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A NEW CHRONICALLY IMPLANTED ELECTRODE
FOR RECORDING NYSTAGMUS IN ANIMAL, ② NA ③
④ NA ⑩ (See foreword)

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FOREWORD

This report was prepared by the following personnel at the School of Aerospace Medicine:

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The authors express appreciation for the advice of the following individuals: Dr. Robert L. Cramer, Vestibular Section; Colonel Robert L. Hummer, Veterinary Services Branch; Colonel Carlos F. Schuessler, Dental Sciences Division; and Frank V. Garbich, Instrument Section. They are grateful, also, for the assistance of A/1C Donald B. Helms in animal care and training.

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ABSTRACT

An electrode was developed to provide a more accurate and adequate method of recording eye position and movement. The electrode is simple to make and apply, and it will remain in the desired sites for some length of time with minimal changes in itself or in the surrounding tissue.

This type of electrode can easily be used in other studies, such as EEG investigations in animals.

This technical documentary report has been reviewed and is approved.


ROBERT B. PAYNE
Colonel, USAF, MSC
Chief, Operations Division

A NEW CHRONICALLY IMPLANTED ELECTRODE FOR RECORDING NYSTAGMUS IN ANIMAL

1. INTRODUCTION

Many recent investigators of the vestibular system have utilized the technic of electronystagmography, a method of recording the displacement of the electrical axis of the eyeball in response to vestibular stimulation (acceleratory, electrical, caloric) (1), or after localized lesions in the labyrinths or cerebellum (2).

Aschan (3), Henriksson (4), Meyers (5), Marg (6), and Mowrer et al. (7) have developed methods of electronystagmography (ENG), in which the eye movements are transduced into electrical signals, which are more susceptible to alternated readout and analysis.

Electronystagmography is more practical than many methods formerly used to record nystagmus. Earlier methods included insertion of the aluminum cross in the cornea of rabbit of Hogenes in 1881; the pneumographic method of Buys in 1925; the optic methods of Dodge (8); the photographic technics of Hoffman et al. (9), Linthicum (10), and Wendt and Dodge (11); and the lever system of Ohm (12).

This study was made for the development of a system for detecting movements of the electrical axis of the eye in chronic animal preparations.

The development of a satisfactory electrode was carried out to comply with the criteria; the implantation must be accomplished with minimum probability of surgical trauma, irritation, or infection; it must remain *in situ*, its impedance must be low, and it must be small enough that it is not cumbersome and will not

hinder availability of the brain in the subsequent induction of lesions.

It is the purpose of this technical report to describe a chronic electrode that approaches these criteria more closely than do chronic wire electrodes (13).

2. SUMMARY

A new type of chronic electrode has been developed for recording the displacement of the electrical axis of the eye. Surgical technic for implanting this type of electrode at the desirable anatomic sites is described. Recordings of cornea-retinal displacements in response to various vestibular stimuli are demonstrated. Microscopic examination supports this chronic electrode implantation in its findings of small inflammatory infiltrate in the penetrated tissue areas.

3. APPARATUS AND METHODS

Description of electrode

The electrode is made from an 18-gage gold alloy rod. Gold was used because of its high electrical conductivity and its relatively small hindrance to the reparative processes as compared with other metals (14). As a noble metal, gold is not very susceptible to the action of blood serum and other fluids.

In figure 1 the design and measurements of the electrode, the nylon nut, and the special wrench are diagrammed. This gold electrode is made by using a $\frac{5}{64}$ -inch gold bar threaded with $\frac{1}{64}$ -inch thread (per thread) on one side and then repeating the threading on the reverse side of the electrode. After the bar is completely threaded, the male plug end is machined

