A New Multipurpose Human Brain Depth Probe

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W e have recently reported the details of construction of a new multipurpose brain probe.\textsuperscript{10} Although this has found significant use in animal studies,\textsuperscript{14} it was originally designed for chronic clinical implantation.\textsuperscript{12} In addition to the “usual” studies performed in depth electrography, such as the recording of spontaneous or evoked depth potentials and changes occurring consequent to depth stimulation, we have recently been interested in the use of other techniques to evaluate metabolic states in the living brain.\textsuperscript{11} There have been many reports built around the use of polarographic methods for evaluating cerebral oxygenation.\textsuperscript{1–4,8,9} Other polarographic techniques have been reported, principally for intravascular circulatory studies.\textsuperscript{5,7} Our probe has made it possible to apply many of these studies to brain tissue.\textsuperscript{11} We have also been interested in the use of alternating current impedance measurements as an index of certain anatomical and physiological characteristics of intracranial tissues.\textsuperscript{5,10,16}

With such a variety of studies in mind, it proved necessary to design a probe having a great number of contacts. Since one can never be exactly sure in advance where an area of interest might lie along the course of a depth probe, it is important to have more contacts than are needed so that the significant areas may be selected for study after implantation. In addition, this modification permits finely spaced measurements and the study of gradient fields within the brain. The basic design for the probe used in this study is shown in Fig. 1.

The 18 contacts are made by laminating 18 wires around a length of \#24 stainless hypodermic needle tubing stock. Using high temperature electrical varnish, this probe has been heat-bonded as a unit and has one contact per wire. The electrical contact is made at a selected location by carefully cutting through the insulation. The wire, which is .0035 in. in diameter, is an alloy of 90% platinum, and 10% iridium; the latter gives rigidity and resiliency to the alloy. Each contact surface is 0.075×1.00 mm. All of the present probes are made with an increased density of contacts near the tip, with additional intercontact spacing further up the probe length. Through the hollow tubing core one may pass a guarded microelectrode, make injections into the tissue, or pass a coagulating electrode. The bare contacts are platinumized which increases the electrical sensitivity of contact by about one hundred-fold over ordinary stainless steel.\textsuperscript{13} This sensitivity varies with frequency but is particularly important at the lower frequencies and DC.

The most common form of electrodes now employed consists of a bundle of wires tightly or loosely twisted together. When the number of wires is more than 8 or 10, the probe becomes stiffened so that it has the size and flexibility of a long, \#20 needle. Although there are theoretical disadvantages to the use of a stiff probe, we have yet to observe any significant limitation related to this factor. Chronic implantations have been maintained from 2 weeks to 1 month. Three of our implanted patients have had grand mal seizures, occasionally accompanied by severe falls, but in none of these have we encountered any significant complication. We believe any possible disadvantage is outweighed by the availability of the large number of contacts and the ease of insertion and chronic maintenance.

Fig. 2 shows the parts for chronic implantation of the new probe. Fig. 3 shows the surgical steps involved in human implantation. A small circular cutter (looking like a cork borer) is used to incise the scalp, removing a skin plug 4 mm. in diameter. A small 2 mm. linear extension is made on either end of this round hole. This produces an incision resembling the Greek letter Phi (ϕ). A simple prick punch is then used to

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* The probe is now available from the Medical Applications Department, Advanced Systems Development Division, IBM, Rochester, Minn. The associated instruments and parts necessary for chronic implantation are also available.
Fig. 1. Diagram of probe. The hollow stainless steel tubing stock core can be seen. The tips of the wires, cut off at the end, are insulated as shown. By cutting through the enamel of the wire at a selected point (*), a contact is established. Contacts may be cut anywhere along each wire. Probe contact spacing used in our clinical cases is shown. Recently we have varied the spacing from that shown to afford more contacts within the superficial cortex.

dimple the surface of the skull. A #54 metal drill (0.055 in. in diameter) is used to penetrate the calvarium. The angulation of the drill hole determines the direction that the probe will take when it is finally inserted; the hole must therefore be drilled with some degree of precision. Just as the drill enters the inner table, the chuck is opened and the drill left in place. The threaded steel pin is screwed onto the end of a special hammer having a 1 lb. captive, sliding weight. The captive hammer is held near and exactly parallel to the axis of the drill in the calvarium. An assistant removes the drill, the pin is then positioned exactly in the same axis at the entrance to the hole. By allowing the captive weight merely to fall, the pin is driven firm after about 6 blows. (The hammer's falling weight develops approximately 50 g's.) The captive hammer rod is unscrewed leaving the threaded pin in place. The threaded retainer cup is then screwed very tightly onto the pin. With the cup locked onto the pin, the dura is then penetrated using a #20 hypodermic needle. The probe, previously sterilized by soaking for 30 minutes in 1:750 aqueous Zephiran, or by ethylene oxide gas, is rinsed, first in acetone, followed by saline and is then inserted and locked in place with the locking ring.

Fig. 2. Diagram of parts used for chronic implantation probes. A threaded-end, stainless steel cranial pin (A) has been driven into a hole predrilled in the calvarium. The retaining cup (B) is then screwed onto the pin. The probe (C) is inserted into the cup and locked into position by the retaining ring (D).