Dioptrically Blind by Means of Electric Phosphenes

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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 perceptive 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 dioptic medium blindness existed. In these cases the perceptive 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 syn-
chronously 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 theo-
retically 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 spatially 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 televsor, 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.