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## A Multiple Point Recorder for Small Animal Locomotor Activity<sup>1</sup>

By HAROLD W. SHIPTON, JOHN W. EMDE, and G. EDGAR FOLK, JR.

*Abstract.* This recorder is intended to simplify the assessment of data gathered from photoelectric actometers registering total locomotor movements. The information is presented automatically in two forms: (1) a curve of total activity over a 24 hour period, (2) a bar graph of the activity in each 30 minute time interval. A further trace is used to enable the time of onset of bursts of activity to be judged with reasonable accuracy. A particular advantage lies in the fact that the recording pens are stationary, making it possible to plot the outputs from several activity counters across the whole width of the recording paper. Standard electrical components which are easily available are used throughout the equipment.

Although designed for the specific purpose of measuring animal locomotor activity this recorder can be used for the display of any relatively slow electrical activity which can be converted into discrete pulses. The presentation is on "Teledeltos" L - 48 recording paper which is obtainable in widths up to 31¼ in. In the present equipment a 12 in. width is used as giving a reasonable compromise between resolution and convenience. A 500 ft. roll of this paper is contained in the base of the recorder console so that approximately one year's supply of paper is available without reloading. The paper drive mechanism is a modified kymograph with a drum diameter of 8 in. and a speed of one revolution per 24 hours. The paper is drawn over the drum as shown in Figure 1 and retained by a single spring loaded ball race. The recording comb is shown in Figure 2, and some details of its mechanical construction may be of interest. A brass hexagonal rod is used to carry the individual teeth. Drilling one hundred holes at equal spaces of 0.12 in. presents no problem if machine shop facilities are available, but in default of these it was found possible to drill with sufficient accuracy by mounting the rod in a screw cutting lathe with the pitch adjusted appropriately. A dental drill was mounted in the tool stock and the holes were drilled with a Number 60 carbon steel drill. In the present equipment the points are stainless steel sewing needles, but tungsten wire could be substituted with advantage. Each needle is insulated with a short length of "Teflon" sleeving chosen to be a loose push fit into the Number 60 holes. At this stage the lead-out wires are soldered to the needles and formed so that 50 are brought out at each end of the hexagonal rod. Assembly of this part of the equipment is greatly facilitated if stranded "Teflon" insulated wire is used for the lead-

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<sup>1</sup>This research was sponsored by the National Science Foundation.

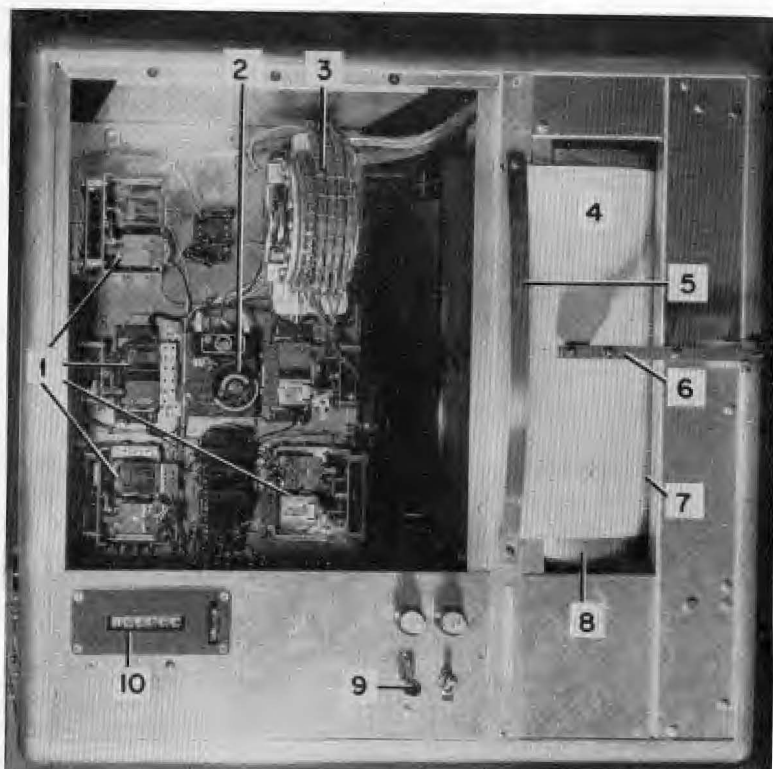


Figure 1. Recorder for graphing activity movements of small animals. (The top panel has been removed.)

1. Stepping relays
2. Timing clock
3. Telephone uniselector
4. Electro-sensitive paper
5. Tear-off bar
6. Paper drive
7. 100 Point contact
8. Drum
9. Reset control
10. Mechanical counter

outs. This material shows no tendency to flow at the temperatures encountered in normal soldering operations. The entire assembly with the exception of the needle points is then cast in "Sty-Cast" epoxy resin. The comb is mounted on a toggle bar so that it can be swung away from the paper to permit paper changing or cleaning of the points (Figure 2). The angle which the points make with the recording paper is somewhat critical and should be adjusted empirically until each point exerts a substantially even pressure on the paper.

