ON THE POSSIBILITY OF PRODUCING AN INTERPRETABLE VISUAL IMAGINE ON THE RETINA OF THE DIOPTRICALLY BLIND BY MEANS OF ELECTRIC PHOSPHENES

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When the retina is mechanically stimulated as by the pressure of the finger inserted between the bulb and the rim of the orbit, a sensation of light is produced in the opposite quadrant of the visual field. Such mechanically produced phosphenes have been known and remarked upon for centuries and the phenomenon has been used as evidence for the "projective" nature of vision. Likewise the adequacy of a mechanical or electrical stimulus in the elicitation of a visual sensation has been adduced as proof of the specificity of sensory end-organs.

Since the initiation of a visual sensation by other than an appropriate radiant energy stimulus is a property of the percepient elements of the eye, a study was undertaken to determine the feasibility of adapting the phosphene phenomenon to the production of visual sensations in cases where dioptric medium blindness existed. In these cases the percepient and interpretive elements (retina, optic nerves and tracts and occipital cortex) are intact; vision being hampered by the interposition of a mechanical barrier to the rays of light destined for the retina. Blindness due solely to lenticular, corneal and/or vitreous opacity is never complete, some degree of light perception and projection being maintained. Never-

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theless such cases make up the larger percentage of the blind and while theoretically this group is amenable to corrective surgery, the latter is not always practical. One hesitates, for instance in a case of complicated cataract to intervene surgically for fear of losing for the patient that modicum of vision, light perception and projection, which saves the patient from absolute blindness.

Since the retina may be intact, its utilization for the synthesis of useful visual images in dioptrically blind subjects, is a tantalizing prospect. The recent advances in television engineering might make it possible to correlate such images synchronously with visible transpirations in the external world.

With this object in mind, experiments were begun early in 1942, in anticipation of a large increment in corneal blindness cases that fortunately did not materialize—to lay a groundwork for adaptation of electrical phosphenes to synthetic images. So far this work has had a purely preliminary character. But the information elicited indicates that the construction of a mosaic phosphene "half-tone" by electrical stimulation of the retina, through the intact coats of the eyeball, is possible.

Stimulation of a single rod or cone would produce an image subtending about 60 seconds of visual arc. It was desired to determine how close an approach could be made, by non-visual stimulation through the intact sclera, to this theoretically minimum limit. Normal human subjects who had the lid reflex of one of the eyes abolished by the conjunctival instillation of 2% butyn and whose other eye was covered by a patch, were instructed to rotate the anesthetized eyeball maximally upward and to maintain it in this position while mechanical stimuli were applied as far back as possible in the conjunctival fornix by means of a No. 32 gauge phosphor bronze wire. In this manner it was possible to produce phosphenes close to the foveal area. Such phosphenes were recorded as to position and subjective size, the latter being estimated by subsequent comparison with a set of perimetry targets.

Though only an approximate indication could thus be gained of the possible size of mechanically induced phosphenes, it was evident that all subjects could identify and project those of 2° and over. Separate phosphenes could be produced and spacially projected when the separation of 5° or more was made between the applied wires.

Increasing the pressure upon the applied wire increases the size of the produced phosphene; this seems to be due exclusively to the increase in the size of the scleral distortion cone produced by such pressure. There is no irradiation of image size with mechanical pressure in any form. The situation was different when electrical stimulation was applied through the apposed wire. Using a single negative galvanic stimulus of 5 milliamperes, the resulting phosphene approximated that produced by mechanical pressure. With faradic stimulation, the size of the phosphene increased with the duration of the stimulus; where the latter was for more than a second, there was an irradiation effect resulting in a phosphene that occupied an entire quadrant of the visual field.

Since the phosphene size is apparently a combined function of the area and duration of the stimulus, the latter could be modulated to produce an actual complex mosaic image. In discussing this matter with Dr. William Edson of the Communications Engineering Department of Georgia Technologic Institute, he has stated that the stage of the television art should render it feasible to form such patterns on the retinae of the dioptrically blind by electronic devices. He suggested in this connection a scanning device which would consist of a multi-wired cable, originating in a televisor, the distal end of which would be molded so as to approximate the curvature of the sclera; that the elements of the cable in contact with the sclera would each furnish a regional stimulation in the proper time, sequence and space relationships to coincide with the external picture and to reduplicate the latter as a rough mosaic in the visual field.