Evoked occipital potentials have been recorded from scalp electrodes in response to focal visual illumination. To accomplish this, a computer specifically designed for this purpose and capable of integrating any area under an evoked waveform and summing these areas to reveal a response has been used. A decoder is available which can signal when any preset digital value is reached or exceeded. Illumination of the optic papilla has been employed with different stimulus intensities and areas under conditions of light adaptation to demonstrate that focal retinal illumination can be achieved. Some patients with visual field defects have been studied in an attempt to demonstrate the possibility of objective visual field testing.

In 1934, Adrian and Matthews described rhythmic changes in the electroencephalogram in response to flickering ocular illumination. This phenomenon, often referred to as photic driving, has received considerable investigation and is best demonstrated with high intensity stroboscopic flashes located close to the eye, and a frequency of flicker approaching that of the inherent rhythm of the electroencephalogram. As early as 1935, the importance of stray light in illuminating the entire eye to induce photic driving and electroretinograms was appreciated. During the past decade there has been the development of elaborate electronic devices which allow the extraction of evoked potentials from relatively larger background noise. With such instrumentation, evoked potentials have been recorded from scalp electrodes in response to somatic auditory and photic stimuli. Again, however, light sources which flood the entire eye with light have been employed. Recently, Armington and others have attempted to record spatial differences in electroretinograms using focal retinal illumination. Simultaneous occipital potentials have sometimes been recorded from scalp electrodes. With a 21 degree diameter stimulus, the sensitivity of the electroretinogram was found to be roughly proportional to the remaining area of visual field in patients with retinitis pigmentosa. The peak to peak amplitudes of the occipital potentials recorded simultaneously, however, showed no correspondence to the functioning area of remaining retina.

It was the purpose of this study to develop a computer with the ability to record small evoked potentials in the midst of...
large background noise in response to focal retinal illumination with flickering light, and to study the feasibility of such instrumentation for objective visual field testing.

Method

Normal subjects and patients with visual field defects caused by various lesions in the optic pathways seen at the College of Medicine of the University of Florida served as subjects for the present study. Fig. 1 shows the stimulus and recording equipment. A cylinder 1.06 M. in length and about 40 cm. in radius was used to obtain relatively even adjustable background illumination. A stroboscopic Xenon flash of 10 msec. duration with an approximate peak intensity (A) of 3.3 x 10^4 ml. was attached to a rod on a runner so that the distance of the light from a subject's eye could be readily adjusted. This arrangement allowed a stimulus placement at variable distances from the eye and at varying loci within the visual field. The stimulus intensity could be reduced electronically to 50 per cent peak intensity (B) and 17 per cent peak intensity (C). A diffuser was used in front of the light source which reduced intensity 86 per cent as determined in a Beckman spectrophotometer. The frequency of stimulation used in all the data presented was 3.9 c.p.s. One of two Wratten filters available was occasionally interposed in front of the light source. The yellow filter, designated "Y," transmitted 91 per cent of incident light in the long wavelength part of the visible spectrum, with the transmittance falling sharply between 500 and 5000 mp. The transmittance of light of wavelength 500 mp is only 10 per cent, and below 450 mp the transmittance is less than 1 per cent. A green filter, "G," was also available with a peak transmittance of incident light of 60 per cent at wavelength 500 mp. The transmittance decreased for wavelengths longer and shorter so that at 440 and 580 mp the transmittance was reduced to 15 per cent. Various size apertures were also inserted in front of the diffuser to obtain circular stimuli of different diameters. The 2.5 degree diameter stimuli and smaller aperture diameters were always located 1.33 M. from the eye, while to obtain 40 degree diameter stimuli a larger aperture was used and the luminous source was then located only 1/2 M. distant from the eye. After a number of preliminary experiments, a background luminance of approximately 8 ml. was chosen as an illumination useful in suppressing retinal sensitivity, but not to an extent such that signals were not readily detectable with the light intensities available from the Xenon stroboscope.

The potentials recorded in response to the flickering light were obtained from 2 brass electrodes 4 mm. in diameter and 2 inches apart. One electrode was placed over the occipital protuberance and the other electrode 2 inches superior in the midline. A ground electrode was attached to the earlobe. Electrode contact with the skin was promoted with EEG electrode jelly under the contacts. Prior to and during examinations, the skin resistance between electrodes was intermittently measured with an ohmmeter built into the computer. An attempt was made to manipulate the electrodes until the resistance was below 10,000 ohms, and tests in general were not performed when readings were more than 15,000 ohms. The EEG was monitored simultaneously from the same scalp electrodes during the test to determine adequacy of electrode contact, and was used in indicating any movement on the part of the subject. The potentials were then led off to a digital computer specifically designed by the Syber Corporation to program a flashing light and process the resulting neuroelectric activity evoked at the occiput. Controls on the operating console allow the settings to be made with regard to flicker rate and intensity of the light stimulus.

