February 7, 1962
File: 7143
JDM:psb-2

Technical Talk On Laser

Delivered By J. D. Myers on 2/6/62

Ever since a certain day in July a year and a half ago, the scientific literature has been full of articles written about a device called the laser. In fact, the subject has even reached the newspapers on several occasions, the culmination of which was a strip in the Sunday comic section a few weeks ago. Also, during this same year and a half, over 600 different organizations (of which CAL is one) have instituted research programs directly connected with this device. One company, Quantatron Inc. of Santa Monica, California, was born as a direct result of the laser. I might mention here that head man at Quantatron, Dr. T. H. Maiman, is the man who built and operated the first successful laser. At that time, he was working for Hughes Aircraft Company. All I've said so far is that there is a considerable amount of interest and money connected with a single device called the LASER. Well, what is this Laser, why is it so important, and what is it good for?

First of all, let's start with the name. Laser, L-A-S-E-R, stands for Light Amplification by Stimulated Emission of Radiation. One also hears the name optical maser applied to this device. We will stick to laser. Essentially, the laser is a device which absorbs energy in the form of multi-colored light and re-emits this energy in the form of an extremely pure single-colored beam of light which has certain unique features. In order to be specific, I am going to consider only the ruby laser. This is the original and best known laser. In fact, I am going to be even more specific and consider only the Cornell Aeronautical Laboratory Laser. This laser is composed of a ruby rod 3 inches long and 1/4 inch in diameter surrounded by four flash tubes similar to those used in photographic work. The ruby is silvered on both ends so that one end is totally reflecting and the other is about 95% reflecting allowing a small portion of the light to pass through. The flash tubes and the ruby are enclosed within a cylindrical reflector which serves to concentrate the light from the flash tubes on the ruby. Along with this ruby, flash tube and reflector combination, we also need a power supply which will put out the energy needed and a condenser bank to store the energy in. Now we are ready. We build up the energy in the condenser bank to a desired level and then discharge all of this energy through the flash tubes in about 1/2000 of a second. At an energy level of 1000 watt sec. this is equivalent to a power dissapation of about 26000 h.p. The flash tubes transform this energy into light composed of the entire color spectrum. The ruby in turn soaks up a certain amount of this energy by absorbing different portions of this color spectrum, principally the green and the ultra-violet portions. The ruby then, by means of a stimulated emission process emits this energy in the form of an extremely intense red beam of light of a single frequency. To better understand this process, imagine the following situation. We have marble-throwing machines that are throwing millions of marbles against a rainbow-colored wall. Let the stripes of the rainbow run parallel with the floor with the red band about the middle and the ultra-violet band near the ceiling. Imagine a long box, situated at the red band that catches a certain number of the marbles after they bounce off the wall. Now, the distance the marbles are from the floor determines their color. In other words, as they fall toward the floor, their color changes, going through all the colors of the rainbow corresponding to the stripes on the wall. The box is situated so that only the marbles that hit the wall at the green stripe and the ultra-violet strip bounce off and fall into the box. All the other marbles fall on the floor. Inside this box resides a little man called Herman. Herman doesn't like these marbles in his box and he runs back and fourth gathering them up and throwing them out his one window located in one end of the long box. Herman is a little strange, however, he can run at only one speed and thus has time to throw only about 5 - 10% of the marbles he has gathered through the window on each trip and he loses a few marbles when he bounces off the walls of his box. But, all in all he is pretty good, he gathers up all the marbles as they fall into the box and throws them out the window. Remember, the marbles are all red now because the box is situated at the red level of the wall.

Now let's draw the analogy, the marbles are photons, the marble-throwing machines are the flash tubes, the box plus wall combination is the ruby and Herman is the stimulated emission process. The blank end wall of the box represents the reflecting end of the ruby and the window represents the partially transmitting end. The red marbles that Herman throws out the window represent the laser beam.

Now we can answer the question, why is the laser so important. Its importance lies in the unique properties of this red beam of light. No other method is known by which one can produce light of this kind. First of all, the light is extremely intense. In short bursts, its power output reaches 10,000 watt/cm^2, or about 13 h.p. To produce an equivalent intensity at this same frequency or color by conventional means would require an atomic explosion. If desired, the laser's power can be focused to produce intense heating. For instance, one can focus the beam with a common lense so that it produces a spot of light only 1/100th of an inch in diameter. In this spot the laser beam will deliver power at a density of 200 million watts per sq. centimeter. Brief though the flash is, its power is thousands of times greater than could be obtained by focusing sunlight and is enough to melt or vaporize a spot on the surface of any material. Second, the light is directional. The sides of the beam are parallel to within less than one-half a degree; at lower power, the divergence drops to about 1/20 of a degree. The latter corresponds to a spread of only five feet per mile, and it could be reduced by running the beam through a telescope backward. With telescopic de-magnification it should not be difficult to project on the moon a spot of light only two miles in diameter. The third and most unique aspect of this red beam of light is that it is coherent in both space and time. Before the laser, the earth had never known coherent light. By coherent light, I mean that the light is in phase throughout the pulse. For a better explanation, let's return to Herman and his red marbles. You remember Herman is throwing these marbles, sometimes two, three, or more at a time out the window. However, Herman is not just an ordinary marble thrower. He throws his marbles only in one direction, all with the same speed plus one other property. Herman has an inherent timing mechanism; he throws at distinct intervals so that each marble he throws has an integral distance in space between itself and the marble in front and behind. This is what is meant by coherence in time. Coherence in space can be represented by the fact that Herman can throw more than one marble at a time. Thus, we have rows of marbles proceeding at definite intervals and as a result, the light can be modulated in much the same way as radio waves can. Ordinary light is of random phase and cannot be modulated. Therefore, we can now transmit T. V. signals by means of light waves. Also due to the high frequency of light, the information carrying capacity of presently available communication channels will be effectively doubled by the addition of optical communication.

The laser is such a radically new kind of light source that it taxes the imagination to canvass its possible applications. Message-carrying, of course, is the most obvious use and the one that is receiving the most technological attention. It has been suggested that the laser could be used to establish contact with life on other planets out to a range of ten to twenty light years. In such a long range communication system, the directional qualities of the beam will permit energy to be concentrated on the target, while the spectral purity will help to distinguish the signal from the light background. These same features are also useful in radar. There has also been much interest in the use of blue-green lasers, not yet developed, for underseas radar and communications.

There will certainly be other uses for lasers. The very intense heat spot produced by focusing a laser might be used for fabricating all sorts of electronic devices. For instance, it would be possible to weld a small joint after the joint has been sealed in a glass tube. The medical profession has already used the laser to weld severed optical nerves together and as a precision cutting instrument. One of the more exotic suggestions for the use of a laser is to use it as a weapon. It is reported in the literature that work is under way to develop a laser capable of destroying or disabeling intercontinental ballistic missiles. The list of potential applications of the laser could be extended almost indefinitely. With the advent of the laser, man's control of light has reached an entirely new level. Indeed, one of the most exciting prospects for workers in the field is that this new order of control will open up uses for light that are as yet undreamed of.

To give you a sample of what the laser beam looks like, I brought the Cornell Aeronautical Laboratory's laser with me.

John D. Myers

John D. Myers