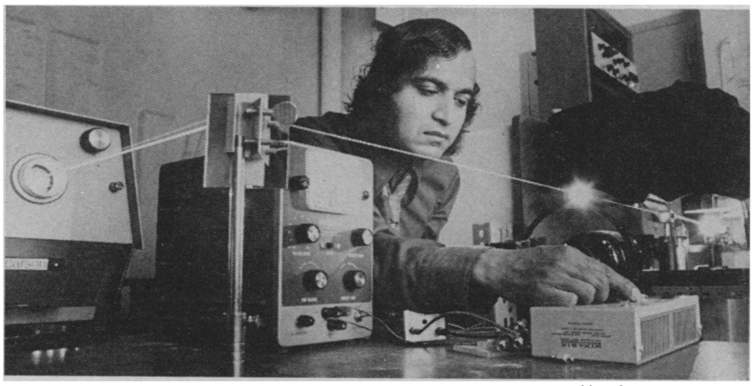
Leashing lasers

There are no national laser safety standards. Two groups are working to produce some.



U. of Rhode Island

Lasers, here being used to measure effects of pressure changes on crystal structure, are being put to an increasingly wide variety of uses in basic research and industry.

by Louise A. Purrett

The special properties of lasers, such as their ability to concentrate high-intensity light in a narrow beam, have made them valuable tools in an ever-expanding range of uses. But the same qualities that make lasers useful also make them potentially hazardous; the intense radiation achievable with some lasers can damage living tissues.

Lasers are generally treated with great respect, and there have been few reported injuries to date. The Bureau of Radiological Health of the U.S. Food and Drug Administration maintains a Radiation Incidence Registry, to which accidents involving lasers may be reported voluntarily. For the period from 1965 to 1971, the registry lists nine accidents with lasers. A Federal law passed in 1968 requires laser manufacturers to report accidents occurring with their lasers, but the law is just now being implemented.

Lasers are relatively new on the industrial and scientific scene—the first one was built just over a decade ago—but their use is expanding explosively. Though some organizations and agencies have their own safety standards governing operation of lasers, no national standards have been set. Both industry and the Government are pressing for development of safety standards for production and use of lasers, and two groups are currently in the midst of doing just that.

The task will not be easy; there are many kinds of lasers, and the effects of each depend not only on the laser's intensity and wavelength but also on the nature and characteristics of the exposed tissue. A person does not have to be standing in the main beam to be exposed; some laser light is easily reflected from metallic or glass surfaces.

What lasers do, essentially, is channel the photons emitted by atoms that have been artificially stimulated. The lasing medium—the substance whose atoms are excited—varies from laser to laser, but the most common media are ruby, carbon dioxide and helium-neon. The wavelength produced by a laser depends on the lasing medium, and the biological effects of laser exposure depend in large part upon the wavelength.

When a laser beam penetrates tissue it can cause burns or even explosive destruction of the tissue. At high exposure levels, steam may be produced, which could be especially dangerous if it occurs in an enclosed and completely filled volume, such as the cranial cavity or the eye. Injury may also be caused if some of the energy of the light pulse hitting tissue is converted to acoustic energy, creating a mechanical compression wave that can rip and tear tissue.

The laser is usually hazardous only to those tissues through which the beam can penetrate and which will absorb the particular wavelength produced. With most lasers, the eye and the skin are the most vulnerable areas.

The part of the eye affected depends on the wavelength of the light. Roughly 90 percent of the light from a ruby laser, which emits light at wavelengths of 694.3 nanometers (a billionth of a meter), penetrates to the retina, and the most damage occurs in the second and thinner of the retina's two layers, the pigment epithelium. The carbon dioxide laser produces light at 10,600 nanometers, which does not penetrate the eye but can burn the cornea.

Most research on eye damage has concentrated on finding the minimum amount of irradiation necessary to produce a visible lesion. No national consensus exists on these threshold levels, but a guidebook published by the Bureau of Radiological Health notes that it takes about 0.8 joule per square centimeter to produce visible lesions on the retina with a single pulse of light from a pulsed ruby laser. One second of exposure to the continuous beam from a carbon dioxide laser that produces 0.2 joule per square centimeter will produce a burn on the cornea. By comparison, 6 joules per square centimeter per second is required for white light to burn the retina.

