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Technical Note

ELECTRONIC MICRORELIEFMETER FOR SEEDBED CHARACTERIZATION

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ABSTRACT

Van Ouwerkerk, C., Pot, M. and Boersma, K., 1982. Electronic microreliefmeter for seedbed characterization. *Soil Tillage Res.*, 2: 81—90.

A technical description is given of a new electronic microreliefmeter. With this apparatus seedbed depth (mean and standard deviation) and roughness of the seedbed surface and the seedbed bottom can be determined easily, quickly and accurately.

INTRODUCTION

Seedbeds are characterized by their depth (mean and standard deviation), roughness (seedbed surface and seedbed bottom) and aggregrate size distribution.

Depth and roughness may be determined by means of a simple mechanical microreliefmeter, like the one developed by H. Kuipers (Agricultural University, Tillage Laboratory, Wageningen in 1957 (Fig. 1). It consists of a wooden board with steel needles 2.5 cm apart and reads in mm. The needle board is placed vertically onto a steel frame (27.0×27.0 cm^2) with vertical walls, which is pressed a few cm into the firm soil underneath the seedbed so that the flat upper edge of the frame is horizontal. When the measurements are carried out after sowing, the steel frame is positioned in such a way that the seed row runs exactly through the middle of the frame.

The ten needles are lowered from their zero-position onto the seedbed surface and readings are taken from left to right. The measurement is repeated after parallel displacement of the needle board over the frame over a distance of about 15 cm.

Without disturbing the firm soil underneath the seedbed, the loose soil of the seedbed within the steel frame is removed by hand and collected in plastic bags for subsequent determination of the aggregate size distribution. Next, the needle board is placed onto the steel frame in exactly the same places as before and, after the needles have been lowered onto the firm soil, again readings are taken. To obtain reliable average figures, the measurements

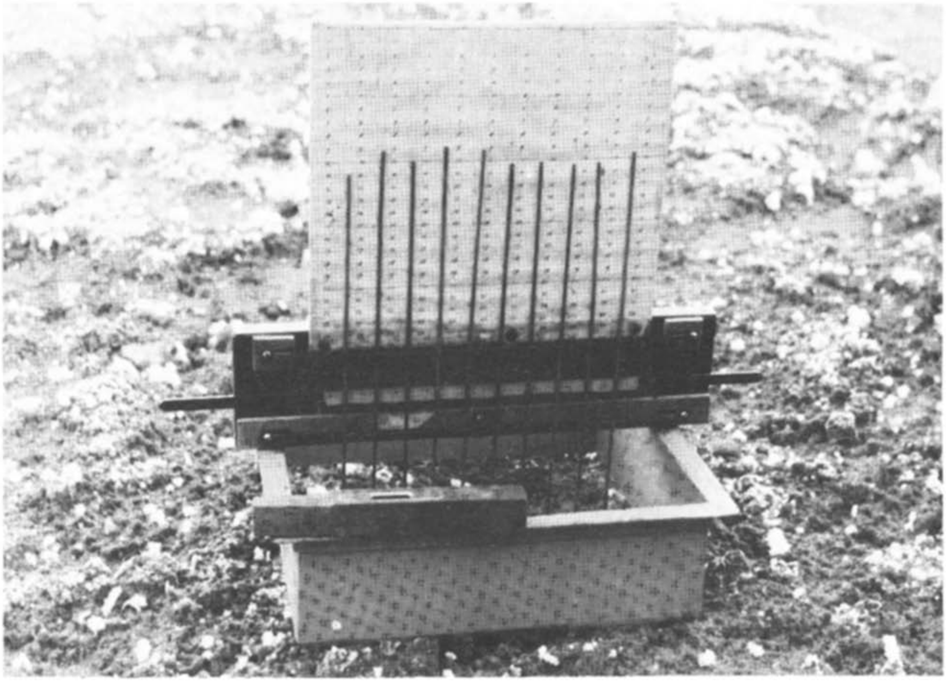

Fig. 1. Mechanical microreliefmeter, developed by H. Kuipers in 1957.

have to be carried out on at least five places per plot. Since one reading of ten needles takes about 30 s, measurements on one plot take about 20 min, including removal of the loose soil by hand.

