A clip-on cable connector for chronically implanted monkeys and cats*

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One of the most troublesome, if not the most difficult, problems involved in chronically stimulating or recording the electrical activity of the brains of monkeys and cats is the junction between the implanted connector or head plug and the cabling leading to the amplifying and recording equipment. The problem hinges on the fact that a good connector arrangement requires satisfying two conditions that are typically quite contradictory. On the one hand, it is necessary to achieve excellent electrical continuity, i.e., low and stable resistance, at the connector junction because of the small voltages normally associated with electroencephalographic (EEG) activity. On the other hand, it is also necessary to have a connector arrangement that is easily attached and removed in order that the physical stress on the connector and the psychological stress on the E and S be kept to a minimum. In the typical male-female pin connector arrangement (see, for example, Delgado, 1961; Sheatz, 1961; Thompson, Lindsley, & Eason, 1966), these two considerations are often in opposition. The present report suggests an inexpensive alternative to the standard male-female pin connector arrangement.

The proposed connector utilizes a Pomona Electronics "Dip Clip" integrated circuit test clip, Model 3916.¹ As illustrated in Fig. 1, the "Dip Clip" integrated circuit test clip is conceptually similar to a spring-loaded clothespin with (across the inside of the jaws) a single horizontal groove to grip the body of the integrated circuit (IC) and a series of vertical grooves to fit around the IC connecting pins. Within each vertical groove is a single gold-plated contact that makes electrical contact

Fig. 1. Photograph of the Pomona "Dip Clip" IC test clip Model 3916. The clip measures approximately $1/2 \times 7/8 \times 1\frac{1}{2}$ in. in height and weighs approximately 12.5 g. The clip can be used with either 14- or 16-pin dual-in-line IC packages.

with a pin of the IC and extends through the body of the test clip, exiting at the top. The jaws of the test clip are opened by pressing the two halves of the clip together at the top and slipping the test clip over an IC (see Fig. 2). Releasing the test clip then allows the spring-loaded jaws to clamp the IC and forces the contacts of the clip firmly against the pins of the IC. The horizontal and vertical grooves of the jaws prevent it from slipping, and the contacts extending from the top of the test clip enable alligator-type test leads to be easily attached for evaluating the functioning of the clamped IC.

The "Dip Clip" IC test clip is similarly used when functioning as a cable connector for chronically implanted animals. A dual-in-line IC socket holding a nonfunctioning IC is chronically affixed to the animal's skull to form the "head-plug" portion of the connector arrangement. This head plug is constructed by bending the pin connectors of a standard dual-in-line IC socket to form a 90-deg angle with the plastic body of the socket. Lead wires for eventual connection to implanted electrodes are soldered or wire-wrapped to these bent pins. During bending, some of the individual pin sockets may slip slightly above the plastic body of the IC socket. These must be pushed back into the plastic body of the socket or they will interfere with the seating and

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Fig. 2. Photograph illustrating the normal position and utilization of the "Dip Clip" for testing IC packages.

electrical contact of the "Dip Clip" test clip during recording. After the electrode leads are attached, a layer of dental acrylic is applied to the bottom of the IC socket to electrically insulate the socket pins and the solder or wire-wrap junctions of the lead wires. When the acrylic dries, any excess portions of the IC socket pins are clipped off as short as possible and two 1/8-in. holes are drilled through the center of the IC socket for mounting with stainless steel screws. Figure 3 illustrates an example of such a prepared IC socket. Depending upon the IC and the socket, a head plug containing up to 16 leads may be constructed; when completed it will measure less than 1 in. in length x 1/2 in. high x 1/2 in. wide.

The IC used in conjunction with the socket is prepared by drilling a 7/16- or 1/8-in. hole directly in the center of the circuit case. Since the IC functions simply to provide a base and electrical contacts for the "Dip Clip" IC test clip, the goal of this operation is to electrically isolate each of the 14 or 16 pins of the IC. The success with which the small electronic package was

removed by the "lesion" and the pins electrically isolated is easily tested by determining if electrical continuity exists between any pin combination. If the lesion is complete, i.e., the pins are electrically isolated, the hole is filled with dental acrylic to prevent future shorting across the closely packed wires within the IC case.

During surgery, the IC socket is attached to the animal's head in accord with standard implantation techniques using stainless steel screws and a small amount of additional dental acrylic to insure electrical isolation and to provide additional strength. With the IC socket attached to the S, the previously lesioned IC is inserted. For maximal stability, one or two of the pins on each side of the IC are soldered to the corresponding metal connectors of the socket itself. During this operation, care should be taken to use only a small amount of solder in order not to interfere with the subsequent attachment of the "Dip Clip" IC test clip during recording. That is, a large amount of solder on one or more IC pins could prevent the "Dip Clip" test clip from securely gripping the body of the IC and seating against the IC socket. Finally, the leads from the IC socket are attached to the electrodes and the surgical incision closed. For sterile operative procedures, the IC and IC socket must be cold sterilized and not autoclaved.

To utilize the "Dip Clip" IC test clip as a cable connector, the leads from the experimental apparatus are simply soldered to the pins extending from the top of the test clip. The major consideration here is that the cable be flexible and free of electrical artifact when moved or twisted. Operation of the "Dip Clip" as a cable connector is identical to its normal use inasmuch as it is simply clipped to the IC mounted within the socket attached to the S's skull. When the spring-loaded IC test clip is released, it grips the inactive IC and the contacts

Fig. 3. Completed construction of the head-plug portion of the connector assembly. The illustrated head plug is set up for two bipolar electrodes, a monopolar vertex lead, and a single ground lead for a total of six leads.

Fig. 4. Photograph of the complete connector assembly as currently used for recording averaged evoked responses from primates during discrimination training.

of the test clip make an electrical junction with the pins of the IC that are linked through the IC socket to the leads of the implanted electrodes. Figure 4 illustrates the arrangement as currently used with chaired rhesus monkeys to record averaged evoked responses. In practice, the "Dip Clip" connector is routinely attached to (or removed from) the primate by a single E in a matter of seconds with virtually no resistance from the animal.

Considering the quality of recorded electroencephalographic activity, Fig. 5 presents an example of a bipolar recording taken from the visual cortex of a rhesus monkey. The upper tracing presents the record when the S is relatively quiet; the lower

Fig. 5. An illustration of the EEG recordings obtained using the described connector assembly. The upper trace was taken when the S was relatively quiet; the lower trace was taken when the S was active and moving its head. Both recordings were made at the minimum filter settings possible with the Grass Model 79 polygraph and with the 60-Hz filter out.

tracing shows the record when the S turns his head. In both cases, the recordings were taken with the polygraph (Grass Model 79) set to filter the signal as little as possible and with the 60-Hz filters off. Even at these settings, the recorded signal appears relatively free of noise and movement artifact.

The only possible problem that we anticipate is that the pins of the inactive IC may become soiled over a period of time and increase the resistance of the connector system to the extent that it would interfere with the recorded signal. However, the wiping action of the "Dip Clip" IC test clip during attachment and removal has, at least during our weeks of daily recording, succeeded in keeping the IC pins clean enough to produce recordings similar to that of Fig. 5. Cleaning the IC pins with a small emory board is a simple matter.

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NOTE

1. Pomona Electronics Co., Inc., 1500 E. Ninth St., Pomona, California 91766.

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