A 25-position telephone selector switch is used to select the appropriate contact. A variety of such switches is obtainable and the type chosen is not at all critical. A minimum of 4 banks is required, and these should have half-wipers. Because the transitions from

contact to contact are very rapid either bridging or non-bridging contacts can be used. Reference to the circuit diagram will show the means by which 100 successive points are counted by the 25-way selector. A relay is operated by the last contact on each bank so that successive wiper arms are selected. If it is required to reset the counter to zero at the end of each day's run, this can be achieved by means of an additional contact bank in which all the contacts except that corresponding to the zero position switch are connected together. By completing the circuit through the reset button the selector switch will home until the circuit is interrupted at the zero position.

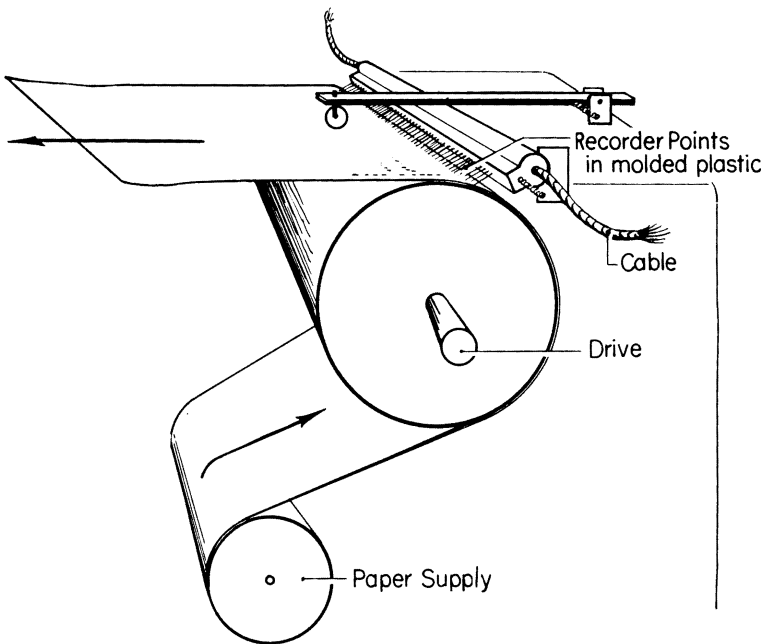


Figure 2. The recording comb.

Each point on the comb is connected to the corresponding contact on the telephone selector and current from the AC supply flows through R1 to mark the selected point. Because the last contact on each bank is used to operate the change-over relays, marking does not take place on these positions. The resulting error of 1 percent of full scale deflection has not been found sufficiently serious to warrant the adoption of more complicated switching methods. The switching circuit is shown in simplified form in Figure 3.

It will be seen that the application of a pulse to the solenoid of the telephone selector switch will cause the write-out to move by 1 percent of the total paper width. Thus, as so far described

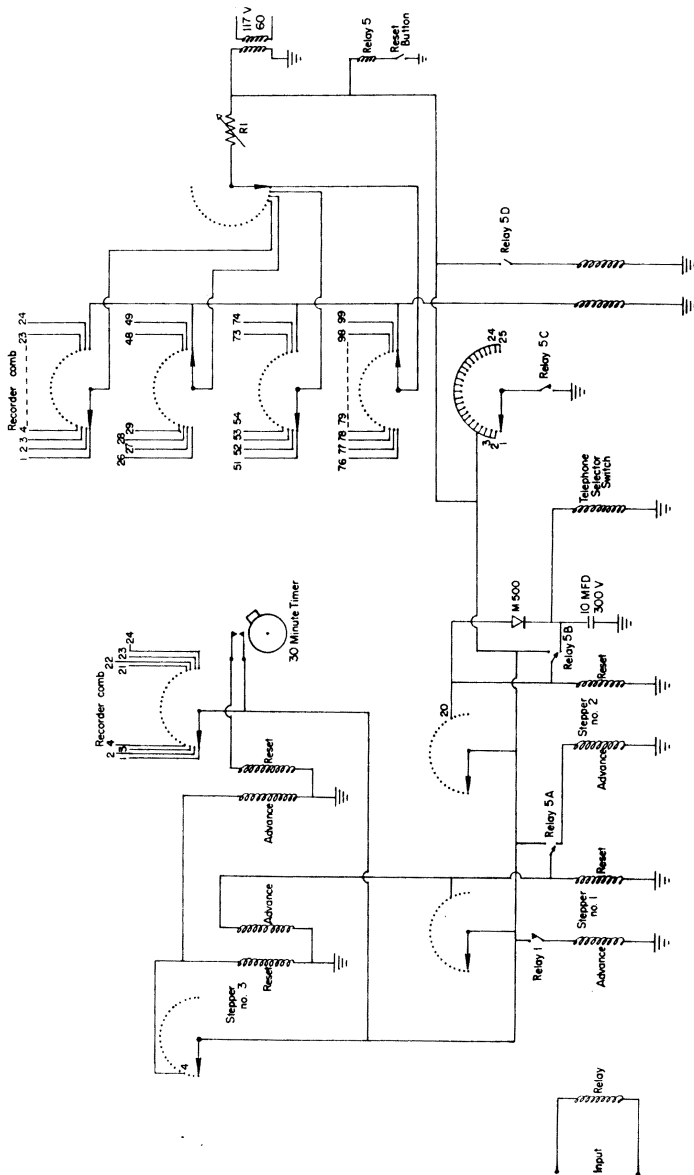


Figure 3. Simplified circuit diagram.

