time, the pipe was tapped and moved slightly. Once the bird was eating regularly from the food dish, "magazine training" began. When food was presented, the buzzer sounded, the magazine light came on, and the house light went off. These cues were present from the moment of food delivery until the meatball was consumed by the owl.

When Igor readily approached the food cup at reinforcement, key-pecking was hand-shaped. Then followed six days of continuous reinforcement (CRF). During this period, the circuitry was changed so that first the house light, and then the magazine light remained on continuously. The buzzer thus remained as the only cue to food delivery. (This procedure avoided the complications that changes in the lighting pattern would introduce to future visual experiments.) Also during the CRF phase, the duration of buzzer presentation was reduced to 3 sec.

Each daily session lasted until Igor had received 39 reinforcements. The sessions following the six days of CRF included a series of fixed ratios (FR), a variable interval (VI), and a series of fixed intervals (FI).

Magazine training was successfully achieved in both Ss. The second owl died during the period of key-training. For Igor, the shaping procedure required about 20 reinforcements.

RESULTS

Figure 1 shows cumulative records of Igor's responses on some of the schedules described above. (These records include eating time, approximately 4 sec, since the pen moved continuously during the session.) The records demonstrate clear differential effects of the various reinforcement schedules. Further study, using a larger number of Ss and varying such parameters as deprivation level and amount of reinforcement, would reveal more exactly the nature of schedule-controlled behavior in this species.

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NOTES

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2. Since ordinary ground beef is apt to be deficient in protein it is important to purchase meat containing a relatively low fat content. Forty of these meatballs were not quite enough to maintain the birds at the desired weight level; however, the ground beef and bone meal did constitute the major portion of their diet during the experiment.

A combination stereotaxic drill press and electrode carrier¹

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A method of transforming a vertical rack and pinion-type electrode slide into a miniature drill press is described. Advantages of the instrument are noted and several applications suggested. Specifications are included for the aluminum electrode mold for cat cortical electrode casts.

Drilling through the calvarium with a hand-held dental drill is a variable and time-consuming procedure. Because the handpiece cannot be well supported, a rose burr is usually used. Moreover, holes are drilled undesirably large, with irregular margins and non-vertical walls. Smaller, circular holes, with vertical side-walls offer several advantages.

Commercial units are available (David Kopf; Trent Wells) which circumvent the above-mentioned difficulties. However, these units are not free of disadvantages: they are expensive (approximately \$200), large, and most importantly, they are separate units. Thus, drilling and implanting electrodes requires changing from the drill press to the electrode carrier and a new determination of stereotaxic coordinates. We describe here a drill press-electrode carrier (Fig. 1) with which perfect holes may be drilled and electrodes implanted. Use of the instrument reduces the number of operations necessary to implant any kind of electrode or cannula and simultaneously improves the calibre of these implantations. One application of the instrument utilizing an efficient cast cortical electrode is also given.

Fig. 1. Stereotaxic Drill Press-Electrode Carrier.

Fig. 2. Aluminum electrode mold for cat cortical electrode casts.

The drill press was developed from the Lab-Tronics electrode carrier.² Many manufacturers use the vertical rack and pinion system and similar modifications could be made to these carriers. In some cases, it is also possible to modify the horizontal bar of the Lab-Tronics electrode carrier to fit the side bar clamp of another instrument (or vice versa).

The essential feature of the modification to the electrode carrier consists in removing the standard spindle from the vertical slide (which raises or lowers the slide on the rack) and replacing it with a longer spindle to which a drill-press handle has been attached by means of a set screw. Attaching a spring to the new spindle provides the return movement of a drill press. Putting adjustable stops above and below the slide, provides both variable degrees of return-spring tension and adjustable vertical travel.

Attaching the dental drill handpiece (handguard removed) to the slide can be accomplished in various ways. In our modification the handpiece holder of the drill press is fitted to the electrode slide exactly as the electrode holder is. Thus the electrode holder and the dental drill handpiece are quickly interchangeable, on the same unit. By machining the handpiece holder to the appropriate thickness, it and the electrode holder may be interchanged on the slide with no change in stereotaxic coordinates. This thickness depends on both the diameter of the dental drill handpiece and the thickness of the electrode holder.

Necessary materials include brass screws (screws in the photograph have been chrome plated), a steel rod, an aluminum rod, aluminum bar, and plastic knobs.³ Manufacturing time should not exceed 10 h.

Use of the drill press-electrode carrier enables the same procedural advantage as any drill press—that electrodes may be implanted more quickly through better holes of smaller diameter, the increased bone area around the electrode substantially improving support. In addition, since the handpiece holder and the electrode holder fit interchangeably on the vertical slide of this unit, a *straight* electrode is automatically centered in the hole when the electrode holder is placed on the slide. Thus, coordinates need not be redetermined. Also, it is not necessary to check the vertical coordinate while lowering an electrode; simply set the bottom stop at the correct position and slowly lower the slide until it goes no further. Lower the upper stop down to the slide, position gelfoam around the electrode, and cement the electrode in place.

To take advantage of the instrument in cortical implants, we designed a circular aluminum mold with a top to bottom taper of .020 in. (Fig. 2). The upper diameter of the mold for cat cortical electrodes is .170 in.; for the rat cortical electrode .090 in. Two, .013 in. diameter holes are drilled through the bottom of the mold at a convenient, but constant spacing for all molds of the same size (10 such molds can be machined in a very small piece of aluminum). Electrode wire of less than .013 in. diameter with insulation is inserted through each hole and the mold filled with a thin mixture of dental cement. When dry, the cast is removed. The mold may be either a split mold or a solid mold, either works well. A solid mold requires that the inner surfaces be well burnished, however. In any event, a small quantity of mold release will permit easy removal of a cast from any mold.

The cast bipolar plug may be pushed gently into the non-tapering drill-hole in the calvarium (for either epidural or subdural electrodes). The protruding electrodes should, of course, have been cut to the correct length and "feet" bent into them if desired. Plating is also readily done. For best results, the calvarium hole should be about the same diameter as the midpoint of the cast. The cast should be about .150 in. thick for cats, thinner for rats. Acrylic cement is flowed around and over the cast to make a solid bone-electrode junction. Electrode wires (previously soldered to flexible phono wire) are then soldered to a standard female connector.

In addition to the considerable benefit resulting from the small size of this unit, it is easy to manufacture and efficient to implant. Either monopolar or bipolar electrodes can be used; the bipolar electrodes are also a constant distance apart. Although other cortical electrodes have been reported (e.g., Retzlaff & Fontaine, 1964) none is both simple to produce and simple to implant.

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NOTES

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2. H. Neuman Co., 8136 N. Lawndale Ave., Skokie, Ill. Part No. G-102.
3. Plans and materials on request.