Processing of the evoked neuroelectric activity consists of performing well-known autocorrelation techniques in order to extract very small signals in the midst of large background "noise." "Noise" is considered to mean electrical activity recorded from the scalp electrodes, which is not regularly related in time to the stimulus. The major component of such noise is the electroencephalogram. The computer is capable of electronically inspecting the data to make a decision as to the presence or absence of an evoked response. Immediately after any retinal locus corresponding to any chosen point in the visual field is tested, a decision is made as to whether a response was evoked at the scalp electrodes over the occiput and, if in the affirmative, a signal light is displayed.

The major components of the computer consist of an A.C. preamplifier and several additional amplifiers which receive and amplify the incoming electrical activity from the occiput via a differential set of electrodes, a variable band-pass filter to eliminate frequencies which contain little informational content about the evoked response, an analogue to digital converter for digitizing the neuroelectric activity, and a digital computer for extracting, by summation, the small evoked potentials which were about 5 to 10 microvolts in height were amplified approximately 30,000 times.

By means of monitor units, the incoming EEG trace and evoked response waveform may be displayed by cathode ray tubes. In addition, various controls on the operating console allow the manip-
ulation of other test parameters. For example, the stroboscopic flash can be programmed to flicker at any chosen frequency and the total number of evoked responses summed (samples) at any test point may be varied. The computer may also be programmed so that any area of the waveform is summed and digitally displayed. In these experiments, the area summed is referred to as the "integration period" and refers to the time interval in milliseconds following the onset of the stimulus which is integrated and summed. In most of these experiments, the area of each evoked waveform between 50 and 200 msec. after the onset of the stimulus was summed to give a digital response. The display light indicating an evoked response may be adjusted to signal a response according to predetermined values. Similarly, the band-pass frequency filter is readily adjustable as it must be to allow recording with various frequencies of the flickering light.

Results

Pilot experiments were conducted on several normal subjects to determine the effect of frequency of stimulation on peak to peak amplitude of the occipital potentials. In general, the frequencies of 4, 8, 16, and 32 were investigated and there was a decrease in amplitude with increasing frequency of flicker which was most evident when the peripheral retina was stimulated. Responses from macular stimulation were still present at a frequency of stimulation of 32 c.p.s., when a 2.5 degree diameter stimulus was used (intensity A). As the frequency of stimulation was altered, so too were the waveforms of the summed evoked responses.

Preliminary experimentation with electrode placement led to the adoption of the placement described previously. When the electrodes were placed more anteriorly in the midline, and particularly the midline between the ears, evoked potentials from the click of the stroboscopic flash were

Fig. 1. The cylinder enclosing the flickering light source is shown on the left with the computer in the right background.
Fig. 2. Tracings of the summed evoked occipital waveforms each resulting from 150 summations (samples) under different recording conditions are as follows:

<table>
<thead>
<tr>
<th>Waveforms</th>
<th>Upper and lower frequency cutoff of band-pass filter settings in c.p.s.</th>
<th>Stimulus location in visual field of right eye</th>
<th>Stimulus diameter (degrees)</th>
<th>Stimulus intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Control)</td>
<td>2-50</td>
<td>Light occluded</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>B</td>
<td>2-50</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>2-40</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>D</td>
<td>2-30</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>E</td>
<td>2-20</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>F</td>
<td>2-10</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>G</td>
<td>2-6</td>
<td>Central (fovea)</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>H (Control)</td>
<td>2-6</td>
<td>Light occluded</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>I</td>
<td>2-6</td>
<td>15° nasal</td>
<td>2.5</td>
<td>B</td>
</tr>
<tr>
<td>J</td>
<td>2-6</td>
<td>45° nasal</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>K</td>
<td>2-6</td>
<td>45° nasal</td>
<td>1.25</td>
<td>A</td>
</tr>
<tr>
<td>L</td>
<td>2-6</td>
<td>30° nasal</td>
<td>1.25</td>
<td>A</td>
</tr>
<tr>
<td>M</td>
<td>2-6</td>
<td>Central (fovea)</td>
<td>1.25</td>
<td>A</td>
</tr>
<tr>
<td>N</td>
<td>2-6</td>
<td>Central (fovea)</td>
<td>1.25</td>
<td>B</td>
</tr>
<tr>
<td>O</td>
<td>2-6</td>
<td>Central (fovea)</td>
<td>1.25</td>
<td>C</td>
</tr>
</tbody>
</table>

Frequency of flickering light was always 3.9 c.p.s. (Amplification of visual display = 1X.)

