The Light Laser Power for

By Howard Simons
Staff Reporter

SCIENTISTS HAVE tripped the light fantastic. They have learned how to organize light waves into energy beams that can reach the stars or create temperatures hotter than the sun's surface.

These beams have already illuminated the moon and pierced flesh and steel and diamonds.

Nothing in recent memory has so excited physicists, engineers, industrial managers and military planners as has the potential of these extraordinary beams of light called lasers (for the process of light amplification by stimulated radiation emission that produces them).

Buck Rogers Atmosphere

SOME OF THE potential uses for lasers foreseen by imaginative minds are so fantastic that even normally conservative scientists have had to reach into fiction to characterize the promise of this infant technology.

Thus, in talking of constructive applications for the laser it is referred to as a modern "Aladdin's Lamp." And where destructive applications are proposed, the term heard most often is "Buck Rogers Death Ray."

Not all scientists think that lasers will fulfill the many promises assigned to them. For example, there is a healthy skepticism of the notion that lasers will prove to be the "ultimate" or "all-out" weapon, or indeed, an effective weapon at all.

But if only a few of the potential uses for the laser are realized it will constitute a major scientific and technological revolution. It is for this reason that hundreds of American companies, large and small, have plunged into laser research and development efforts. No one wants to be left behind in what is now certain to become a new multibillion dollar industry affecting such areas as communications, space, medicine, chemistry, data processing and defense.

The laser market last year was $20 million. This year the investment will reach $50 million. And conservative estimates indicate a further climb from $100 million in 1964 to more than $1 billion by 1970.

Much of the money is coming from the Defense Department. The military's interest and investment, although shrouded in secrecy, is known to be substantial.

The Air Force, for example, is exploring the possibility that laser beams sweeping the heavens like searchlights could knock down hostile ballistic missiles. Some enthusiasts claim that laser beams would be able to destroy missiles by the hundred, taking only hundredths of a second—per kill.

For its part, the Army is reported studying the practicality of a laser "death ray" that could be shot from the hip like a .45 caliber pistol to kill silently and stealthily.

Whether these awesome weapons will ever be perfected is subject to considerable technical debate. But it is already clear that the effort to perfect them—both by the United States and Soviet weapons scientists—is under way.

More immediately feasible and far less terrifying are the peaceful uses to which lasers are likely to be put.

The greatest benefactor will probably be communications. Lasers open hitherto untapped frequency ranges. It is theoretically possible, therefore, for a laser beam to carry 100 million telephone calls simultaneously or 10 million television channels. Today's transatlantic cable can carry only 100 telephone calls at once. Scientists at Bell Telephone Laboratories have already succeeded in communicating across 25 miles using a primitive laser.

Limitations and Problems

IT IS DOUBTFUL, however, that laser beams will be used as naked messengers for carrying earthbound communications. They are limited by atmospheric effects, such as clouds, which low energy laser beams cannot penetrate. And, like the microwaves that carry today's TV and FM radio, laser beams do not bend. Transmission must be line-of-sight, a serious limitation in a round world.

These limitations are far from fatal. Scientists are already talking about sending their special light beams through evacuated pipes and using mirrors to bend them to man's desire.

There are still other problems to be overcome before communication by laser becomes a reality. These include finding efficient and cheap methods to modulate light beams, that is, to change them into message carriers, as well as to demodulate the beams, or pick out the message that is received. Laser advocates do not minimize the seriousness of effective solution to these challenges, but none will concede they are insoluble.

Indeed, rarely a week passes that some advance in laser technology is not reported, so fast has the pace of development become.

Laser use in space communications is another matter. The vacuum of space allows laser beams to move at the speed of light (approximately 186,000 miles per second) for unlimited distances. This fact has already stirred hopes that laser beams can be used to "broadcast" to other civilizations that may exist in the universe.

Closer to the earth, laser beams could serve to transmit messages between earthbound stations and manned spacecraft; from one orbiting communications satellite to another; and between two or more space vehicles speeding through the heavens in interplanetary flight.

There are other space applications, too. Experts have suggested that such beams could apply steering pressures to space vehicles. Laser beams seem also probable energy transporters for recharging failing power supplies aboard a vehicle in space or for literally beaming energy to remote sites on the earth, such as radar stations.

In medicine, a laser has already been used at Columbia-Presbyterian Hospital in New York City to "spot-weld" a detached human eye retina. Similar "knifeless" surgical techniques now look promising for brain and nerve operations.

In chemistry, laser beams are being talked about for creating chemical reactions never before possible, as well as for providing a tool to tamper with a single atom in a chemical molecule.