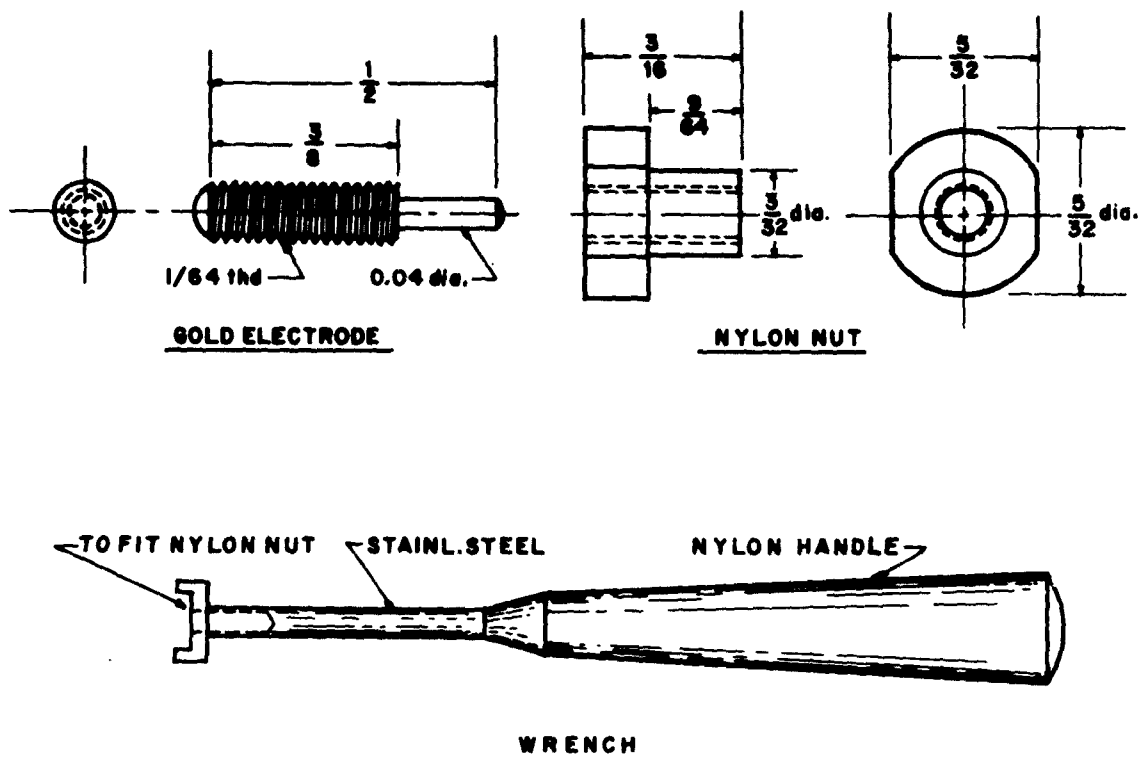


FIGURE 1

Diagram of gold "screw-in" electrode, nylon nut, and a special wrench to fit nylon nut.

down to a diameter of 0.04 inch to fit a Cannon connector (DB.25S). A nylon nut, threaded down over this gold electrode, with an extended sheath, is used as an electrical insulator; it has the advantage of withstanding autoclaving.

Electrode sites

In order to monitor nystagmus or any other eye deviations of cat, the electrodes were implanted at the following sites (fig. 2):

1. The zygomatic process of the malar bone, located by palpating the prominence (usually cartilaginous) of this bone just slightly lateral and ventral to the lateral canthus of each eye.

2. The frontal bone just above the middle of the rim of the orbit.

3. The malar bone just below the ventral rim of the orbit.

4. The frontal suture where it is intersected by a line drawn across the forehead at the level of the dorsal aspects of the two orbits.

Electrodes at site 1 record horizontal deviation of the eyeball, while electrodes at sites 2 and 3 record vertical movements. The electrode at site 4 serves as the indifferent electrode or the ground.

