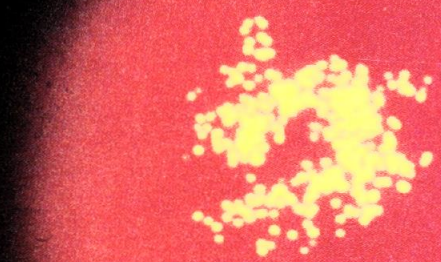


LASER THEATRE TECHNOLOGY

By Dr. Brian B. O'Brien

Use of the laser for theatre presentations is a logical step in the progressive use of technological advances in the media. Developments in photochemistry permitted photography, and developments in electronics permitted radio and television. Developments in physical optics made a giant step with the development of the laser in the late 1950's.

The word "laser" is an acronym for "light amplification by stimulated emission of radiation." This term was coined by Gordon Gould on November 13, 1957, when he conceived this idea for the generation of an intense beam of light. His patent no. 4,053,845 was granted only after a long battle of 18 years against powerful industrial corporations with competing interests.

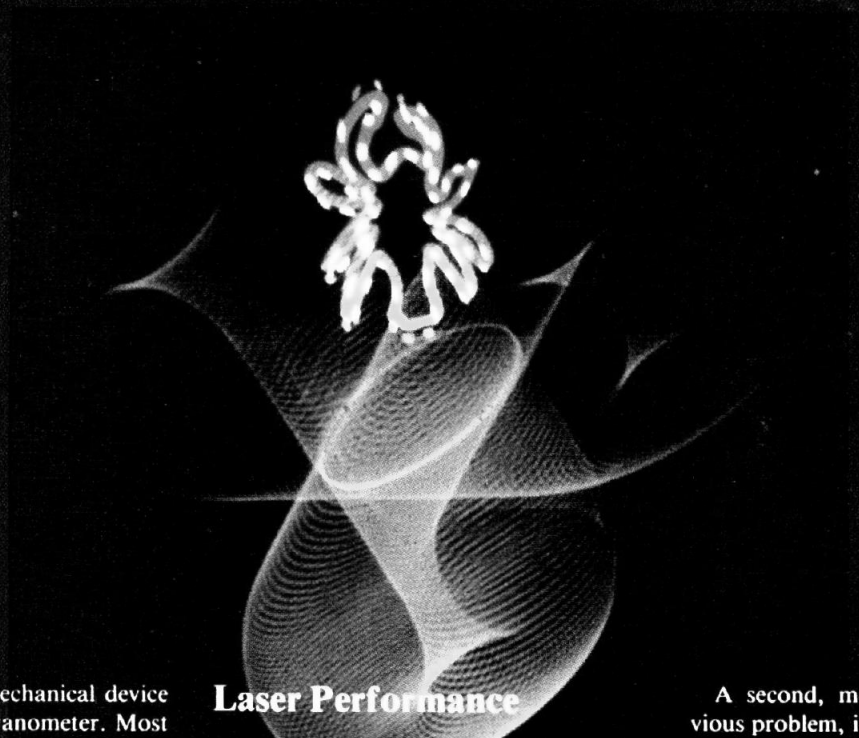
Creating Images

The intense narrow beam of light from a medium power laser is brighter than the sun, but only over the small spot illuminated. If this beam is projected steadily on a screen, a very bright small spot is created. If the beam is projected on the screen by means of two mirrors, such that each mirror can move the beam in one of two dimensions at right angles, then the spot may be moved in any direction on the screen by moving the two mirrors.

The moving spot, if moved very quickly, will be perceived by the eye as a line. By controlling the motion of the mirrors, this line can be caused to form an image of an abstract or real figure. These images can be very impressive for several reasons. Laser light is a very pure color. Although lasers may produce several colors of many different hues, each color is of a very narrow, almost pure wavelength, which makes the color striking to the eye. The contrast can be very high if the scattered light level is very low. When contrast is very high, the lack of background references makes the images seem to float in space. Movie film cannot equal either the color saturation or contrast achievable with a laser.

The fast moving mirrors move the flying spot over the image form repeatedly in order to maintain the image impression in the eye. If the image is repeated approximately 25 times per second, then the eye will see a steady image with little or no flicker. As the repetition rate is reduced, there is more time to add detail to the image. Flicker becomes quite objectionable if the repetition rate is decreased to less than ten times per second. Therefore, a compromise must be made between the amount of detail and the reduction or elimination of flicker.

The high speed mirror motion is usually



produced by an electromechanical device called a moving iron galvanometer. Most laser theatre equipment uses the high speed galvanometers developed and patented by Jean Montagu and Pierre Brosens of General Scanning, Inc., Watertown, Mass. These devices are among the fastest electromechanical devices known. Despite their high speed, speed is still the limiting factor determining the amount of detail that can be drawn.

In a multi-color system this limitation can be minimized by separating the colors with a prism, then projecting each color separately with its own pair of mirrors and galvanometers. In this way, different colored parts of the image are created simultaneously permitting the maximum amount of detail with each individual color. For example, if four or five colors are used with the same number of projection mirror pairs, then the performance may have four or five times the detail than could be obtained if various colors were projected by one pair of mirrors as is sometimes done in simpler systems.

