to the first. Finally, a strip of kraft paper the size of the slide and with a one-half-inch hole in the center is cemented to each side of the slide.

Specimens prepared in this way have been found to be quite durable and to resist handling very well; and, of course, they may be used either side up without interfering with the correction of the ordinary objective or condenser.

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SPECIAL ARTICLES

THE EFFECTS OF ALTERNATING CURRENTS UPON CUTANEOUS SENSORY THRESHOLDS

I BEG to express appreciation of Dr. Peterson's interesting historical communication on local electric anesthesia.[1] The note by Dr. Inman and myself[2] dealt with the application of a certain phenomenon to the anatomical procedure of outlining cutaneous nerve areas, rather than with the phenomenon itself; Dr. Peterson's note directs attention to the latter, and seems to render desirable the following discussion, which, however, is merely preliminary to more ample publication.

Seeking to improve Hughson's method of outlining cutaneous nerve areas by using the small alternator referred to in our note, Dr. Inman and I found that at certain levels of current strength the cutaneous area supplied by the nerve under the influence of the current was sufficiently insensitive to light touch to be outlined with reasonable accuracy and consistency, which was not true of painful and thermal sensations; although we recognized some effect upon the other thresholds, especially that of pain, only in the case of touch was it striking. My assistants and I have lately directed our efforts toward establishing quantitatively the occurrence or non-occurrence of the differential masking which Dr. Inman and I believed that we detected, utilizing the larger generator mentioned in our note, and elaborating accurate methods of gauging cutaneous sensory thresholds; a preliminary report has appeared.[3]

Fig. 1 exemplifies the results obtained in a number of experiments upon several subjects; some of its points may seem obscure, pending a detailed account of technique and discussion of results. It does show, however, a clearly differential susceptibility to elevation by the current on the part of the thresholds of the different sensations. In our experiments with the superficial branch of the radial nerve, the threshold for pressure[4] was most susceptible to elevation by

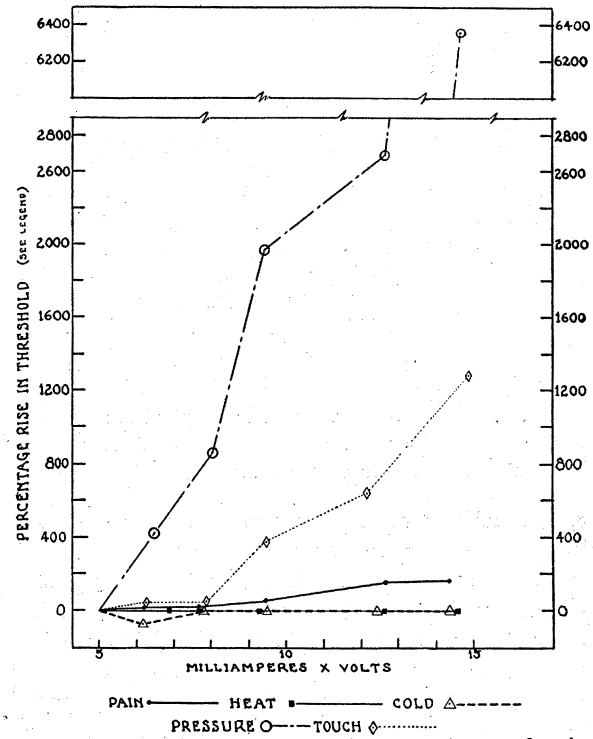

FIG. 1. Graph of the results of an experiment wherein the superficial branch of the left radial nerve was subjected (through the skin) to the influence of an alternating current of 400 cycles per second, and of strength increasing as indicated along the abscissa. The thresholds of the sensations were measured at different spots in the area supplied by the nerve, each sensation being tested at the same spot throughout the experiment. Before each experimental observation, the normal threshold for that sensation was measured. The ordinate records the rise in threshold above the immediately preceding normal reading, expressed as a percentage of the average of the normals throughout the experiment.

such means, next that for touch; pain was affected much less than these, but usually quite significantly; whilst the elevation of the thresholds for heat and cold was very slight, inconsistent and probably insignificant.

Since the appearance of our note, Dr. Arthur S. Gilson, Jr., of the Department of Physiology, Washington University, St. Louis, has informed us (*in litteris*) that, using the current from a Thyratron oscillator, he and Dr. H. B. Peugnet have obtained

[1] F. Peterson, SCIENCE, 77: 326, 1933.
[2] I. M. Thompson and V. T. Inman, *ibid.*, 77: 216, 1933.
[3] I. M. Thompson and A. Barron, *Anat. Rec.*, 48: 35 (Suppl.), 1931.
[4] Probably the sense of pressure is neither simple nor cutaneous. The outstanding sensitiveness to this current of the threshold for pressure was revealed by our method of stimulating (as we think) the sensation of pressure apart from that of touch.

qualitative results like those indicated by Dr. Inman and myself; I am grateful for permission to include this statement herein.