Preoperative measures

On the day prior to surgery, antibiotics (100,000 units of procaine penicillin) are administered to minimize the possibility of infection, as it is very difficult to be insured of a completely sterile surgical field on the head of the cat without causing undue irritation to the

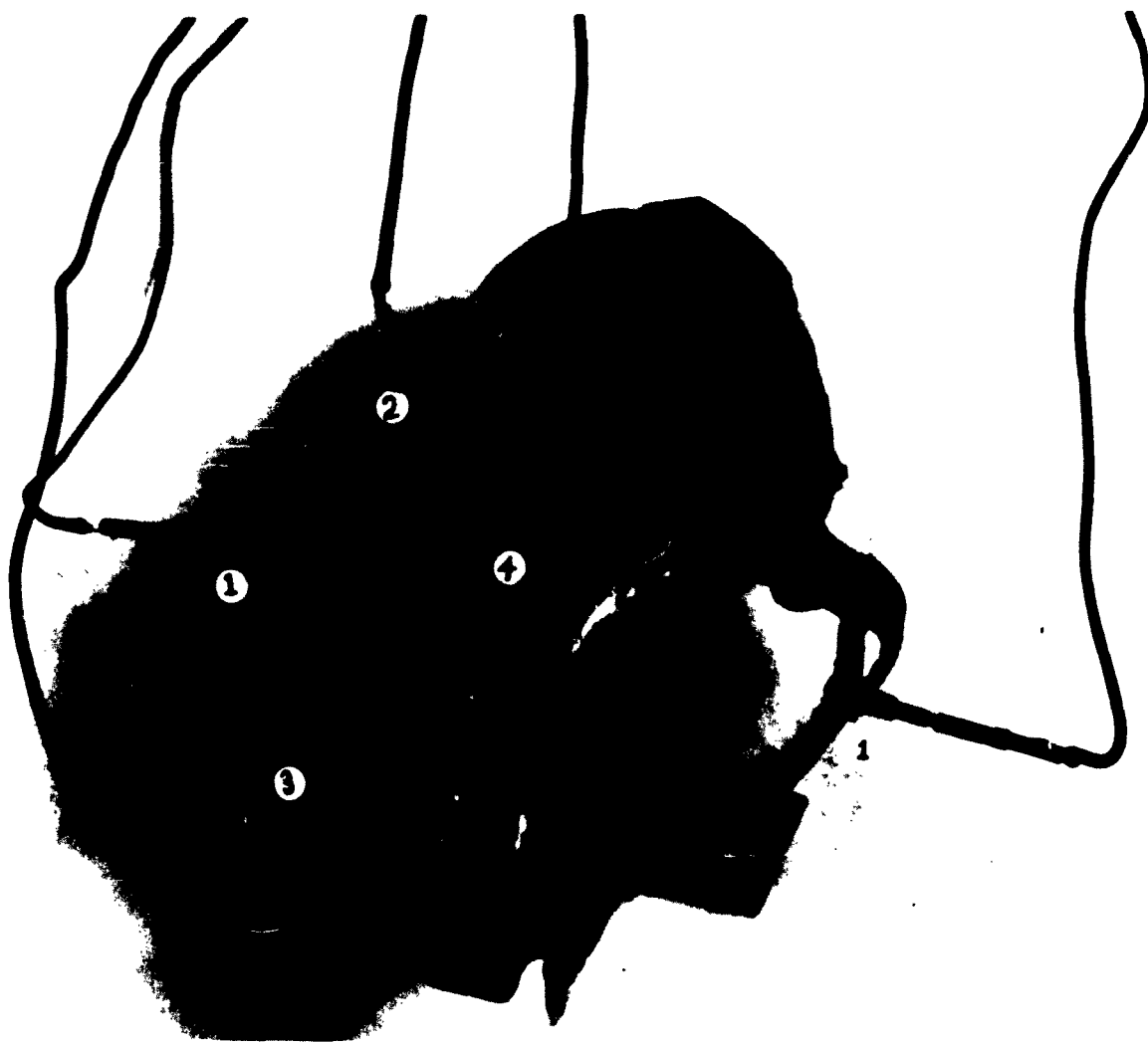


FIGURE 2

View of gold implant electrodes in situ of cat's skull.

