection digital display	"
Reset/Runout Generator	1 rev/sec synchronous motor	Magnetic Devices Ltd., Newmarket, Suffolk.
	Standard Magnet, Reed Switch	West Hyde Developments, Ryfield Crescent, Northwood Middx. HA6 1NN.
Encode Mesh diodes	Diode 6F5	Farnell Electronic Components, Canal Road, Leeds.
Relays 48v supply components	Type 7A, 34A 30v Rectifier Transformer, diodes type REC 50A 2000 μF electrolytic capacitor	RS Components Ltd., Epworth Street, London, EC2P 2HA.

*Items marked * are secondhand, and although suppliers still had stocks at time of writing, no guarantee can be made for availability.

Components for the construction of this machine cost approximately £94 (excluding cabinet metalwork) in 1971.

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Technical reports available

5. A survey of the problem of aquatic weed control in England and Wales. October, 1967. T.O. Robson. Price - £0.25.

6. The botany, ecology, agronomy and control of Poa trivialis L. rough-stalked meadow-grass. November 1966. G.P. Allen. Price - £0.25.

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17. The pre-emergence selectivity of some newly developed herbicides, Orga 3045 (in comparison with dalapon), haloxydine (PP 493), HZ 52.112, pronamide (RH 315) and R 12001. January, 1971. W.G. Richardson, C. Parker and K. Holly. Price - U.K. and overseas surface mail - £0.25; overseas airmail - £0.50.

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