The abscissa on all figures showing evoked response waveforms is in milliseconds. The time between successive flashes was 250 msec.
readily detectable with the initial stroboscopic light used. Because this light made a loud snapping noise, a second, much quieter stroboscopic flash was obtained which is the light used and described in this study. With the second light, no auditory evoked responses could be obtained even with the electrodes over the vertex of the head. To further exclude the sound of the light and other extraneous influences as sources of stimuli influencing the signal, control readings have been taken on all subjects and patients. These "noise readings" (controls) were obtained by keeping all test conditions constant, but with the flashing light occluded.

The digital numbers referred to in this study are relative values and are significant, therefore, only by comparison with each other.

The "noise readings" on the subjects described in this paper were generally negative digital values. However, on one nor-

Fig. 4. Graphic representation of some data obtained from subject 4 (see Fig. 5). The stimulus diameter at each location in the visual field of the right eye indicated by a dot was 2.5 degrees and the frequency of stimulation 4 c.p.s. An integration period of 50 to 200 msec. was used and each dot represents the average value of two summed evoked occipital responses (150 summations each). A = high intensity, B = medium intensity, and C = low intensity. D refers to the data collected for a 1.25 degree stimulus at the highest intensity. A. The shaded area below represents the range of five control readings (light occluded).

mal subject under the usual experimental conditions, considerable variability was found in 58 control readings. Nine per cent of the total were actually small positive numbers (thus, false positive readings).

Attempts to influence the control readings by talking, broad ocular excursions, blinking, and closing the eyes had no influence, so that ten such readings taken on the same subject resulted only in negative values in the usual range. Moving the head particularly forward and backward, which presumably caused the greatest electrode movement, definitely resulted in larger negative values. An experiment with a 6,000 ohm resistor in the electrode box to simulate a patient also resulted in large negative control readings when the resistor contacts were manipulated or jarred. Even without electrode movement, the computer itself contributed a small negative bias to the digital values obtained.

Patients did not wear their glasses during testing. By the interposition of convex lenses in front of an emmetrope, obvious decreases in the magnitude of the evoked response were evident for an induced myopia of ten diopters, if a 1.25 degree
c.p.s.). The tracings B through G indicate the smoothing of contour and also the changes in general wave shape as the band-pass filter is progressively narrowed while the fovea is illuminated by a 2.5 degree diameter stimulus. When the macula is illuminated with a large stimulus (subtending a visual angle of 2.5 degrees) or the periphery is stimulated, the response is primarily negative with a peak latency of about 100 to 125 msec. It should be noted that such negative responses on the oscillographic display occurred only when the stimulus was directed at the scotoma of the blindspot.

In Fig. 2, the waveforms are shown from the same individual during different conditions. The waveforms are from tracings obtained from the oscillographic display of the summed evoked waveform. Waveform "A" demonstrates the oscillations obtained during a control reading when the band-pass filter is wide (2 to 50 c.p.s.). Waveform "H" illustrates the much smoother "noise" reading obtained when the band-pass filter is narrowed (2 to 6 c.p.s.).

For dimmer stimuli there was suggestive evidence that smaller refractive errors might affect the responses.

In Fig. 6, the evoked occipital responses obtained from stimulation of each eye separately with flickering light (3.9 c.p.s.) are compared. This 14-year-old patient had 20/15 vision O.D. and 10/100 vision O.S. The central vision in the left eye was reduced by a chorioretinal scar, which created a central scotoma 10 degrees in diameter with the 0.25 mm. test object on the Goldman perimeter. With the same test object, another chorioretinal scar in the right eye resulted in a circular scotoma extending from 5 to 23 degrees directly superior to the point of fixation. Some integrated digital values recorded simultaneously with the evoked response waveform are shown. Dashed line = O.S.; solid line = O.D. (Amplification of visual display = 1x.)
Evoked occipital potentials from scalp electrodes

Evoked occipital potentials from scalp electrodes 399

graphic display are represented as positive numbers on the digital display and vice versa. A late positive oscillation is evident in the waveforms obtained from foveal illumination which is maintained as smaller and dimmer light stimuli are used, although the first negative oscillation decreases with more central macular stimulation and lower intensities. (Compare summed waveforms G, M, N, and O.) Fig. 3 shows the even more dramatic complexity of the evoked waveform which appears for both central and paramacular stimulation when the band-pass frequency filter is open to its fullest extent.