No. 1—loci for recording horizontal movements; Nos. 2 and 3—vertical movements; No. 4—ground.

skin or eyes. On the day of the surgery, the animal is premedicated with $1/150$ gr. of atropine sulfate administered intramuscularly, one-half to one hour before anesthesia. The animal is anesthetized and maintained in a state of light surgical anesthesia with pentobarbital sodium administered intravenously to effect.

The entire head of the animal is clipped with an Oster clipper equipped with a number .40 "surgical blade," and the skin in the area of the desired electrode sites is shaved. The head is scrubbed several times with PhisoHex surgical detergent and finally draped with sterile towels.

Surgical technic

The technic for surgical implantation of the gold "screw-in" electrodes is the same for all four sites. Fortunately, from the standpoint of allowing for minimum surgical trauma, the bone is very superficial at all of these sites. After palpating to determine the desired location, an incision not longer than 1 cm. is made through the skin and then through the underlying subcutaneous tissue. This tissue is bluntly spread away from the site until the bone is exposed. Care is taken to disturb the periosteum of the bone as little as possible. The tip of a small Steinmann intramedullary pin is used to start a hole in the bone at the exact desired location (this prevents "walking" of the drill when the hole is being drilled). This hole is then completed with an undersized drill (size 53) and a tap ($1/_{64}$ -inch) fitted into a Smedberg hand drill. The electrode is secured to a universal pin chuck so that its threaded base is exposed and is then screwed securely into the bone. To increase the stability of the electrode, a nylon nut ($3/_{32}$ -inch diameter) is threaded down over the post and is drawn snugly (not too tight) to the bone (a special wrench was made by the Instrument Section for this procedure). A piece of polyethylene tubing, size PE 60, is finally placed over the post and threaded onto its base. The tubing is undersize with reference to the base and oversize with reference to the male adapter portion of the electrode. This allows it to be secured to the base but to be loose enough to the remainder of the post for the female adapter to be placed over the post and into the tubing. Since the polyethylene tubing occasionally came off, the nut and sheath were lengthened to remedy this trouble (fig. 1). The skin and subcutaneous fascia are then closed

with a few (usually only two are required) simple interrupted stitches using 000 silk.

Postoperative treatment and care

The animal is maintained on procaine penicillin, 100,000 units I.M., daily for four days or given a single injection of Bicillin, 400,000 units, I.M. A light Elizabethan collar made of cardboard is fitted to the animal's neck to avoid scratching and the possibility of dislodging the electrodes. The recovery cage is padded to help minimize the chances of the electrodes being dislodged while the animal revives from the anesthesia.

4. PERFORMANCE

The performance of this gold "screw-in" electrode is demonstrated in figure 3, in which the horizontal cornea-retinal displacements were recorded from the described electrode sites in cat (fig. 4). The electrical potential was preamplified by a Taber 202G-4 amplifier which is capacity coupled to a Philbrick (model P2) set to 1 megohm input impedance. The time constant of the circuit was 1.8 seconds. The output filter at the Philbrick amplifier was set to one-half amplitude at 15 c.p.s.

The signal was fed to an Ampex (model CP-100) magnetic tape recorder-reproducer and to a Heiland d.c. power amplifier, Honeywell model T6GA-100, then to a Heiland galvanometer, M 1000, in a Heiland oscillograph, Honeywell model 906B. A segment of a recording demonstrates the responses to sinusoidal stimulation of peak acceleration of $0.2 \sin .024t$ rad/sec.² (upper section) and to a peak acceleration of $0.4 \sin .042t$ rad/sec.² (lower section) in figure 3. The top trace is of the tachometer



FIGURE 3

Electrically recorded vestibular responses to sinusoidal stimulation. Upper section: Acceleration = $0.2 \sin .024t$ rad/sec.² Lower section: Acceleration = $0.4 \sin .042t$ rad/sec.² In both sections the top trace is of the tachometer generator signal; second trace is ENG; and the third is the derivative of ENG. Time is one second between each vertical line.



