HIGH-ENERGY LASER WEAPONS

Development of 'death ray' weapons is accelerating, but critics argue that even the research is a waste of time

BY JOHN H. DOUGLAS

High-energy laser weapons, emitting bursts of light powerful enough to damage enemy missiles or satellites, may soon become the most controversial new weapons system since the antiballistic missile (ABM), and for many of the same reasons.

Lasers powerful enough for the task have already been demonstrated. Mobile "test beds" carrying these devices into the field are being used by the various armed services, and defense analysts are considering which full-scale military applications should be developed first.

But a growing number of critics charge that the ultimate effect of laser weapons can only be to destabilize the arms race. They say that the costs of such systems will outweigh benefits for the foreseeable future and that undue secrecy has been used to stifle public debate of the issues.

Because of the secrecy surrounding laser weapons development since its inception, the capability of high-energy lasers has progressed faster than most people realize. The critical breakthrough came in 1968, with the invention at the Avco Everett Research Laboratory of a gas dynamic laser (GDL). This marked the first time that the thermal energy of burning fuel could be used directly to produce laser light, without the intermediate step of conversion to electricity.

Heated carbon dioxide from a jet engine was driven into a chamber where its molecules lost their energy to form a beam of infrared laser light with a wavelength of 10.6 microns. The laser power thus generated, 60 kilowatts, was hundreds of times greater than that of previous units—as if all the light used to illuminate a football field were riding on one thin beam.

Three closely related, but separately funded and managed, lines of research then quickly formed. One line produced a new generation of cutting and welding instruments for industry, using laser light of about 20 kilowatts. Another is still trying to perfect a laser configuration to explode tiny hydrogen pellets to produce fusion energy. The third line of research, weapons development, was almost immediately submerged in a quagmire of unprecedented secrecy, under the code-name "Eighth Card."

Eighth Card was headquartered at Kirtland Air Force Base near Albuquerque, N.M. Though few people supposedly knew what was going on there, a leading trade publication, LASER FOCUS, reported in 1972 that a 60-kilowatt gas dynamic laser was being used to set fire to wooden planks two miles away. Tracking was good enough to puncture an object the size of a playing card waving at the end of a 20-foot pole one mile away. And eventually the laser was reported to be firing successfully at unmanned aircraft.

Further publicity arose when low-energy lasers were used to guide so-called "smart bombs" precisely to their targets in Vietnam, and there was published speculation about the development of a laser "eye-popper" to blind antiaircraft crews. But generally the field remained in a peremptory obscurity.

Already, potential tactical laser weapons are being field-tested by each of the three services.

In 1974, Richard L. Garwin of IBM's Thomas J. Watson Research Center held a seminar at which he presented what is still perhaps the most complete nonclassified discussion of the potentials and limitations of high-energy laser weapons. Having earlier emerged as one of the most influential critics of the ABM, Garwin delivered a devastating critique of the developing laser weapons program.

As antiaircraft devices, he concluded, lasers would be far more costly than missiles. All applications in the atmosphere would be subject to a variety of disturbances and would face relatively simple countermeasures. As a space-based defense system, lasers fail "because neither the U.S. nor the USSR would tolerate the other to build gradually such a capability."

Atmospheric propagation difficulties, as well as other aspects of the current laser weapons research program, were summarized in a series of articles by Philip J. Klass in AVIATION WEEK & SPACE TECHNOLOGY in late 1975 (SN: 9/20/75, p. 191). Light beams traveling through the atmosphere are subject to a variety of disturbances: absorption by molecules similar to those doing the lasing, scattering by aerosol particles diffraction due to turbulence, and "thermal blooming"—a picturesque term for the defocusing of a beam that occurs as air heats up along its path.

To attack these problems, a new line of research called COAT (for Coherent Optical Adaptive Technique) has been established to test ways of shaping beams and pulses to minimize interference. Also, new lasers are being developed to provide different power sources and better frequencies for atmospheric transmission. Perhaps the most important of these is the so-called "chemical laser," in which energy released by various violently reacting chemicals can be used to generate different wavelengths of light.

