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TECHNICAL NOTE

A RAPID RETRACTABLE RESPONSE LEVER[1]

Although more difficult to construct than those previously described (Huneycutt, Crowder, and Wilkes, 1964; Hoffman, 1964), the retractable response lever described here provides a useful combination of features not hitherto available. Its outstanding features are its ruggedness, which permits use with animals ranging from rats to monkeys, and the rapidity with which it can be inserted into or retracted from an experimental chamber. This rapid action, 0.2 sec or faster, is especially useful in discrete trial procedures where response latencies are important. Most commercial models are severely limited in such applications; they typically take 2 or 3 sec to insert or retract, and the animal may be responding before the lever is fully extended or after it has begun to retract. The present lever can also be used in ordinary free-operant procedures, for it follows high rates of responding while in fixed position. It employs a snap-action switch, and allows for overtravel between switch closure and a firm stop, thereby providing features that favor a cleanly defined response. It does not bounce or chatter (one response produces one and only one count), and its force requirement is adjustable.

When retracted, the lever leaves no open slot in the wall, and accomplishes this without danger of pinching the animal. The retracted lever forms a panel flush with the wall of the cage, and may still record depressions if so programmed. This is a useful feature, for with a more conventional retracting lever, which is insensitive when retracted, the animal may poke about the aperature and even attempt to press the retracted lever, with the experimenter none the wiser. With the present device, such behavior is easily recorded.

The device has four main parts mounted on a Bakelite and Plexiglas frame (Fig. 1). The response lever and its wedge-shaped carriage are suspended on a single axle, mounted on a Bakelite panel through which they protrude when extended. A linear actuator is securely anchored to the frame; its armature is connected to the carriage by a yoke.

The sides of the carriage are easily made by cutting two 150° wedge shapes from circular brass discs (detail

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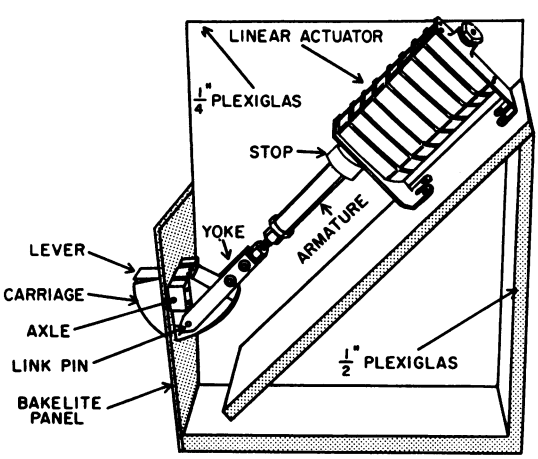

Fig. 1. Basic parts of the retractable lever.

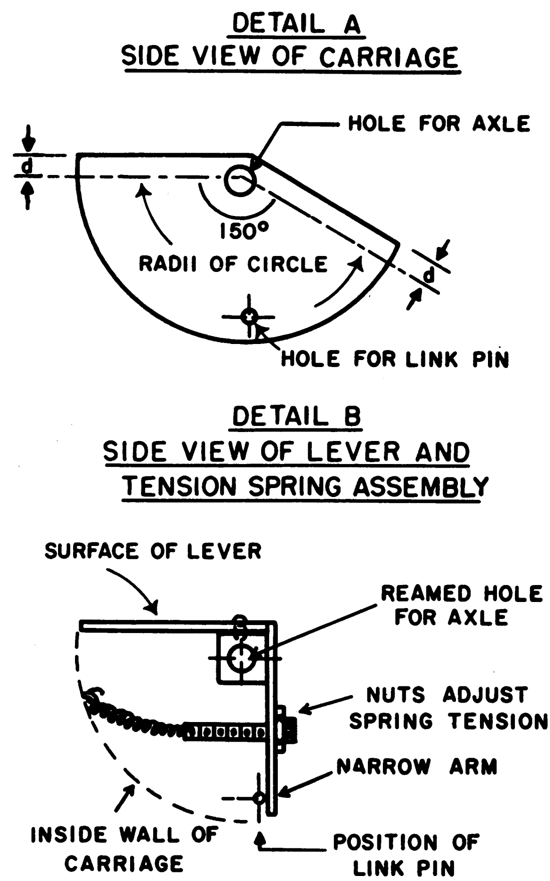

Fig. 2. Details of lever and carriage.