The mean ($\bar{d}$) and the standard deviation ($s_{\bar{d}}$) of seedbed depth are calculated directly from all 2 × 10 × 5 = 100 figures on the differences in height between the seedbed surface and the seedbed bottom (relative to the zero-position of the needles), obtained on each plot.

The roughness of the seedbed surface (R_s) and the seedbed bottom (R_b) is calculated separately for each place, according to the formula $R = 100 \log s_x$ (Kuipers, 1957), in which s_x (mm) is the standard deviation of the appropriate twenty height figures (seedbed surface or seedbed bottom; relative to the zero-position of the needles). From the five appropriate roughness figures thus obtained on each plot the mean roughness of the seedbed surface and the seedbed bottom are calculated.

ELECTRONIC MICRORELIEFMETER

The above equipment and procedure have been used satisfactorily for about 25 years, but with the advent of the electronic era it was decided to take the readings electronically and to have them stored on tape, which makes computer treatment of all data possible, including the drawing of cross sections through the seedbed. Maintaining the same principle, a new apparatus was developed in which the steel needles were replaced by plexiglass rods, provided with horizontal, blackened grooves 1 mm apart over a length of 200 mm, and with a thickening at the top (Fig. 2).

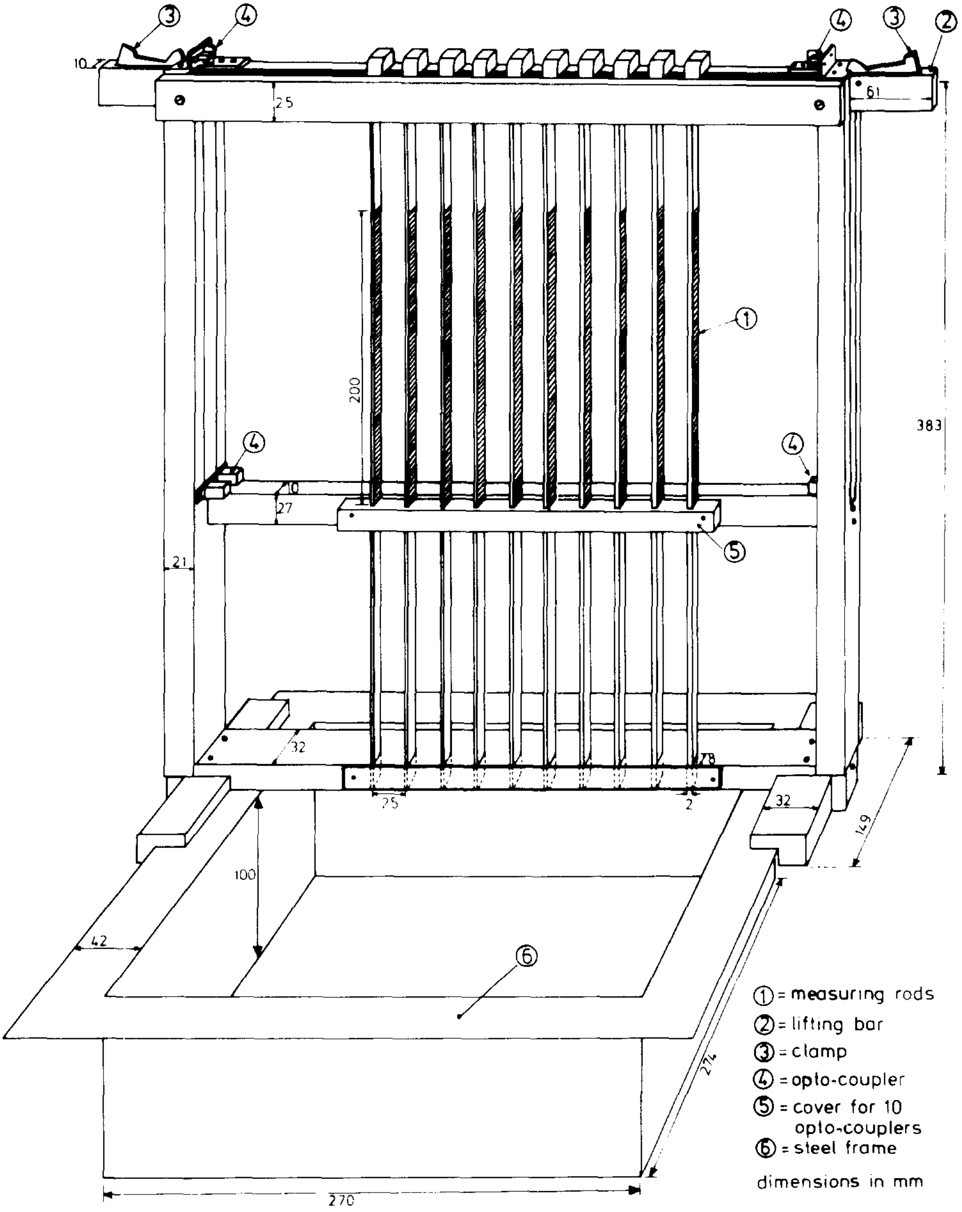

Fig. 2. Electronic microreliefmeter (schematic).

