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EFFECTS OF ELECTROMAGNETIC RADIATION ON BIOLOGICAL SYSTEMS

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SUPPORTED BY
U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND

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In regard to Grant DA-MD-49-193-64-G136, the following report summarizes research activities for the period 15 June 1964 through 1 April 1965.

1. Neodymium laser irradiation of rabbit eye. A breadboard model of a Nd laser device, provided by Joint Operations Group, was tested for potential injurious effects to the eye. The unit produced 4.1 joules in a pulse time of 0.5 milliseconds. The wavelength was 1.06 microns with a beam divergence of 83.1 milliradians. Tests were conducted where the eye of the rabbit was placed at distances from the laser ranging from 26 feet to 2 inches. This gave corneal energy densities of 1.2 millijoules per square centimeter to 5.2 joules per square centimeter respectively. It was also demonstrated that ophthalmoscopically visible lesions were produced in the retina with the rabbit in close proximity to the laser. No effects were observed for distances exceeding 20 feet. A modified version of this device is to be supplied for extensive experimentation in our laboratory.

2. Effects of laser radiation on visual function. In collaboration with Professor William Schoenfeld of the Department of Psychology at Columbia University, we are undertaking condition experiments on primates. The object of the study is to establish selective responses based on visual resolution and brightness discrimination. The method under development is similar to that successfully used by Blough and Ratliff which is essentially a modification of von Bekesy's tracking technique for examining auditory threshholds in man. In effect the technique will enable us to determine such visual functions as absolute sensitivity of the eye, visual acuity, the course of dark adaptation, vernier acuity and pattern recognition. It will then be possible to study the effects of laser exposure on these visual functions using as stimulus parameters the size of the retinal lesion and the locus of injury, e.g. foveal versus peripheral, artery vs vein occlusion, nerve bundle block, etc.

3. Electroretinogram and cortical evoked response. In addition to the psycho-physical conditioning experiments outlined above, an objective technique for studying functional defects resulting from laser exposure is desirable. The results obtained by these techniques may then be correlated with the subjective data. Ophthalmoscopic observation of retinal damage may not provide the ideal criteria for establishing threshholds of injury. Functional loss probably occurs at significantly lower energy density.

In order to study these effects, we are exploring the utilization of electrophysiological methods. These include the electroretinogram (ERG) and the light-evoked cortical response (EEG). The ERG gives primarily the electrical response of the entire retina and, by appropriate manipulation of stimulus parameters, rod and cone function may be differentiated. The evoked cortical response, on the other hand, reflects primarily the activity of the central retina owing to the dominance of the macula projection near the surface of the visual cortical areas. Therefore, by simultaneous recording of ERG and EEG, both discrete and diffuse retinal effects can be objectively evaluated.

4. Ocular fluorescence with ultra violet light. There is a possibility that fluorescence of ocular tissues, when illuminated by uitraviolet radiation, may degrade visual capability. A search of the literature indicated that no relevent experimental work has been performed. However, some information was available as regards the fluorescence properties of the lens. The action spectrum of lens fluorescence as measured by Bachem extends from 300 mu (with the maximum at 377) to 390 mu. Maximum emission occurs at 425 mu. Unfortunately there is no indication of the conversion efficiency of this process. Consequently, it was necessary to arbitrarily select an exposure level for a pilot study.

The source was a 150 watt high pressure Xenon arc lamp. The beam was collimated and passed through a narrow band interference filter made by Baird-Atomic Inc. Its peak transmissivity was 366 mu (within 3% of the wavelength maximum for lens fluorescence) with a half band width of 12 mu. By means of a short focal length field lens, the image of the arc was brought to a focus in the plane of the lens. Both rabbit and human lenses were irradiated in vivo. The bluish-white fluorescence of the lens was readily seen through a selected blocking filter, i.e. one which transmits wavelengths above 425 mu. It was impossible, however, with the available apparatus to measure either the luminous conversion efficiency or the radiometric conversion efficiency of the fluorescence. In the human subjects a veiling glare was definitely produced but was not sufficiently intense to reduce visual resolution below 20/25 Snellen acuity.

These data are for the experimental conditions cited and are

certainly inconclusive as regards the feasibility of utilizing ultra violet light as a veiling glare source. Higher power densities can be obtained with mercury-xenon lamps or higher wattage xenon arcs. However, a general solution to the problem would require detailed analysis of the conversion efficiency of fluorescence in the cornea, lens, and retina.

5. In addition to the above activities, brief reports were submitted to the Joint Operations Group on problems relating to flash blindness and radiofrequency induced biological effects. We are also consulting with Drs. Leo Amar and Marc Bruma of Centre Nationale de la Recherche Scientifique, Bellevue S. O., France concerning the results of their experiments dealing with intraocular and intracranial pressure waves generated by laser irradiation of the eye.

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10 April 1965

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