Laser Performance

The actual program material must be generated in an electronic manner such that the magnetic coils in the galvanometers cause the mirrors to be deflected in the way desired to create the image.

The earliest laser theatre equipment required an artistically talented electronic technician to operate the various knobs and dials on electronic signal generators, creating a variety of bobbing and weaving abstract figures. Sometimes a small computer type memory is used to store a few written words for display.

This approach has worked well enough to supplement some other performance or to produce a simple independent performance. It does, however, have very serious limitations. One obvious limitation is the availability of the artist. He can create only one performance in one place at one time. Multiple performances at several locations require multiple artists, and very talented, qualified artists are hard to find.

A second, more serious but less obvious problem, is the human limitation of two hands per body. Expert manipulation of one color is enough to keep two hands busy. If four or five colors are used, then several artists ideally should be orchestrated together. This is especially true if figures such as animals and people are to be drawn. Despite these limitations, some laser theatre systems still operate in a "live" manner as just described.

Fortunately there is a solution to these limitations. If the performance is completely "canned" on computer format tape, then only a relatively unskilled operator is required to load the tape and monitor the operation of the system (much as in a movie theatre). There are other advantages to a completely automated tape system:

1. Copies can be made and played at several locations at the same time.
2. A much larger investment in a sophisticated program can be justified, since once created, it is permanently re-

corded and used over and over.

3. Each color can be separately recorded and later combined with the other colors so that the programmer can concentrate on one color at a time.

4. The program can be recorded at a modest pace, then edited and speeded up to create a very complex program.

It is the last capability which enables fully animated motion such as dancing figures, flying dragons, and flowing water.

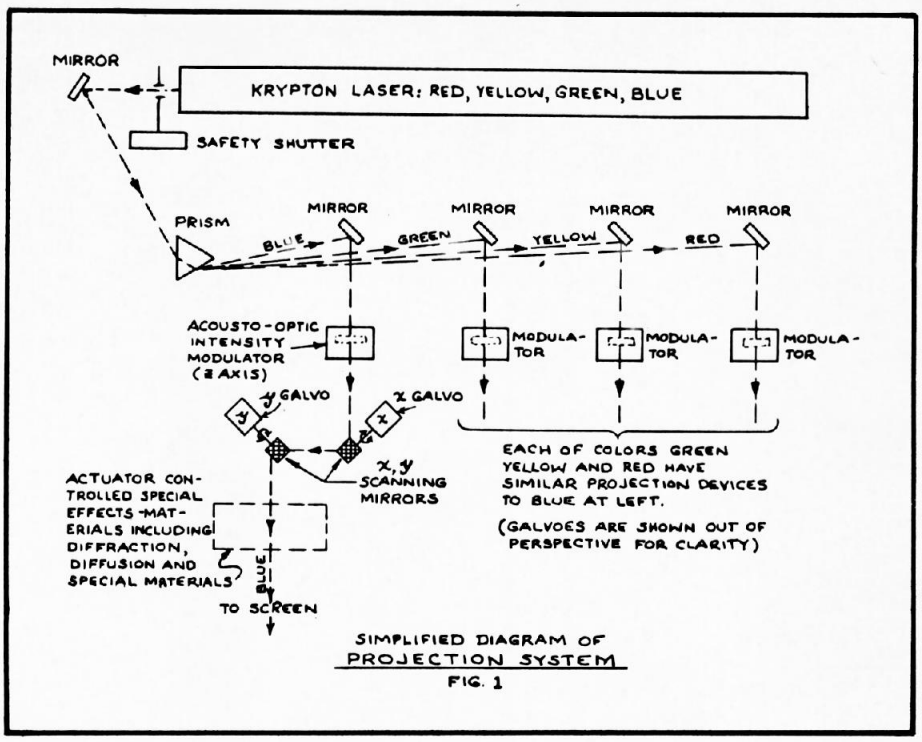
Lovelight: A Laser Musical

The first such fully automated "canned" laser theatre performance was the laser musical called "Lovelight." This performance opened February 4, 1977, at the Charles Hayden Planetarium of the Boston Museum of Science. It was so well received that a second projection system was built and a copy of the tape was used to put on another "Lovelight" performance at the Metropole Theatre in London. A scene from "Lovelight" was used as a cover story for the laser technical journal, "Laser Focus," in May 1977.

The performance is so completely automatic that even button-pushing functions are automated from a special computer control track on the tape. The performance content is also the most advanced. There are three themes of one act each — "Earthlight," "Spacelight," and "Lovelight." Each theme is developed with narration, specially recorded music and elaborate imagery. Each act has several scenes, each of which develops the theme of that act. The audience reaction was excellent with many sitting on the edge of their seats in awe during most of the 40-minute performance. As of January 1980, these systems are operating at the Metropole Disco in Berlin, West Germany.

The "Lovelight" project was undertaken by a joint venture called Interscan which has since been disbanded. Much of the optical equipment was specially designed by Jean Montagu, president of General Scanning. The image generating electronics and some of the other special equipment was designed by the author. A simplified block diagram of the system is seen in Figures 1 and 2.