When the slotted lifting bar which carries all plexiglass rods is lowered, the grooved part of each rod passes through its own electronic opto-coupler, the pulses of which are transferred to Binary Coded Decimal (BCD-)counters.

When the lifting bar has reached its lowest position, all measuring rods have reached the seedbed surface. The values of the 10 BCD-counters now represent the respective distances over which the rods have moved downwards. These values are converted to serial American Standard Code for Information Interchange (ASCII-)signals, which are recorded on a small audio cassette-recorder. Via a simple interface the recorded data can be transferred to any peripheral which uses ASCII-code, including a computer. A detailed description of the electronic circuit may be found in the Appendix.

With the electronic microreliefmeter each reading (10 rods) takes about 5 s (3 s for lowering the lifting bar and 2 s for recording), which means a considerable saving of time. Consequently, in about 20 min readings can easily be taken from seven parallel positions of the needle board (2.5 cm apart), which gives a total of 70 height figures per place (Fig. 3) and, thus, 350 figures per plot for both the seedbed surface and the seedbed bottom. Another advantage is that errors in reading or writing down height figures are ruled out.

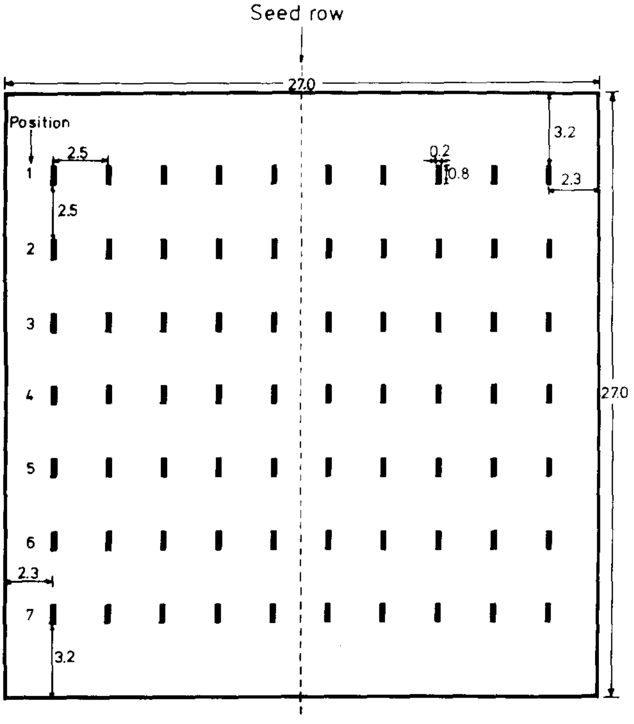

Fig. 3. Footprints of measuring rods in parallel, equidistant positions 1—7 within the steel frame.

