STUDIES IN PHOTOCOAGULATION*†

IV. LASER PHOTOCOAGULATOR

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THE purpose of this paper is to describe a laser coagulator designed according to requisites outlined in the preceding papers of this series. The instrument (Fig. 1) is composed of two essential parts, a coagulating source and an observation system.

(1) Coagulating Source.—A ruby crystal 2 in. long and 0.25 in. in diameter was used as a light source. It emits a beam of deep red light composed of a band which is about 3 Å wide located at 6,943 Å. The energy output of this crystal is variable and may reach up to about 1 Joule (watt/sec.). The energy output depends from several factors, one of which is the temperature of the crystal. The output drops when the temperature of the crystal rises. It will be remembered that the absorption of the pumping light by the ruby is followed by a very fast transition from the band level of 5,500 to 6,600 Å to the band level of 6,943 Å with emission of heat. Therefore, every emission produces a rise of temperature in the crystal. The temperature rises further because of the heat radiated by the pumping flash lamp. Therefore, if the repetition rate of laser firing is such that the crystal cannot cool to its initial temperature, the energy output will vary in spite of the constancy of the input. In order to permit faster repetition of laser firing, a cooling system was designed, using circulating water in a closed circuit. It was found that, with

FIG. 1.—Laser coagulator.

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this system, the first few laser firings raise the temperature of the water to a level which remains fairly stable even when the repetition rate of firings varies. This temperature stability results from the large coefficient of specific heat of the water. The above arrangement allows a repetition rate of laser firing every 5 sec.

The source used for the pumping light is an EGG* 1000-watt xenon flash lamp. The crystal and the flash lamp are placed on the focal lines of an elliptical reflecting cavity. The threshold of lasing is located at about 350 watt input. The increase in input is not linear and is very sensitive near the threshold. A knob for rough and fine adjustment provides an accurate means of presetting the input. After firing, the condensers of the power supply are automatically recharged and kept at a constant level.

As the beam of light emerging from the crystal diverges about 30 min. of arc, it makes a retinal image of about 0.15 mm. in diameter in the emmetropic eye. In an eye with 4D myopia, the image under the same condition is about 0.25 mm. in diameter. Evidently the size of the retinal burn will be several times larger and can be increased or decreased by varying the energy output. However, this energy is always concentrated in the central area of the burn where the retinal image of the beam is formed. The result is the production of a tiny central hole in the retina with a reaction around it. Increase in the energy produces a stronger reaction with increase in the width of the burn, and simultaneously it increases the depth of the central hole. Therefore, a more practical way of increasing the size of the burn is to increase the divergence of the beam by an optical system. The system used is composed of two biconvex lenses with a focal length of 15 and 7 mm. respectively (Fig. 2). The lenses are so located that the principal focal plane of the second coincides with the plane of the circle of least confusion of the first. After the light beam has passed through this system, its divergence is increased to about 1.5° of arc, which corresponds to a retinal image of about 0.7 mm. in an emmetropic eye. This image size permits one to adjust the energy output in such a way that the burn produces no hole in its central part.

FIG. 2.—Optical system.

* Edgerton, Germeshausen and Grier, Inc. 160 Brookline Ave. Boston, Mass.

(2) **Observation System.**—Since the coagulating beam is practically monochromatic, it can be deflected towards the patient's eye by a dichroic mirror (Fig. 3).

FIG. 3.—Observation system.

Observation is then performed through this mirror with an indirect stereoscopic ophthalmoscope. The ophthalmoscope lens is placed above the dichroic mirror. The ophthalmoscope must be attached to the instrument in order to make sure that the observation axis coincides with the axis of the coagulating beam. A reticle is placed on the intersection of the observation axis with the plane of the fundus image. This reticle permits one to aim the coagulating beam at the desired target. The light used for fundus illumination is provided by the ordinary light source of the indirect ophthalmoscope. Since this light passes through the dichroic mirror, which reflects the red coagulating beam, the image of the fundus is deprived of that portion of its red component which is around $6,943 \text{ \AA}$. As the red radiations with wavelengths inferior to $6,943 \text{ \AA}$ are present in the ophthalmoscopic image, its colour is barely altered.

Fig. 1 (above) shows a pilot model of the instrument, the electronic and mechanical parts of which were designed and built by Maser Optics.*

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