A, Fig. 2). The straight edges are parallel to radii of the discs and should be equidistant from the center of the discs. This distance, d, is the sum of the radius of the axle, the thickness of the Bakelite panel, and the thickness of the wall of the experimental chamber, minus the thickness of the lever. "d" is a critical dimension, since the surface of the retracted lever is to be flush with the wall of the chamber, and should completely cover the aperture in the wall. The curved facing between the wedge-shaped sides of the carriage is made by cutting a short section of brass tubing whose outside radius equals that of the discs; the sides can be soldered to this section.

The lever is L-shaped (Fig. 2, detail B). One arm forms the surface that the animals will press. Its width is equal to the outside width of the carriage; when depressed, this arm forms a surface of the wedge-shape, and the carriage sides provide a firm stop to limit the excursion of the lever. The other arm should be just narrow enough to fit inside the carriage. A threaded shaft passes freely through this narrower arm and is attached, by a coil spring, to the inside wall of the carriage (Fig. 2, detail B). A nut threaded onto this shaft (and locked in place by a second nut) rests against the narrow arm to maintain spring tension, which determines the force requirement of the lever. The spring tension also holds the undepressed lever against the link pin, which connects the carriage to the yoke (Fig. 1 and 2). When the animal presses the other arm, this narrower arm of the lever operates a miniature microswitch bolted to the inside of the carriage.

The yoke, shaped much like a tuning fork, is threaded into the armature of the linear actuator. Its forward tips, pierced by the link pin, straddle the carriage and rest against the Bakelite panel when the carriage is fully extended. The lengths of these tips should be such that the surface of the undepressed lever is horizontal when the tips touch the Bakelite panel. The yoke must be hinged at its crotch and at the link pin to convert the linear motion of the actuator to rotary motion of the carriage.

The linear actuator retracts and extends the carriage and lever. Available from Skinner Precision Industries, Inc., New Britain, Connecticut (about $40), the device has the following desirable features: it supplies constant force throughout its excursion; the direction of force can be reversed by switching a connection to its capacitor; extent of excursion depends only on the length of the actuator rod or armature (excursions are available up to 32 in.); the magnitude of the force is proportional to the square of the applied voltage. Its main limitations are its short duty cycle at high voltage, its large power requirement, and its excessive sparking across a breaking power switch. Ordinary spark suppression is not feasible, for this changes electrical phase relations necessary for operation. Continuous-duty holding coils are presumably available for holding the actuator in a given position with low power expenditure, but they may require an impracticably long delivery time from the factory.

Model 01B0813-311-10 is appropriate here, along with an 8-in. rod providing a 3-in. stroke. Power is supplied directly from the 110-v line instead of from the control rack, and is switched through two heavy-duty relays, which are controlled by conventional remote switching circuitry. The relays may be mounted on the Plexiglas, below the actuator. One relay controls power to the actuator; the other determines the direction of thrust. The linear actuator is mounted at about a 45-degree angle so gravity assists in extending the carriage and in holding it in the extended position. The armature passes through an annular stop that determines the exact retracted position (Fig. 1).

To hold the lever in its extended or retracted positions, one of three methods can be used. One is to use holding coils (if one can wait for them to be manufactured). Another is to maintain a continuous low voltage across the actuator while it is in its terminal positions. This introduces heating problems that can be overcome by a blower moving air directly across the actuator. The third method employs an over-center spring arrangement, the details of which can be supplied by Skinner Polynoid, Inc.

Wiring to the lever switch can be accomplished either by a commutator, which requires ingenious machining, or by coiled flexible leads. Failures due to breaking of these leads, which move with the carriage, can be largely eliminated by running two wires in parallel from each side of the microswitch. Since it is unusual for two paired leads to break even within a few hundred trials of each other, a break on one lead can be spotted between experimental sessions, and if all leads are then replaced at once, no failure will have occurred. Lead replacement by this formula becomes necessary on the order of once every 100,000 excursions of the carriage.

REFERENCES

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Philip N. Hineline[2]
Harvard University

[2]Reprints may be obtained from the author, Department of Experimental Psychology, Walter Reed Army Institute of Research, Washington, D.C. 20012.