Fig. 4 illustrates that in spite of considerable variability in the integrated summed waveforms, not only between different subjects but in the same individual, there is a rough correlation between the size and intensity of the stimulus and the magnitude of the signal. The coefficient of variation \( \frac{\sigma}{X} \) of 20 consecutive waveforms obtained in response to macular stimulation was 20 per cent. Also, as is suggested by the values in this figure, there is a characteristic decrease in the size of the signal for any stimulus peripheral to 30 degrees from the fixation point. This was observed in all subjects tested peripherally.

Table I presents the data collected from normal subjects who were able to appreciate subjectively a difference when light of low intensity and small size was projected onto the blindspot as compared to the adjacent retina. In short, their fixation was adequate for them to serve as subjects for blindspot experiments. It may be noted that with the background illumination previously described, negative values were usually obtained when the blindspot was illuminated with flickering light. Responses are included to indicate that, in these same subjects, responses were detectable when comparable areas of the retina were stimulated, either adjacent to the blindspot or on less sensitive retinal areas. However, it should be observed that in subjects 4 and 5, positive values (signals) were obtained when the blindspot was illuminated with the 2.5 degree stimulus light at its highest intensity. This was also true for subject 4 with the medium intensity stimulus. In reference to Fig. 4, it will be seen that even the slightly negative values for the 2.5 degree diameter stimulus at low intensity are less negative than the control readings, which suggests some scattering of light either reflected from or overlapping the blindspot so as to stimulate function-
Table I. Tabulation of data of subjects for blindspot experiments

<table>
<thead>
<tr>
<th>Normal subject</th>
<th>15° Nasal</th>
<th>Fovea</th>
<th>Blindspot</th>
<th>15° Temporal and 5° superior</th>
<th>20° Temporal</th>
<th>30° Temporal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. 1 Right eye</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25° Diameter stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity A reduced by Wratten filter No. C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration period 50-150 msec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples = 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 2 Right eye</td>
<td>132.7</td>
<td>138.1</td>
<td>-76.9</td>
<td>127.4</td>
<td>152.0</td>
<td></td>
</tr>
<tr>
<td>1.25° Diameter stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity = C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration period 50-150 msec.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Samples = 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 3 Left eye</td>
<td>16</td>
<td>-46.3</td>
<td>48.2</td>
<td>126.5</td>
<td>55.6</td>
<td></td>
</tr>
<tr>
<td>1° Diameter stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity = A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration period 50-150 msec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples = 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 4 Right eye</td>
<td>488.6</td>
<td>555.6</td>
<td>630.5</td>
<td>295.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5° Diameter stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity A</td>
<td>486.4</td>
<td>456.3</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Intensity B</td>
<td>263.9</td>
<td>231.1</td>
<td>91.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity C</td>
<td>236.1</td>
<td>175.5</td>
<td>-8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration period 50-200 msec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples = 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 5 Left eye</td>
<td>219.7</td>
<td>153.6</td>
<td>19.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5° Diameter stimulus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity A</td>
<td>216.1</td>
<td>88.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity B</td>
<td>235.0</td>
<td>75.8</td>
<td>53.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity C</td>
<td>122.9</td>
<td>-52.2</td>
<td>49.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration period 50-200 msec.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samples = 150</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All control readings (range) -7.3 to -321.6.
Evoked occipital potentials from scalp electrodes

In subject 5, negative values (no signal) were obtained when the papilla was illuminated, and the 2.5 degree diameter stimulus on either medium or low intensity was used. Although a signal was present for the 2.5 degree diameter stimulus at high intensity, no signal was detectable when the disc was illuminated with a 1.25 degree diameter stimulus on high intensity.

In Fig. 5 the magnitude of the evoked responses is expressed in bar graphs. The results in this patient with a macular hemorrhage in the left eye indicate that no significant differences in the occipital responses were obtained with the use of a foveal stimulation with a stimulus object subtending a visual angle of 2.5 degrees in diameter. However, with the 1.25 degree diameter stimulus, the values obtained from illumination of the left fovea are suggestively smaller than those from the right, while little difference is evident in the magnitude of the response obtained by stimulation of the nasal periphery of both eyes. When this patient was examined with a tangent screen, no central scotoma could be detected with the 1/1000 test object, but a small central scotoma was found with the stereocampimeter.

Fig. 6 shows the correlation of some evoked response waveforms with the digital value. In this patient, the vision in the left eye (represented by the dashed line) was 10/100 as the result of a central chorioretinal scar, while the right eye was normal. The difference in evoked response from stimulation of the left macula is readily apparent.