In metallurgy, laser beams have already demonstrated their promise for cutting, welding and piercing materials such as tungsten, steel and diamonds.

And as a tool for scientific research, the laser appears limited only by the scientist's imagination. For example, one possibility suggested by Peter Franken of the University of Michigan would be to use a laser beam to attempt the start of a thermonuclear reaction.

The most dramatic demonstration to date of what a laser can do came on the memorable evening of May 9 when a team of researchers from Massachusetts Institute of Technology and Raytheon Co. shot laser beams at the moon and detected their reflections on earth. Each of the 13 short bursts of a pencil thin red beam made the half-million mile round-trip journey in 2½ seconds. Man had, for the first time, illuminated

Fantastic War and Peace

a celestial body.

Another dramatic demonstration—of laser utility will come sometime this spring when National Aeronautics and Space Administration scientists from Goddard Space Flight Center, Greenbelt, Md., attempt to track a satellite placed into orbit using a laser beam.

And what is this light fantastic?

Basically, it is electromagnetic energy made to do man's bidding according to the rules of quantum theory whose basic process was first postulated by Einstein 40 years ago.

Electromagnetic radiation is made up of tiny packets of pure energy called photons. It comes naturally from the sun in the form of heat and light. Light waves and radio waves are electromagnetic energy, as are microwaves, infrared, ultra-violet, X-rays and gamma rays.

To understand the laser, it is first necessary to discuss briefly the maser (Microwave Amplification by Stimulated Emission of Radiation) for masers and lasers are closely related. Both lasers (concentrated light waves) and masers (concentrated microwaves) are electromagnetic energy differing only in their frequency or wavelength.

Start With Masers

IT WAS IN 1951 that the seed for maser growth was sown. Charles H. Townes, then a young physics professor from Columbia University, sat on a bench in Franklin Park here and mused about the quantum theory of physics. Townes, now Provost of M. I. T., was seeking a way to make microwaves more useful. The trick, he thought, would be to tinker with atoms in such a way so as to be able to harness the energy they emitted normally.

Townes pursued his idea and was successful. In 1954 he and his coworkers demonstrated that it was possible to force atoms to emit a stable, coherent level of energy. Masers were soon put to work at a variety of scientific tasks, most notably in enhancing the sensitivity of radio telescopes. More recently, masers became more familiar as the key component of ground receivers used in the Telstar broadcasts between the United States and Europe.

As a result of his maser work, Townes, together with his brother-in-law, Arthur L. Schawlow, then with Bell Telephone Laboratories, sought to apply a similar technique to the vast unused light portion of the electromagnetic spectrum. In mid-1960, Theodore H. Maiman, then of Hughes Aircraft, demonstrated the first laser, a ruby crystal device, which, like the maser, could harness energy waves to work for man.

Excitable Electrons

THE KEY TO masers and lasers lies in the scientist's new found ability to manipulate the normal behavior patterns of electrons and atoms.

Essentially, electrons surrounding the heart of an atom will become excited when they absorb energy. Abhorring excitement, however, the electrons rid themselves of the excess energy in a rush.

If left alone, the electrons emit the excess energy in a helter-skelter fashion. Ordinary light, such as that from the sun or an incandescent bulb, behaves this way. Electromagnetic energy tumbles forth in these cases in the form of light at different times and in waves that are out of step or phase. It is said to be incoherent light.

By teasing or stimulating this energy emission the electrons can be induced to give forth light before they would do so spontaneously. This causes a chain reaction of stimulated emissions, amplifying and re-amplifying the wave that is generated.

Because of the rules of quantum theory, the energy beam that results will be waves of the same frequency and phase, and will travel in the same direction as the stimulating field.

This complicated process can be likened to stimulating everyone in a random crowd on a football field after a game to line up and march in the same direction and in step.

The effect of stimulated emission of radiation in the visible spectrum is to create a powerful, pencil-thin beam characterized by narrow spectral width, high directionality and very high intensities. This is called coherent light. It is what Townes and Schawlow predicted and what has been achieved with lasers.

Energy From a Ruby

THE VERY FIRST lasers were called ruby optical masers (optical maser and laser are synonymous). It works, in essence, this way:

A synthetic ruby rod about a quarter of an inch in diameter and up to six inches long is heavily silvered at one end and much less so at the other. The rod is then wrapped in a helical photo-flash somewhat like the flash used by photographers.