Comparison of the differential susceptibility of thresholds to this current with the results of other types of interference with nerves (*e.g.*, pressure, local anesthetics, section and recovery) suggests itself, as do explanations in terms of the work of Ranson, Erlanger, Adrian and others; to these matters we shall presently address ourselves.

The local "benumbing" effects of various electric currents have been known for a very long time, electric local anesthesia figuring prominently in the medical literature of 1858, and appearing sporadically since then. In spite of occasional reports of success, it has not proved consistently satisfactory for clinical purposes, which does not surprise us, in view of our experience as exemplified in Fig. 1.

Robert[5] used the phrase "anesthésie de diversion," expressing the idea that there is no reduction of physiological sensibility (as in true anesthesia), but diversion or occupation of attention, with diminished perception. We think that it is confusing to call this anesthesia, and prefer Robert's other term "masking." At present our interest is centered upon the strikingly differential quality of this phenomenon, to which, so far as we know, we first drew attention.[3]

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FUNCTION OF THE ROUND WINDOW[1]

SOME time ago, Hughson and Crowe, of Baltimore, reported[2] that when the membrane, which closes the round window of the cochlea, is "made rigid by pressing on it with a plug of moist cotton, the perception of spoken words and practically all tones is increased at least 50 per cent." Later it was suggested that if a fascial graft were implanted in contact with the round-window membrane, thus reducing its normal mobility, the impaired hearing of those who are partially deaf could be distinctly ameliorated. These statements, by virtue of their scientific and clinical implications, have aroused the keen interest of all who are concerned with problems of hearing.

The first question seems to be: Will an animal, whose round-window membrane is thus blocked with a plug, actually *hear better* (respond to fainter sounds) than normally?

The subject (dog) is placed in a stock with right fore-paw resting on a metal grid (which can be charged with electricity). A stimulus-tone (1,000 cycles) is sounded for two seconds, directly followed with a charge just strong enough to effect hasty withdrawal of the foot. The animal soon learns to withdraw his paw as soon as tone begins, thereby avoiding the imminent shock. When the tone is made fainter and fainter, he continues to react as long as he hears it; when it becomes inaudible, he no longer responds. Auditory acuity in a dog may thus be measured with great precision and consistency. The normal limen having been established, each bulla is exposed on its ventral aspect through which a circular hole is reamed; the round-window recess appears directly opposite. A plug is gently pressed into the fossula and brought into snug contact with the round-window membrane. (Plug consists of moderately soft gum enveloped in gauze, the whole forming an elongated saccule of mesh filled with gum). The bulla-opening is closed with a rubber stopper to protect middle ear from extraneous fluids. Within five hours animal's hearing is tested; the plug is then immediately withdrawn by an attached thread and hearing again tested. The change in performance from plug *in* to plug *out* is regularly (ten animals) positive: hearing is impaired whenever plug is in contact with the membrane and again improves when plug is withdrawn. In the first five cases, while our technique was still developing, the gain = 8.0 decibels, standard deviation = 4.11; in the second five, after procedure was perfected, the gain comes out far more sharply and consistently (10.0 db, s.d. = .84). The operation itself (merely entering the bulla) was found, by test, to have no appreciable effect upon the limen.

The second question is: How do these plugs affect electrical pick-up from the auditory nerve? Animal is prepared by entering one bulla, as before, and also exposing the homolateral nerve. A whistle of 1,000 cycles, operated by an interrupted air-stream, provides an ideal stimulus-sound. The electric pulses thus evoked in the nerve are led off by an electrode into ear-phones, where they can be reduced by means of an attenuator until they become just inaudible to the observer. The pick-up with plug *in* and plug *out* can thus be readily measured and compared. The same effect appears with every animal tested (thirteen in number): plug in, sound is reduced; plug out, sound is increased. (First half of cases, mean gain = 4.4 decibels, s.d. = 1.46; second half, mean gain = 9.9 decibels, s.d. = 2.52.) The following relation is thereby established: plugging the round-window fossule reduces both the animal's ability to hear and also the electrical pulses over the auditory nerve. Despite wide-spread discussion of the "Wever-Bray effect," little or no evidence has hitherto been submitted to show whether the effect does, or does not, correlate with actual hearing.

[5] Robert, *L'Union Médicale*, 12: 487, 1858.

[1] Communication No. 1 from the Alpha Research Laboratory. A generous grant in aid of this work by the Trustees of the Research Fund, American Otological Society, is gratefully acknowledged.

[2] *Jour. Am. Med. Assn.*, 96: 2027, 1931.