MEASUREMENTS

The versatility of the electronic microreliefmeter may be illustrated by data obtained in a field experiment laid out on a silty loam (22% clay, 65% silt, 13% sand) in the Noordoostpolder.

After winter wheat harvest in the middle of August and straw baling by the end of August, a stubble cultivation was carried out, consisting of stubble ploughing (12 cm), followed by cross wise fixed-tine cultivation (15 cm) and, finally, by a single tine cultivation (10 cm) for weed control.

Early ploughing (P1) to 25 cm depth and fixed-tine cultivation (C1) to 20 cm were carried out on 2 October on dry soil. Late ploughing (P2) was car-

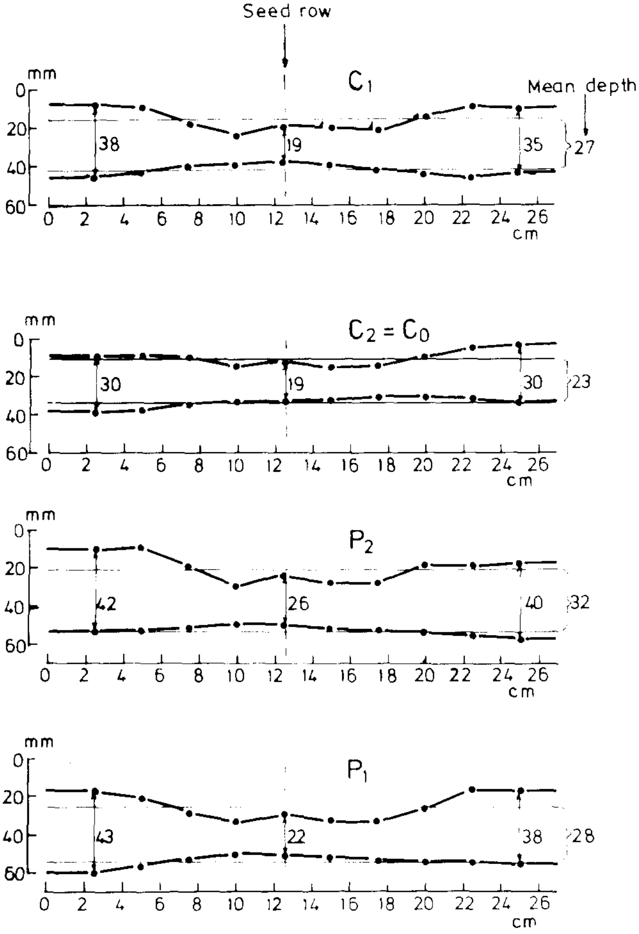

Fig. 4. Cross section through the seedbed for sugar beet on a silt loam soil, 13 April 1981. P1, P2: 25 cm ploughing early (2 October) and late (26 November), respectively; C1: 20 cm fixed-tine cultivation early (2 October); C2=CO: 15 cm stubble cultivation only.

ried out on 26 November when the soil was so wet that fixed-tine cultivation (C2) was impossible. Therefore, the C2 plot was left as it was and regarded as 'stubble cultivation only' (C2=CO). Early in April seedbed preparation by spring-tine cultivator + crumbler roller + light harrow (twice) and sowing sugar beet with a six-row precision drill equipped with press wheels, were carried out uniformly on all plots.

From measurements with the electronic microreliefmeter, carried out shortly after sowing, it was found that the mean depth of the seedbed for early-tilled treatments P1 and C1 was about the same: 28 and 27 mm, respectively (Table I). After late ploughing (P2) the seedbed was slightly deeper (32 mm) and after stubble cultivation only (C2=CO) it was much shallower (23 mm). The standard deviation of mean seedbed depth for treatment C2=CO was clearly smaller than for the other treatments, which is not unreasonable for a shallower seedbed.

From the cross sections (Fig. 4) it is apparent that the depth of the seedbed in the seed row and, over a distance of about 10 cm on both sides of the row, was clearly less than in the rest of the seedbed, which is due to the effect of the press wheels of the seed drill. The press wheels not only had an important effect on the surface relief but also compacted the lower part of the seedbed to a similar degree of compactness as the firm soil directly underneath, over a distance of about 5 cm on both sides of the seed row.