Despite advances in atmospheric propagation, however, the best environment for operating high-powered lasers is in the vacuum of space, and a shift of emphasis toward space applications is reflected in this year's budget message from the Defense Department's Advanced Research Projects Agency. George H. Heilmeier, ARPA director, told Congress, "The high-energy chemical laser, because of its higher mass efficiency and ability to produce laser power [without] a large electrical power supply, could lead to a device whose size and weight would enable it to be used in space. We pioneered high-energy chemical laser technology and are now exploring the technical problems of extending the concept to operation in a space environment."

Two problems immediately arise. The technical problem is that chemical lasers use very corrosive, hard to handle ingredients. They involve more complex reactions than gas dynamic lasers and are less well understood. The other difficulty is one of policy—the United States has already promised in the SALT I agreements not to "develop, test, or deploy" an air-based or space-based ABM system, including any system "based on other physical principles [e.g. lasers] . . . capable of substituting" in an ABM system.

Thus three critical questions face the United States as it begins to develop high-energy laser weapons: Which of these weapons are feasible and cost-effective? Which are legal? And which are the

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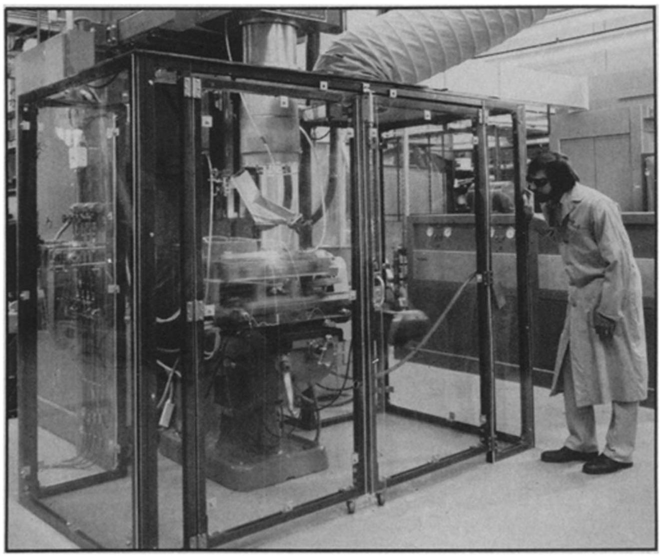
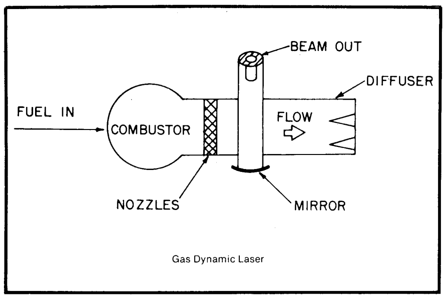


Metal working by high-energy industrial laser. An Air Force NKC-135 outfitted with laser to test aircraft protection capabilities. Army's Mobile Test Unit with laser-beam turret on top.

Soviet Union likely to make?

The feasibility question depends, in part, on details of the present program that remain classified, but a rough approximation can be formed by using Garwin's equations to analyze what information is available. Damage to a metal surface depends both on how much energy hits it and how quickly the energy arrives. (Energy is usually measured in joules—a laser with the *power* of one watt emits in one second the *energy* of one joule.) Since a short burst of energy tends to do the most damage, let us consider a pulse of laser light 10 nanoseconds long, with a wavelength of 10.6 microns, and propagating in space, away from atmospheric interference. For a small area of an aluminum target to receive enough energy to puncture it, roughly 100 joules per square centimeter, a laser 10 kilometers away would have to emit a pulse of 100 kilojoules in a beam initially one meter in diameter. (For comparison, a hand grenade gives off about 300 kilojoules of energy.)

If anyone has actually built a laser that big they've kept very quiet about it. In the laser-fusion program, a 100 kilojoule pulsed laser is not expected for a few more years. Also, a water-cooled copper mirror a meter across would be pushing the state of the art. If the light were to be propagated in the atmosphere, the mirror would also have to be deformable to shape the emerging pulse so as to minimize interference, a very expensive proposition. Finally, one can also begin to appreciate the inherent size of these weapons—totally aside from the weight of the mechanical equipment, at least 2,000 liters of fuel would be needed just to create that one 100 kilojoule pulse. Obviously, Buck Rogers's hand-held ray guns are impossible with today's technology!



