A BIDIRECTIONAL CUMULATIVE RECORDER¹

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Fig. 1. Bidirectional cumulative recorder.

(A) Constant speed drive; (B) Guide beam; (C) Pen carriage at mid point; (D) Event marker; (E) Ratchet drive.

The many cumulative-response recorders currently available provide two main facilities: (1) the pen-marker carriage is stepped a fixed distance at right angles to the direction of movement of the recording

inforcement (either positive, *e.g.*, food, or negative, *e.g.*, shock).

Since much of the work in our laboratory involves measurements of multiple responses (Hurwitz, 1955; Millenson & Hurwitz, 1961), a cumulative recorder was needed which recorded the occurrences of both responses either plotted as a function of time or as a function of their serial order. Figure 1 shows such a recorder. At the start, the pen carriage rests at the midpoint of the paper roller. The pen can be stepped either to the left or the right of the midpoint by a specially built bidirectional ratchet mechanism, activated by solenoids. The carriage is indirectly coupled to the ratchet mechanism. Briefly, the ratchet plate drives a wheel, around which a nylon thread has been wound. The ends of the nylon thread are attached to the left and the right ends of the pen carriage. Whenever the ratchet is activated, the carriage is pulled a fixed distance. By disconnecting one of the leads to the ratchet drive, the apparatus could be used as a simple, unidirectional, cumulative recorder.

When the carriage has been moved the full length of its travel along a guide beam, it resets to the central position because of the microswitches at each end of

Fig. 2. Sample of record by using constant-speed drive.

paper; and (2) on each occurrence of a selected event, the pen can be moved without moving the carriage on which it is mounted. This shows up as a pip on the graph, and it is used primarily to indicate re-

Fig. 3. Sample of record by using ratchet movement.

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the guide beam. Operation of either microswitch releases the ratchet clutch, leaving the carriage drive wheel disengaged. The carriage is then returned to the mid-position by a set of weights. At the same time as the clutch is released, a tongue-like metal flange at the center of the guide also acts as a switch: When hit, the clutch is re-engaged and the flange itself is withdrawn.

Two paper drives are provided: (1) a constant-speed, synchronous motor; and (2) a ratchet drive. The motor can be geared so as to provide two or more speeds. Both the motor and the ratchet drive can be disengaged by a simple uncoupling operation.

A separate event marker is also supplied, as in Fig. 1. This marker can be used to mark off time periods or to indicate the occurrence of events, *e.g.*, reinforcements.

Samples of records obtained by using both the constant-speed drive and the ratchet movement are shown in Fig. 2 and Fig. 3, respectively. The records were sampled from a rat trained under a reinforcement schedule where five lever responses followed by one tray response produced a 0.04-gram food pellet. In this experiment the fifth lever press produced a brief bell. The recorder was wired so that the recording pen moved one step to the right when the lever was

pressed and one step to the left when the tray was contacted. If the sequential order of the emitted responses follows the requirement of the schedule exactly, so that five consecutive lever responses are made before the tray is approached, the pen traces a constant path of slope Alpha. On the other hand, irregularities of the path indicate variability in the sequential response pattern. These come out more forcefully when the paper feed is ratchet-operated, rather than operated by the synchronous motor, since the record is then uncontaminated by a temporal factor. On the other hand, when the paper drive is connected to the constant-speed motor, the emission of patterns becomes correlated with time; this correlation is particularly useful for temporally defined schedules of reinforcement, such as fixed-interval schedules, and it is desired to study responses in the chain.

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