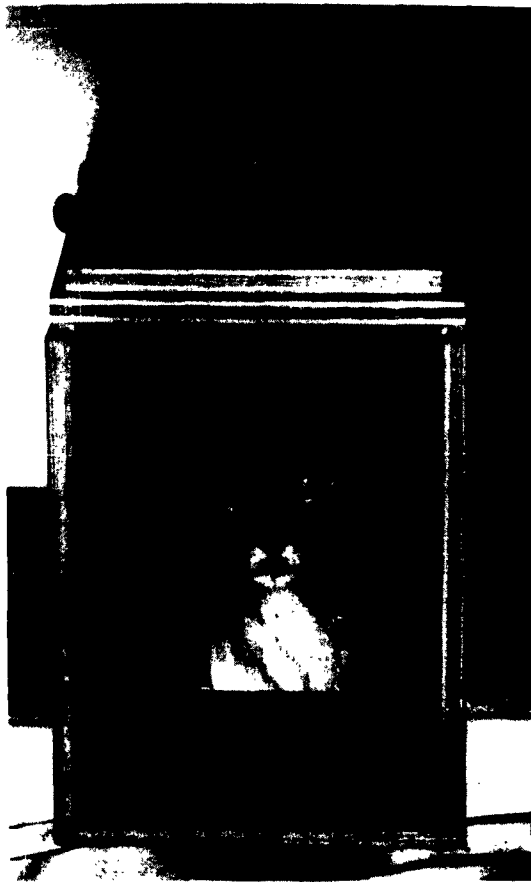


FIGURE 4

A frontal view of Cannon connectors attached to chronic gold implant electrodes in cat in a restraint box.

generator signal, the second trace is the electronystagmograph response, and the third is the first derivative of the electronystagmograph trace above it. Note the phase angle and directional change in relation to the stimulus.

Pathologic examination of five electrode sites after three and one-half months showed in all instances that the cutaneous tract, left by the electrode, was lined by slight inflammatory tissue. In two instances in which the electrodes were loose, the tract proximal to the nylon nut had significant inflammatory infiltrate. No such inflammatory infiltrate was found in the three sites of the securely placed

electrodes, where the periosteum was intact with the bone (15).

5. DISCUSSION

This gold "screw-in" electrode provides a single instrument for a more practical and direct contact with the sites described (figs. 2 and 4). It complies with the criteria of causing minimum tissue trauma, of minimizing surgery and eliminating severe inflammatory reaction, and of noninterference with subsequent craniotomy.

The threaded end provides a secure grip and prevents the electrode from slipping out of the desired site. This type of electrode has been in service for the satisfactory recording of nystagmus for more than three and one-half months in cat.

The nylon nut is not completely satisfactory, but nylon was the only material available at the time. Ideally, this should be of gold. The main disadvantage with nylon is the small amount of inflammatory infiltrate it causes in reaction with its surrounding tissue. However, if the electrode areas are swabbed daily with Nitrofurazene ointment, severe inflammatory infiltration can be prevented. Furthermore, a major advantage of this nylon nut lies in its insulating properties, the support it gives to securely tightening the electrode to bone, and the fact that it can readily be autoclaved.

In comparison with other electrodes, such as beaded or balled, pointed or hooked ends of wires anchored to a screw or pedestal arrangement (13), this screw-in method is more efficient in that it complies with the technical criteria for stability, durability, simplicity in design and ease of fabrication, conductivity, postoperative care, and a minimization of traumatic effects of surgery and of any significant tissue reaction to foreign bodies. On the whole it appears to provide a more practical means of sensing cornea-retinal displacements, as shown in figure 3. Because of d.c. polarization, this electrode was not designed to record fixed eyeball placements. It is also possible to utilize such chronic implant electrodes for research in electroencephalography.

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