Gas Dynamic Laser

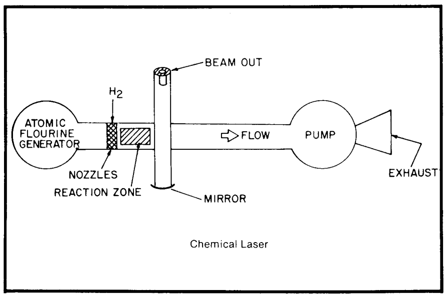
These rough calculations support the general conclusions various experts have told Science News concerning high-energy laser weapons: Massive strategic laser systems capable of knocking down an intercontinental ballistic missile by doing structural damage are far in the future and require further technological breakthroughs. Tactical systems for use against homing missiles with delicate sensors may become feasible fairly soon, but their economics are unclear. Devices *capable* of blinding spy satellites as they pass overhead probably already exist, but the motivation to deploy them is small. Laser weapons for use against people also seem possible now, but except for airborne "eye-poppers," their development seems unlikely for the moment—they would be heavier, more expensive and more vulnerable than the guns they would replace.

Even within these limitations, however, high-energy laser weapons may exert profound influence on the arms race. The authoritative *Jane's Weapons Systems* this year warns of a "superscientific struggle to be first with a practical laser weapon," raging between the United States and the Soviet Union. In that struggle, *Jane's* says, the United States is probably "a little further ahead."

While playing down the "arms race" aspect, Defense Department officials concede that the Soviets have launched a major effort in the laser weapons area, including some approaches not yet being pursued by the United States. Visiting American scientists have found that each of the Russian physicists who shared the Nobel Prize for inventing the laser has assembled a staff of several hundred people to work in laser physics and that they particularly excel in advanced theoretical work, sometimes predicting a phenomenon that is discovered only later in the United States, through experiment. It is almost impossible, however, to tell how much of this work is directly defense-related.

Meanwhile, the American effort is growing rapidly. For fiscal 1977, the Defense Department is requesting $187.1 million for its high-energy laser program, a 20 percent increase over the present fiscal year. The uniqueness of the program was underscored when Malcolm R. Currie, director of Defense Research and Engineering, announced that his office would take "a much stronger coordination role" than is normal for such speculative projects. White Sands Missile Range in New Mexico has been designated as the site for a triservice laser test facility, and construction funds will be requested in the next budget message.

Already, potential tactical laser weapons are being field-tested by each of the three services. The Air Force has installed a relatively lightweight (several tons) gas dynamic laser in a Boeing NKC-135 jet.

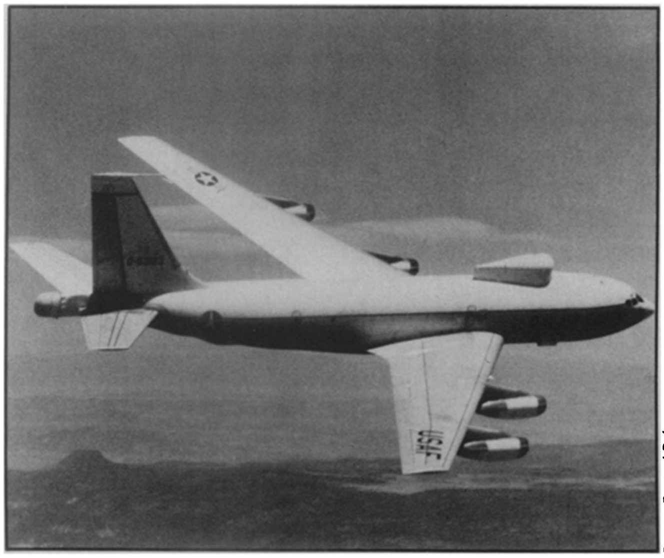


Chemical Laser

Since the GDL's 10.6 micron light does not travel as well in the vapor-laden air near the ocean surface, the Navy is working with various chemical lasers in hopes of finding one with a more suitable wavelength. The Army has mounted a 10- to 15-kilowatt laser on an amphibious landing vehicle and dubbed it the Laser Mobile Test Unit. And as the advanced research arm of the Defense Department, ARPA is concentrating on more speculative projects, such as X-ray lasers and chemical lasers for space application.

The question of space applications comes up again and again. Not only do all laser wavelengths travel better in space—losing energy density only through unavoidable beam spreading—but some particularly destructive wavelengths, such as those in the ultraviolet, can only propagate in a vacuum. Chemical lasers, which may one day be very light and efficient, work best in space. And satellites make very tempting targets, since by their nature, they must be lightweight and thus relatively fragile.