the equipment can count only 100 events. To extend the range of the recorder, it is necessary to precede the selector switch by some means of dividing the incoming pulses by an appropriate factor. In the present instrument this factor is 400 so that the full scale range of the recorder is 40,000 events and the uncertainty of reading is  $\pm 20$  counts. Division is effected by 2 "Guardian" stepper relays which are provided with re-set coils. Each counter is wired (Figure 3) to pass only the 20th impulse to the succeeding counter and then re-set to zero. If the re-set button is operated during the count the re-set coils are engaged by Relay 5.

To provide a measure of the "count per unit time" a second selector switch and one divider relay is provided. This is re-set to zero every 30 minutes by means of an electric timer which operates the re-set relay for this chain of counters. In our system the scale factor is 1 division = 80 counts although it is clear that this can be changed to meet individual requirements. Only the first 25 points are used to indicate the one-half hour counts

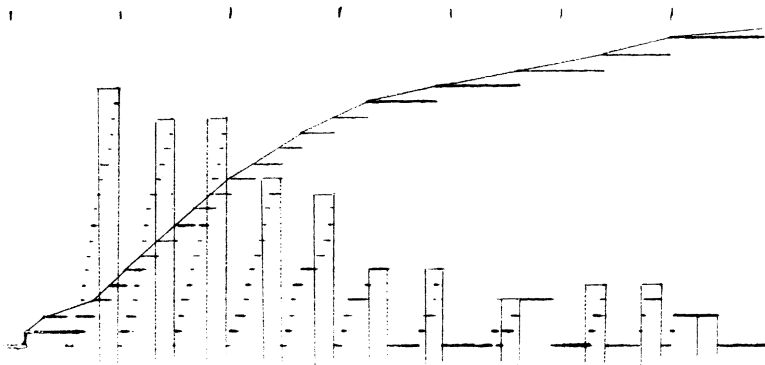


Figure 4. Typical record of activity of small animals.

so that a "Guardian" stepper relay can be used in place of a telephone selector switch. A typical record of activity is shown in Figure 4, and it can be seen that the one-half hour bar graph is a good approximation to the time derivative of the cumulative curve.

In animal experiments it is sometimes desirable to have an accurate indication of the time of onset of a burst of activity. This is achieved in this unit by making use of the 75th contact on the recorder comb which is not normally used since it corresponds to a position when the change over relay is being operated. This contact is connected to the AC supply via the 20th contact on the first divider. The recording speed is too slow to permit individual marks on the paper to be distinguished but the time of onset of a burst of activity can be read to about 5 minutes in 24 hours.

One of the main advantages of this method of recording is the ease with which a number of divider chains and 100 point switches can be fed to the same recorder comb. This permits the simultaneous recording of the output from three or more activity cages to be recorded simultaneously. The full width of the recording paper can be used for each channel. To avoid ambiguity where the curves overlap it is advantageous to interrupt the supply to the recorder comb by means of a slow speed motor driven switch. By suitable adjustment of the duty cycle of this switch a code can be set up so that, for example, the first channel presents a solid line, the second a dotted and the third a dashed line.

If it is desired to use the "count per unit time" facility on more than one channel the zeros of these counts can be appropriately displaced so that successive channels display their bar graph on separate sections of the paper. Interpretation of the data is complicated if more than 3 cumulative and 3 half-hour counts are displayed on 12 in. paper.

A high speed relay is used to operate the first counter to isolate the unit from the activity counter. By a suitable choice of this relay almost any data gathering device can be used to feed the recorder. For reliable operation using "Guardian" stepper relays the input pulse rate should not exceed 5 per second.

Power for the entire unit is derived from the 110V. 60 cycle house current. Since the recording drum is necessarily connected to one side of the marker power supply, an isolating transformer is required to eliminate the danger of electric shock to the operator.

A minimum of maintenance is required to ensure satisfactory operation. The comb should be cleaned as required using a little carbon tetrachloride on a fairly stiff brush and the switch contacts should be cleaned if intermittent or unreliable operation occurs. It has also been found advantageous to lubricate the selector mechanisms with a thin film of petrolatum.

It should be noted that the electro-mechanical components are inherently noisy and the unit is thus not suited for use in the animal room. Only one light duty pair of wires per recording channel is required however, and remote operation of the recorder presents no problems.

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