Lower light levels that don't produce visible burns may still do some damage, such as partial bleaching of the pigment for a particular light color.

The skin is not as sensitive as the eye, but it can also be burned. The effects of laser irradiation depend on many factors, such as darkness or lightness of skin, amount of hair and density of blood vessels. Absorption of light occurs mostly in the pigment granules and the blood vessels. Sometimes, the visible light may pass through the skin to be absorbed by an internal organ such as the liver.

None of this means that anyone who comes near a laser is in immediate danger of being instantaneously disintegrated. The majority of the 80,000 or so lasers now in use in the United States are relatively low powered, producing less than five milliwatts of power. C. Harry Knowles, president of Metrologic Instruments, Inc., which produces low-powered helium-neon lasers, notes that "more than 60,000 such lasers are in use today in schools and industry throughout the country and not a single complaint of ocular damage has ever been reported." Another laser manufacturer says there are no documented cases of injuries with low-powered lasers. But George Wilkening of Bell Telephone Laboratories points out that laser injuries are just beginning to be systematically reported, so that the absence of documented injuries doesn't mean that no injuries have occurred, or that low-powered lasers pose no hazard.

Lasers are relatively simple to construct, and an article in the September 1971 SCIENTIFIC AMERICAN's "Amateur Scientist" column, giving instructions on how to build a carbon-dioxide laser, prompted Knowles' company to issue a press release warning about the dangers of such a home-made laser. The beam from the instrument described, Knowles said in the release, would be very high powered and could cause physical harm. He also pointed out that carbon-dioxide laser light is invisible, so that the eye's normal defenses, such as blinking, would not operate. "Construction of the 10-watt carbon-dioxide laser described in the article puts a highly dangerous instrument into the hands of inexperienced amateurs."

C. L. Stong, who edits the SCIENTIFIC AMERICAN column, says he had taken great pains to point out the hazards of the laser, and that all lasers are dangerous in one way or another, "and so are all acetylene torches and high-powered automobiles which we put in the hands of teenagers to whom we also give alcohol . . . we live in a hazardous age." Stong further comments that he has been describing laser experiments since 1964 and has had no reports of injuries. "Unless a person is extraordinarily bright, he can't build the laser in the first place, and if he's that bright, he's bright enough to observe the precautions I've suggested."

Leon Goldman of the University of Cincinnati College of Medicine has been conducting studies of laser effects both on animal and human subjects. To determine if prolonged or chronic exposure to low-powered laser beams could cause injury, he exposed a spot on his arm once a day for a year. Another spot has received a total of 423 impacts with a ruby laser. Neither spot showed any ill effects. Goldman says these and other experiments have convinced him that the laser, when handled properly, can be perfectly safe.

The problem of developing safety standards for laser users is made difficult not only by the inherent complexity of laser-tissue interactions, but also by the amount and type of research that has been done. Most research has been on the minimum exposure levels required to produce visible lesions, but there are other, more subtle effects. Since human subjects are scarce, most research on the eye has used rabbits and monkeys. It is not known just how closely their eyes correspond to human eyes. Further, these experiments often use a "worst case" approach, in which the pupil is dilated, the head fixed, the eye focused at infinity and the laser aimed directly at the fovea.

Beyond the scientific determinations, there are many value judgments that must be made. For example, what level of biological change should be considered as damage? How much responsibility should fall on the user—should lasers be so designed that no one could possibly harm himself?