The number of strategically important satellites is constantly increasing. Current spy satellites are credited with helping stabilize the arms race by preventing un-



Photos: Dept. of Defense

pleasant surprises, and their use by several countries is sure to increase. Instant global communication is a growing necessity for military as well as civilian use, and the Air Force expects to launch in 1979 a new satellite capable of handling an encyclopedia's worth of information each second. By 1984, a satellite-based navigation system will allow American military vehicles of all sorts to locate their position within a few tens of feet.

While it would violate the SALT I agreement to launch a satellite-based antiballistic missile laser, one that could attack some military satellites *would* be permitted (so long as it was not "capable of substituting" for an ABM). Disarmament officials told SCIENCE NEWS that testing such systems *on land* would also be legal, but as one put it, "If somebody gets a system that really works, there will be pressure to change the treaty." Others argue that even if developed, neither the United States nor the Soviet Union would hurry to deploy "killer satellites" because both sides benefit from the existing detente in space.

Two small shadows mar that optimistic view. First, Malcolm Currie has confirmed reports that the Russians are resuming satellite shoot-down tests, though not necessarily with lasers. Second, late in 1975, American early-warning satellites were blinded several times as they passed over the Soviet Union. Such satellites are not covered by international agreement and there was immediate speculation that the blinding was being done by a Soviet laser. An explanation was eventually given that the cause of interference was infrared radiation coming from a gas pipeline fire; but critics remain unconvinced, saying that even if true, this explanation still shows the dangerous vulnerability of the satellites. Treaties and incidents aside, Currie admits, "The question of warfare in space or space as a sanctuary inevitably will arise."

The debate over high-energy laser weapons, though generally submerged, is thus developing along the following lines. Officially, the Defense Department views the issue as one of maintaining a "logical exploration of this technology"—making an investment whose benefits can now only dimly be perceived. Critics retort that most practical applications can already be

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ruled out, either because of expense or sheer undesirability. Garwin told SCIENCE NEWS he also sees the funding for the related research as being "driven purely by the technologists who have oversold the idea," while over-classification is being used to squelch criticism and comparative cost estimates.

A provocative middle view is provided by a congressional laser expert. He agrees that ARPA is "enamored with the sound of their own technology," and compared to laser weapons, "almost anything will be a lot cheaper initially." But the cost of the Defense Department's program, he says, may someday be paid back just by the civilian spinoffs. One of the most important of these is likely to be photochemistry, where powerful lasers will be used to sustain chemical reactions that would be impossible to achieve any other way. Such reactions could lead to cheaper ways of separating fissionable uranium or producing new aerospace materials.

A more complete list of possible spinoffs, including laser-propelled rockets, is the subject of the Army's first technology assessment (Publication AD-A010 100/6WH, vol. 1, available for $4.25 from the National Technical Information Service, Springfield, Va. 22161). Even this Army study noted that "inordinate secrecy" may have proven counterproductive and that "the extent to which a freer information interchange can be achieved will influence the overall rate of progress in the field." Moreover, "basic research in the laser field has been hampered by a relative lethargy on the part of both government and industry to move aggressively to seek breakthroughs outside the weapons and fusion areas."

As if current technology were not enough to spark a controversy, three new developments promise to revolutionize the laser field again, though their possible military application would come only after several more years. At Stanford University a new kind of laser has been created using the interaction of an electron beam with a magnetic field. This research promises to lead to development of the first really high power tunable laser, a key to photochemistry. Recently, NASA announced successful completion of a major step toward development of a "self-critical" laser, which would take its energy directly from the nuclear reaction in a gas-core reactor (SN: 5/15/76, p. 309). Even a small reactor might eventually be able to produce a whopping 20 megawatt laser beam—a thousand times more powerful than today's commercial units.

Most speculative of all are the extremely short wavelength lasers—those emitting X-rays and gamma rays. Soviet scientists have pioneered research in this area for some years (SN: 1/5/74, p. 8). Not only could the civilian spinoffs of these lasers be very important, but as weapons, nothing could withstand them.

The next two or three years are expected to be crucial in the decision-making process concerning military applications for high-energy lasers. And as the congressional expert told SCIENCE NEWS, "It is time this issue was debated outside the government's inner circles. The implications [of laser weapons] are too significant to be decided in secret." ☐