When the flash is fired, light energy is fed into the rod. Scientists call this optical pumping. The energy from the flash causes a few of the chromium atoms present as an impurity in synthetic ruby to become highly excited. As these atoms fall back to normalcy they emit radiation in the form of light. This radiation, in turn, induces or stimulates other chromium atoms to become highly excited and emit energy. The energy so produced is bounced between the mirrored ends of the ruby rod and greatly amplified.

When the build-up becomes great enough the radiation is emitted as an intense red light through the less silvered end of the rod. What emerges, therefore, is a coherent, highly directional, highly intense beam of energy.

Ruby lasers are still being built and used. But in the two years since Maiman first demonstrated the ruby laser a host of innovations have been made. Solids other than rubies have been employed. Lasers which were once limited to sending forth light in short bursts have now been complemented with lasers capable of producing continuous beams. Gas lasers have been developed that have different advantages from those of solid lasers.

For example, a helium-neon gas laser operated by Westinghouse scientists has a beam divergence of only 20 seconds of arc. What this means is that a typical laser of this variety whose beam is less than an inch in diameter at the source would produce a spot 20 miles in diameter on the moon. In contrast, the spot size from conventional radar systems would probably engulf the moon's face.

Development Ahead

SCIENTISTS AND engineers are also finding ways to make lasers work better. Two weeks ago, on the same day, General Electric and IBM announced new types of lasers in which coherent light is generated directly by passing an electric current through a semiconductor crystal rather than by using a flash of light. The implication of these coincidental discoveries, the companies said, is that the chief obstacle to the use of lasers for communications has been overcome.

In spite of the long strides in laser development, coherent light is not out of the dark just yet. A major problem is to make today's grossly inefficient lasers more efficient. Lasers do not create power, they concentrate it. Power, therefore, must be supplied to a laser.

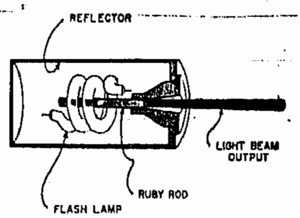
Schawlow, for example, has expressed doubt that lasers will ever become efficient weapons because it would require "practically the Nation's entire power supply" to pump up a laser for destroying a single ballistic missile.

Others disagree. If, they say, one wanted to melt a ballistic missile warhead with a laser beam it would require about 100 million megawatts or more power than exists in the U. S. at any one time. But, they add, this is not the way a laser anti-ballistic missile weapon will work. What will happen is that the laser beam will be fired in short bursts at its peak energy to knock holes in warheads and destroy them.

Schawlow has also said that a coating could protect missiles. "Negative," said one expert. "Protection might be possible," the expert said, "by wrapping wet rags around a warhead and keeping them wet." But this technique, the expert added wryly, "is a difficult one to achieve."

Weapons of the Future

NO ONE HAS said how feasible a laser "death ray" would be. But one source suggested that it will not be able to disintegrate humans as did Buck Rogers' ray gun. Instead, it could be used to burn or blind an enemy. That lasers have this capability is already well known to researchers, who wear special goggles and turn completely away from high energy beams.



This is a sketch of basic laser device.

One researcher, whose eyes inadvertentally caught a laser beam from a mile away suffered eye damage.

While the military pursues its laser weapons research, it is also developing a host of laser field equipment. There is reason to believe that by next year a laser range finder for tanks will be produced. When coupled with a tank's cannon, the laser would determine the range of an enemy vehicle two miles away in a few hundred thousandths of a second and make the first shot a hit. Also coming are highly accurate laser radars and laser beams for military communications that cannot be intercepted.

Speaking of lasers recently, Air Force Gen. Bernard A. Schriever noted that this "revolutionary discovery may prove to be even more important to the world than the development of the ballistic missile, the discovery of the transistor, or the reality of Telstar."

Russian Efforts

SCHRIEVER WENT ON to report what he termed "ample evidence" that Soviet Russia is just as hard at work in laser research as is the United States.

"The Soviets," he said, "claim to have discovered the laser in 1951, and in 1959 they awarded the Lenin prize to the authors of important Russian papers on lasers . . . It appears that Soviet efforts to date have roughly paralleled those of the United States. But the Soviets may secretly have specific laser applications under strenuous development. They have always been quick to make military applications of their scientific advances."

If one listens to the most ardent laser enthusiasts he will hear that if given the green light—which means unlimited money, manpower and material—it would be possible to develop both satellite-based and ground-based laser weapons before decade's end. Those less enthusiastic are proportionately less optimistic.

But when and if such sinister weapons are developed they will negate the Biblical exhortation of John (III: 20) that "Everyone that doeth evil hateth the light."