The measuring procedure permits calculation of seedbed roughness across the seed rows as well as parallel to the seed rows (Fig. 3). When calculated in longitudinal direction, the roughness of the seedbed surface was much less than when calculated in transverse direction (Table I). This is related to the fact that, in principle, the shaping of the surface by the press wheels only

TABLE I

Characteristics of the seedbed for sugar beet on a silty loam soil after sowing with a six-row precision drill with press wheels, 13 April 1981

Tillage treatment	Seedbed depth		Seedbed roughness (R)[a]				MAD[b]
	$\bar{d}$	$s_{\bar{d}}$	Surface (R_2)		Bottom (R_b)		
	(mm)	(mm)	Trans. (mm)	Long. (mm)	Trans. (mm)	Long. (mm)	(mm)
P1	28	0.6	91	52	64	38	4.7
P2	32	0.6	93	61	61	47	5.4
C1	27	0.6	88	63	63	46	5.3
C2=CO	23	0.5	84	67	71	49	6.4
LSD (0.05)	1.6		6.5	8.8	7.6	7.0	1.8

[a] Trans. = transverse; Long. = longitudinal.

[b] MAD = mean aggregate diameter, calculated from the size distribution of the air-dry aggregates (%, *w/w*).

takes place in transverse direction. It is apparent that this effect is positively related to seedbed depth.

The 'longitudinal' roughness of the seedbed surface is mainly affected by the largest clods in the seedbed, which are transported to the surface by the sorting effect of the spring-tine cultivator used for seedbed preparation. Therefore, the 'longitudinal' roughness of the seedbed is positively related to the mean aggregate diameter (MAD).

The roughness of the seedbed bottom was much less than the roughness of the seedbed surface. However, also for the seedbed bottom the 'longitudinal' roughness was much less than the 'transverse' roughness. This is partly due to the transverse pattern induced by the press wheels on the seedbed bottom, but for the greater part it is caused by the well known fact that the deviations of the spring-tine cultivator with respect to the horizontal are much large in transverse than in longitudinal direction.

TREATMENT OF DATA

With the mechanical microreliefmeter, calculation of seedbed depth (mean and standard deviation) and roughness (seedbed surface and seedbed bottom) from the 200 figures with a simple electronic calculator, and drawing of the mean cross section through the seedbed by hand, takes about 35 min for one plot. With the electronic microreliefmeter, however, production of a punched paper tape from the audio tape, control of the 700 figures simultaneously printed, and computer treatment of the data (including drawing of the cross section) requires only 15 min for one plot.

If the mechanical microreliefmeter would be used in the same way as the electronic one, and 700 figures were to be obtained on one plot, the time required for field work would increase from 20 min to 1 h, and treatment of the data would take nearly 2 h for one plot. However, with a programmed minicomputer this may be reduced to less than 1 h.

CONCLUSION

With the new electronic microreliefmeter described above, several characteristics of the seedbed can be determined easily, quickly and accurately. Therefore, the apparatus may be regarded as a useful substitute for existing, non-automatized measuring equipment.

ACKNOWLEDGEMENT

The authors are indebted to Mr. G. Smilda and Mr. G. Bargerbos (Technical Service Department) who constructed the mechanical and the electronical parts of the equipment, respectively.

REFERENCE

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APPENDIX

The electronic circuit consists of four parts (Fig. 1), which perform the following tasks, respectively: (1) counting of the opto-coupler pulses with BCD-counters; (2) connecting the subsequent BCD-numbers to the conversion circuit; (3) converting the BCD-numbers into serial ASCII-signals; (4) controlling the whole process.