Fig. 7 demonstrates the results obtained in a patient with optic neuritis secondary to multiple sclerosis which reduced vision in the right eye to 20/30. With the use of small test stimuli focused on the macula, a marked difference in evoked response is obtained from stimulation of the involved eye as compared with that obtained from the normal left eye. Although a response is present from stimulation of the involved eye, it is reduced in amplitude but reversed in polarity. No difference could be detected with large diameter stimuli, i.e., 40 degrees.

Several patients with moderately advanced bilateral macular degenerations have been tested, showing more marked losses of signal when the foveal area is stimulated. One such patient with large central scotomas usually showed no evoked response when the fovea was stimulated and generally moderate-sized evoked responses everywhere in the periphery. This was true whether both eyes were examined separately or simultaneously. Obviously, congruous homonymous field defects may
be detected by simultaneous ocular stimulation. In Fig. 8, the results obtained from a patient with macular degeneration are shown. In this patient, both eyes were involved, the left greater than the right. The peak deflection of the evoked response with macular stimulation of each eye separately reflects this difference. Also, the evoked responses obtained from peripheral stimulation of both eyes are about equal to those from macular stimulation. This is abnormal since central stimulation usually elicits significantly larger responses than peripheral. Also, all responses are somewhat reduced in amplitude. Because of different amplifications in different figures, this is not readily apparent from these figures.

In Figs. 9 and 10, data are presented which show that in patients with field defects negative response values are obtained from the nonseeing areas, whereas the responses are readily detectable when the remaining portions of the visual field are illuminated.

In Fig. 11, some data obtained on one patient when awake and anesthetized are compared. It should be noted that when the patient was under anesthesia, fixation was inaccurate and this was probably responsible for some of the differences in evoked responses that were recorded.

Discussion

Previously, large or intense light sources have generally been used to facilitate the recording of neuroelectric activity from the eye or cerebral cortex. It has long been appreciated that the use of small light
sources in illuminating the eye does not necessarily result in focal retinal stimulation. In an attempt to reduce the amount of stray light, and thereby achieve more focal retinal stimulation, a number of recommendations have been made. It has been suggested that reducing the sensitivity of the retina adjacent to that stimulated by flooding the eye with light from background illumination would be helpful. This technique has been employed in this study with good results as determined by focusing the flickering light on the blindspot. In these experiments, some scattering of light is still evident. For example, a 2.5 degree diameter stimulus, which is about half the diameter of the blindspot, may result in retinal stimulation by reflection from the papilla, scattering by the optical media, or transillumination of the adjacent functioning retina when the intensity of the stimulus is high. When no background illumination was present and the small flickering stimulus was focused on the optic papilla, the subject had the sensation that the entire eye was being stimulated with light, and evoked responses were readily detectable. Similarly, the subjective correlation of “seeing” the light and the corresponding presence of an evoked response, even in the presence of background illumination at the higher stimulus intensities of focal papillary illumination, was interesting. It has been pointed out that illumination of the blindspot, although useful in serving as a test...
for the presence of focal illumination, may result in more scattering of light by reflectance than if functioning retina containing pigment epithelium were illuminated.18

It has been reported that the peak to peak amplitude of evoked occipital responses has no correlation with the area of remaining visual field.12 It should be re-emphasized that most of the evoked response waveforms presented in these figures were markedly distorted and simplified by the use of a narrow band-pass frequency filter (see Figs. 2 and 3). In this case, there is apparently a gross quantitative correspondence between the peak deflection of the evoked response and the area under this waveform, with the integrity of the retina stimulated. The undistorted evoked occipital waveform bears some resemblance to visual evoked responses previously described14 where some of the oscillations were related to photopic and scotopic activity. The differences probably result from different stimulating and recording conditions. The primary question raised in this study was simply whether an evoked response is present or absent at the occiput if there is an interruption of the optic pathways corresponding to the area of focal retinal stimulation. The general absence of an evoked response in this case was not surprising.

Although 12 different normal subjects have been tested (several repeatedly) and about 25 patients with visual field defects, only some data have been presented. The amount of data is still totally insufficient to answer such questions as whether changes in the size and waveform of the evoked response is present for lesions at different locations in the visual pathways. Certainly, it is not known whether the potentials actually originate in area number 17 of the occipital cortex or visual association areas.

A number of difficulties were encountered in this study. Although the electroencephalogram not "time locked" to the stimulus was relatively well eliminated by the summation technique and band-pass frequency filter, the variability in the control readings, apparently introduced by the movements of the subject's head causing consequent movement of elec-
Evoked occipital potentials from scalp electrodes

15. Coff, W. R., Broster, B. S. and Allison, T.