Laser theatre systems will continue to advance. One of the primary limitations is the cost. Medium power lasers with at least moderate reliability and good color purity are still in the $15,000 to $20,000 range. By the time all the necessary electronic and optical equipment is added, the cost is in the $30,000 to $100,000 range for an excellent system,



SIMPLIFIED DIAGRAM OF PROJECTION SYSTEM
FIG. 1

fully automated, and with sufficient power for a medium size theatre. These are 1980 figures. The cost will lower in time with reductions in the cost of lasers and electronic computer equipment.

Government Regulation

One of the substantial costs is compliance with government paperwork requirements. Laser theatre equipment sold in the United States must be licensed by the Federal Bureau of Radiological Health. This license is actually called a "variance."

The light from a theatre type laser is bright enough to burn the sensitive retina of the eye if one were to look directly into the beam. Therefore, the light beam must not be directed into the audience either directly or by a mirror unless it is very fast moving or very weakened.

Unfortunately the science fiction writers use of the term "laser" has developed a Buck Rogers scare reputation completely beyond the real danger. About 20 people have been injured in the entire 20-year history of the laser, and only a small portion of these injuries could have been expected to have been prevented by government regulation. There is no well substantiated claim of injury by laser light in an entertainment situation. The electrical equipment used to operate the laser is much more likely to cause injury. There have been several people killed while working on the high power electrical power equipment for lasers. This is not a problem peculiar to lasers, but typical of any high power electrical circuits. Most injuries have been due to extreme carelessness or deliberate failure to follow reasonable well known precautions.

Despite this relative safety, the government has been spending millions of dollars on a regulatory system for lasers that places lasers under more severe restrictions than some very dangerous industrial and medical X-ray equipment. A license for a piece of laser theatre equipment can easily cost two or three thousand dollars in lawyers fees and professional engineers fees to prepare the required government paperwork.

Potential buyers of laser equipment should pay special attention to their suppliers' qualifications since there are all too many who are incompetent, unethical, or have a poor credit history. Some suppliers do not obtain competent technical assistance. Before contracting to buy laser system equipment, be sure it has been designed or reviewed by an approved Registered Professional Engineer and get his name and registration number. It is unlikely that a registered engineer would risk his license by putting his seal on a design which does not meet at least a minimum standard of safety and serviceability. Having equipment designed or approved by a Registered Professional Engineer may also help to convince the government regulatory authorities that the equipment is safe enough to protect the public.

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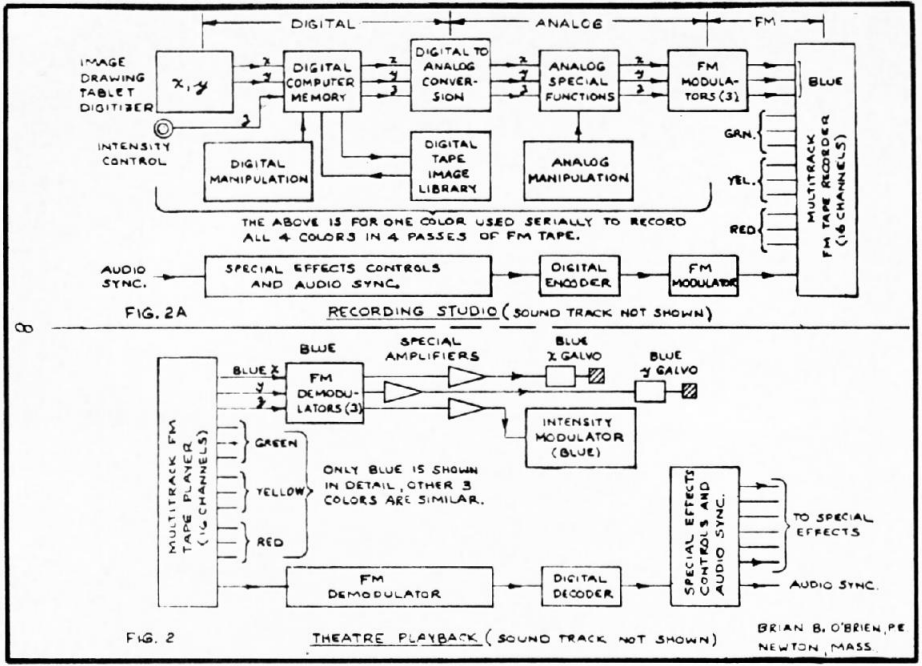

About the Author

Dr. Brian B. O'Brien, 15 County Dr., Weston, Mass., is a Registered Professional Engineer and independent contractor. He has had 16 years of experience in the invention, design and development management of high technology systems, products, instruments and mechanisms. Dr. O'Brian designed and supplied much of the laser theatre equipment described in his article. In addition, he is an attorney at law. He was recently admitted to the U.S. Supreme Court Bar and the Optical Society of America.

An excellent description of the best techniques to date: *Laser Art & Optical Transforms* by Thomas Kallart, Optosonic Press, Inc., P.O. Box 883, Ansonia Post Office, New York, NY 10023. □