Counting circuit

Opto-coupler pulses may be counted in two ways, the most reliable of which is by means of 'up-down' counters. However, this requires two opto-couplers per counting device instead of one, and since the grooves on the measuring rods are only 1 mm apart, the opto-couplers and the grooves should be aligned to very small tolerance (about 0.1 mm). With this method a 'jumpy landing' of the measuring rods would be no problem. However, in view of the difficult installation and the fact that bouncing of the rods on the seedbed surface is unlikely, it was decided to use simple BCD-'up'-counters.

Since there are 200 grooves on each rod, counting must range from 0—200, and thus for each counting sub-circuit one dual BCD-counter (type 4518) and one flip-flop are required. The RC-network transfers the pulses of the opto-coupler when the lifting bar is lowered, but it suppresses the slower and smaller deviations of the rods caused by the operator while lowering the lifting bar or, when the rods rest on the surface, by wind shaking the microreliefmeter. The Schmitt-trigger cooperates with the RC-network in blocking the smaller deviations. To minimize risks, a type with thresholds of 1/3 and 2/3 of the supply voltage was used.

Switching circuit

The switching circuit consists of nine multiplexers (MX1-MX9) which, determined by counter C1, sequentially connect the 11 BCD-numbers to the conversion circuit. Counter C1 is reset before the start of the first conversion and increased by one after each conversion.

Conversion circuit

This circuit converts the 9-bit parallel BCD-numbers 0—199 from multiplexers MX1-MX9 into serial ASCII-signals and adds an ASCII-space charac-