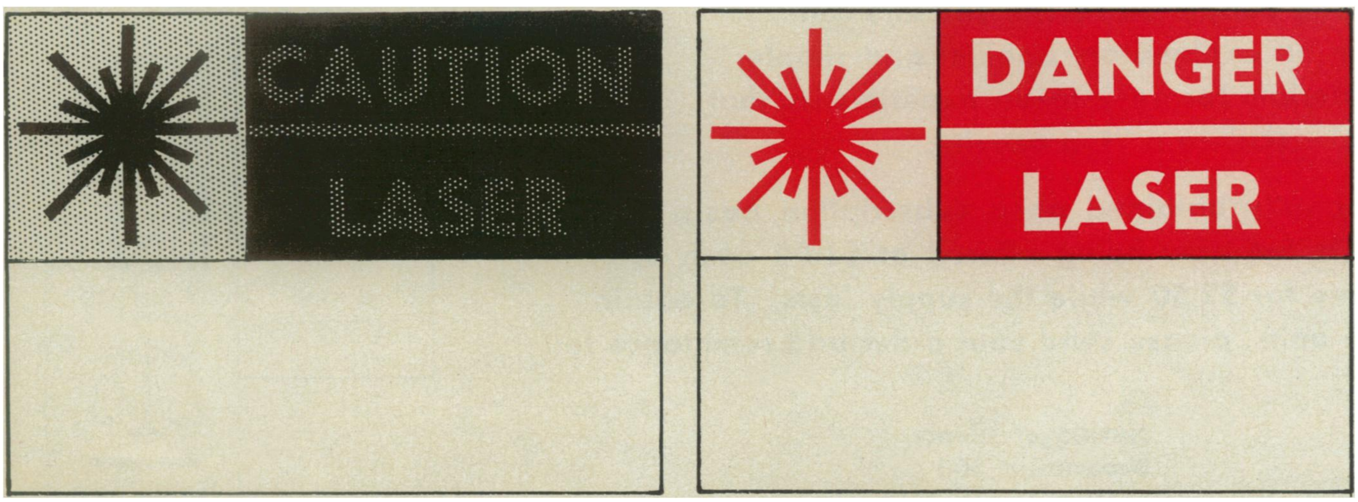
In spite of these difficulties, a number of private corporations, laboratories and government agencies have their own guides and regulations. An Air Force regulation, for instance, gives minimum exposure levels that constitute a hazard and sets guidelines for medical surveillance of laser users. The state of Illinois has a statute requiring registration of lasers. It authorizes the Department of Public Health to inspect all laser systems in the state and requires that accidental injuries involving lasers be reported.

There are no national standards—legal or voluntary. The Bureau of Radiological Health is presently working on performance standards that would apply to laser manufacturers in accordance with the Radiation Control for Health and Safety Act, which also contains standards for televisions and X-rays. Lasers would be classified as "dangerous," "enclosed" or "protected," according to the amount of radiation they produce or to which human users might be exposed. The standards would encompass labeling requirements, protective housing for the laser, position of controls, and information that must be provided by the manufacturer. In addition, there would be separate regulations for lasers having specific functions, such as in medicine and in surveying. Emission limits, however, have not yet been set.

Meanwhile, the American National Standards Institute is nearing completion of its own set of safety standards governing use of lasers. The ANSI's Laser Safety Standards Committee, headed by Bell Telephone's Wilkening, is attempting to arrive at a consensus on what levels of exposure produce what effects under what conditions—to be able to tell what is "safe" or "unsafe." The committee is composed of about 58 organizations and individuals. Some 100 other persons are involved in working groups that are considering biological effects on the eye, effects on skin, and control measures.

Wilkening hopes the next and possibly final draft standard will be finished by the end of February. This draft, if approved by the committee, would then be reviewed by ANSI, and the availability of the standard would be publicly announced, so that anyone interested could obtain a copy and submit comments or suggestions.

Optimistically, says Wilkening, a standard might be adopted as early as the end of April or the beginning of May. This standard would then be available to anyone who wanted to adopt it, including the Federal Government and amateur scientists building their own lasers. The Secretary of Labor, to comply with the Occupational Safety and Health Act, must set standards for laser users, and the Bureau of Radiological Health might consider the ANSI findings in developing its requirements for manufacturers. □



Bureau of Radiological Health

Federal laser regulations will probably require labels warning users of potential dangers.