Quarterly Report on Project 15G-B2299

Contract: NSR-39-005-018

Period: 1 October 1968 - 31 December 1968

I. MULTICHANNEL TELEMETRY

In the period two matters were attacked: first, that of transmission through saline solution (at 100 MC/s) and second, completing all final circuits for a four-channel package.

It was found that our 30 μw fm oscillator was severely loaded by the close proximity of saline solution in the total surround. This situation forced the unit out of oscillation and thus made it useless. The problem was studied, and it was determined that oscillation could be maintained by establishing a low dielectric barrier between the tank coil and the surround. However, in order to penetrate more than two inches of saline solution, the barrier had to be excessively large. We compromised by reducing the barrier and increasing the oscillator input power to ca. 50 μ watts. The barrier was made of a syntactic epoxy foam and provides not only essential isolation, but a light-weight, rigid and extremely rugged outer protective capsule. Thus, the barrier will prove useful for attachment of steel, or other, suture loops. A further anticipated plus to the situation is the fact that we will no longer encapsulate the entire implant circuitry. Our impermeable coating material used with the syntactic barrier will now

permit the maintenance of circuits free of special contaminants. This will permit simpler cell replacement and unit modification at later dates if desirable. In view of the fact that multichannel (more than two) units will be more costly than simple units, salvage is a factor of some economic importance.

Circuit layout and wiring diagrams are now in process for all four channels. There appears to be a real possibility that a full four-channel unit will weigh between three and four grams and have an operational lifetime of above five months. In the course of this work we are exploring new circuit connection techniques so as to improve our component packing density.

II. TRANSDUCERS

Work has continued in the testing and selection of sealant materials. Several new epoxies have been tested. A new epoxy Epotek 201 (Epoxy Technology, Inc.) recommended by this company as immersion resistant has proved to be as good as or better than other epoxies tested. This material has a very short working time, on the order of two minutes and a firm time of about eight minutes; in thirty minutes it is hard. Various proportions of resin to hardener were tested, 1:1 proving most resistant to immersion. It is tough, hard and water clear and has proved to be highly resistant to immersion in normal saline.

Iridium electrodes have been fabricated from 5 mil. diameter and 10 mil. diameter iridium wire and tested against a calomel

reference electrode. These electrodes were made both by sealing directly to glass and by sealing with epoxy in configurations similar to the form previously reported. These iridium electrodes have not proved to be very stable even when operated into a very high impedance. Preliminary tests show that an input impedance of at least 10 megohms is necessary to obtain a voltage near that expected. A copy of a very informative patent has been obtained.* This patent describes the iridium electrode. The most important facts which were gleaned from this patent were the following:

1. The iridium electrode is far superior to the antimony electrode in many respects such as calibration, immunity to various salt concentrations, temperature range, agitation and pH range.
2. It is superior to the hydroquinone electrode in that it does not contaminate the solution.
3. Solid metal sheet or wire is not suitable for an iridium electrode because of hydrogen incorporated into it by the manufacturing process even with very high purity material.
4. Satisfactory electrodes apparently can only be made by a lengthy, complicated process of multiple plating and burnishing (also sputtering or vacuum deposition)

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*Cells for pH measurements, G. A. Perley (assigned to Leeds and Northrup) No. 2,416,949, March 4, 1947

5. Directions for plating and burnishing are given.
6. Recommendations for maximum current to be drawn from iridium electrode ($<10^{-7}$ amperes/sq. cm) to avoid polarization.

Attempts have been made to incorporate in Sylgard coated Ag-AgCl electrodes, KCl so that an equilibrium of KCl ions at the AgCl surface would obtain. These electrodes were made by allowing KCl solution to evaporate on the AgCl surface leaving behind KCl crystals. This evaporation was performed several times, finally obtaining a relatively thick, uniform coating of KCl on the Ag-AgCl electrode. This surface was then covered with a double coating of Sylgard. On immersion in an aqueous solution, water diffusing through the Sylgard should produce a saturated KCl solution in direct contact with the AgCl, thus producing a reference electrode insensitive to Cl ion concentration. It was hoped that the diffusion of the KCl outwards through the Sylgard membranes would be sufficiently slow to give a long life reference electrode. These electrodes when tested performed very well against a glass electrode in measuring pH when they were new. They quickly deteriorated, however, the AgCl either dissolving or flaking off the silver base and the Sylgard becoming perforated and sloughing off the surface. This idea is not being given up entirely, however. Thicker coatings of Sylgard will be tried to eliminate the perforation. Further, some electrodes will be made with the KCl sandwiched between layers of Sylgard. It

is hoped that this technique will prevent the KCl from drastically affecting the AgCl layer and yet will provide immunity to Cl ion concentration. Even if these attempts are not successful the Ag-AgCl electrodes without KCl should prove satisfactory, albeit not ideal, for the applications intended.

Plans for the next quarter will include continuation on the work with Ag-AgCl-KCl Sylgard electrodes. Work will begin on preparation of plated iridium electrodes. Because of the complexity of the plating procedure this will proceed slowly. Both kinds of electrodes will be evaluated and miniaturized as far as practical.

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