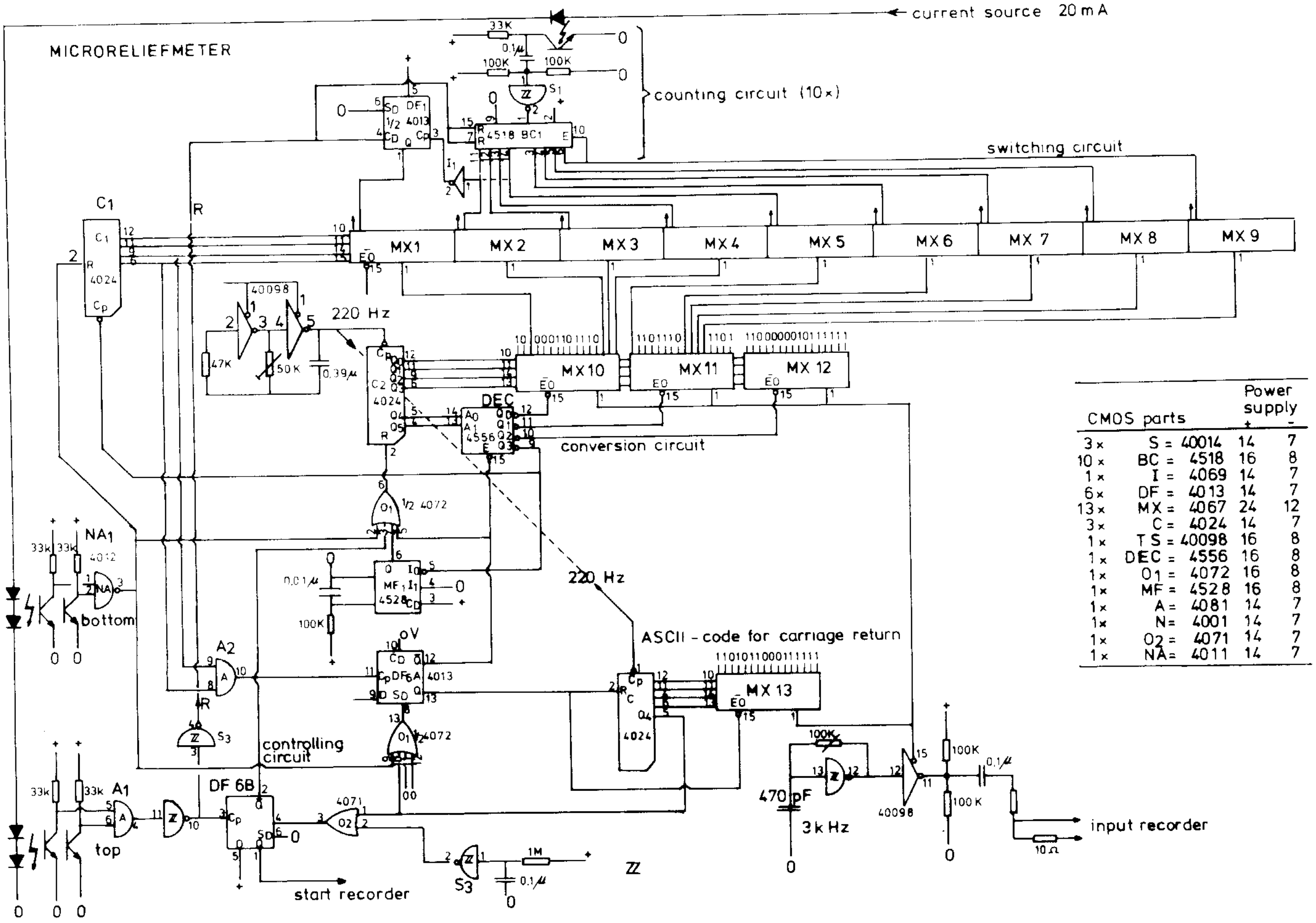

Fig. 1. Electronic circuit of the microreliefmeter (schematic).

	CMOS parts	Power supply +	Power supply −
3×	S = 40014	14	7
10×	BC = 4518	16	8
1×	I = 4069	14	7
6×	DF = 4013	14	7
13×	MX = 4067	24	12
3×	C = 4024	14	7
1×	TS = 40098	16	8
1×	DEC = 4556	16	8
1×	O1 = 4072	16	8
1×	MF = 4528	16	8
1×	A = 4081	14	7
1×	N = 4001	14	7
1×	O2 = 4071	14	7
1×	NA = 4011	14	7

ter to it. This is accomplished by three multiplexers (MX10-MX12) who sense their 48 inputs sequentially. The three multiplexers are controlled by counter C2 and decoder DEC. After each conversion, decoder DEC applies a pulse to one-shot MF1, which resets C2. The same pulse is used to increase C1, through which the next BCD-number is connected.

Controlling circuit

To prevent undue idle running of the cassette-recorder, the lifting bar must be in its top position when the reliefmeter is switched on. Then the electronic circuit is set off by Schmitt-trigger S3, which clears flip-flop DF6B. The top position of the lifting bar is detected by two opto-couplers, one at each end of it (Fig. 1, bottom left), which are connected to an AND-gate. As soon as one end of the lifting bar leaves the top position, the AND-gate output goes ‘low’. The resets of the BCD counting circuits are released and flip-flop DF6B is caused to change state, switching on the power supply of the cassette-recorder. The recorder runs idle now, warming up for registration.

During the upward movement of the lifting bar the pulses of the opto-couplers are counted until all measuring rods rest on the seedbed surface. The conversion of the BCD-numbers to ASCII-signals is started when both ends of the lifting bar have reached their lowest position. This is detected by another pair of opto-couplers and by NAND-gate NA1. The reset of counter C1 is released and flip-flop DF6A is set, putting the conversion circuit into operation. The ASCII-signals from the conversion circuit are modulated by 3 kHz and transferred to the cassette-recorder.

When all conversions have been performed, counter C1 is increased to 12. AND-gate A2 goes ‘high’, after which flip-flop DF6A changes state, suspending the conversion circuit and putting multiplexer MX13 and counter C3 into operation. MX13 generates a carriage return character. Recording is stopped when Q4 of counter C3 goes ‘high’. Then DF6B is cleared, causing the recorder to switch off and triggering the circuit for the next measurement.

Additional comments

Completion of the recording is indicated by a moving coil meter which is connected to the Q output of flip-flop DF6B. This meter also indicates the condition of the battery. The battery has a voltage of 12 V, which makes it possible to connect 2 × 5 and 1 × 4 opto-couplers in series and to stabilize the current through them. The battery also supplies the power for the cassette-recorder; the power supply is stabilized with a type 723 voltage stabilizer.