example, high repetition rate xrasers could be powered by existing types of excimer lasers, which have demonstrated refire rates of a thousand single pulse bursts per second. Other single burst varieties could be powered by small chemical explosive charges.

The net result is that xrasers could be deployed on the battlefield to provide a robust defense against the entire range of offensive munitions—missiles, aircraft, rockets, artillary shells etc.

Contrary to the claims of missile defense critics, it is not impossible to utilize xraser beams within the atmosphere. In the first place, the physics of high power-density xraser beams is only just now beginning to be explored in great secrecy. Indications, though, do exist that concepts have been developed for achieving atmospheric propagation of xraser beams. And it should be remembered that it was only a few months ago that SDI critics claimed that it was fundamentally impossible to shoot charged particle beams on a straight path through any part of the atmosphere. Now, scientists at both Los Alamos and Livermore have experimentally demonstrated that this can be done through the upper part of the atmosphere—the point being that methods could be developed for basing xrasers on the ground for defense against anything that moves.

As a weapon the xraser has a virtually unlimited firepower capability, though at the same time it is highly selective and not a weapon capable of mass destruction. To be utilized effectively the xraser must be focused down to very small areas—a few square meters at most and millimeters in most cases. Therefore it is only capable of destroying specific targets. But within that limitation the xraser is all-powerful.

The primary means of target destruction with the xraser is that of shock kill where the powerful x-ray pulse produces a shock wave on the surface of the target which punches a hole through it. But the xraser pulse is also capable of producing more complicated types of electronic kills at even very low power levels of beam deposition, such as system generated electromagnetic pulses. At the other end of the scale, highly focused xraser beams can produce nuclear disintegration of the target, even before the shock wave has time to punch a hole through it.

In this case the high power beam is deposited within an extremely thin micron layer of the target surface. Because the x-rays knock out electrons from this layer, this leads to the generation of huge electric fields within this layer. And the electric field accelerates ions within the layer to energies otherwise only produced in charged particle accelerators several miles long. (There already exist designs for miniature high energy particle accelerators based on xrasers.) These charged particles are capable of penetrating deep within the target and generating showers of nuclear reactions. Electronics, nuclear fuels and chemical explosives are particularly vulnerable to high energy charged particles. As a result, nuclear disintegration can be the most efficient and effective means to disable military hardware and weapons.

Japan moves to fusion forefront

by Charles B. Stevens

As I reported in *EIR*'s Oct. 4 issue, there is no barrier to achieving fusion power as an industrial source of energy, except money. The Reagan administration has cut the budget for inertial confinement fusion by 50%, despite criticism by the National Academy of Sciences.

Despite the excellent record of the program in achieving its technical goals, the program suffers under the restriction of being classified top secret; and, because of congressional chiseling on the budget for the Strategic Defense Initiative, funds are being vacuumed into that program from every other ongoing program.

This has also affected the magnetic fusion program, which is on the verge of significant breakthrough. Over the past two years, magnetic fusion has seen the initiation of reactor-scale experiments, such as the Princeton TFTR, the Japanese JT-60, and the European JET. The Alcator C at MIT has demonstrated the plasma-density/energy-confinement product needed for net energy generation. Confinements of hot fusion plasmas by magnetic fields has been improved by a factor of 10.

This notwithstanding, an adequately funded laser (inertial-confinement) fusion program probably offers the greatest chance for breakthrough at this time.

Laser fusion energy

Ironically, the other great handicap of the program identified by the National Academy of Sciences, the restrictions due to top-secret classification, appear to have little point, since the Japanese inertial-confinement program is a parallel program that is entirely open.

In laser, or inertial confinement fusion, the laser focuses intense pulses of radiation upon minute target-pellets of hydrogen. There are two basic approaches to depositing energy on the target. One deposits the beam energy directly upon the target surface. This leads to what is called an ablative implosion, which compresses the target.

In the other, the energy is deposited within a chamber, where it is converted into higher frequency forms of energy such as x-rays. The target is then caused to implode, indirectly, by the emission of these x-rays. While possibly necessitating greater amounts of total beam energy, the indirect-drive approach has been credited with having better characteristics in terms of producing compression.

For net energy generation, the total energy invested in running the laser, the laser pulse, etc., must be more than matched by the total fusion energy output. Generally, this output is measured as laser fusion gain. That gain is the ratio of the fusion energy ouput to the laser energy input. Implosions of fusion fuels which are symmetric and isentropic appear to have greater hydrodynamic efficiencies. This method is favored by the Japanese.

The Japanese program

In the United States, the Los Alamos laboratory's Antares carbon-dioxide laser fusion research program has been cut off from funding, bringing CO_2 laser fusion research to an apparently abrupt halt—at least in the public domain. Many U.S. scientists have suggested that CO_2 lasers could overcome certain disadvantages by switching from direct to indirect drive configurations. But the only program known to be carrying out such an effort now, is that of the Institute for Laser Engineering at Osaka University in Japan.

One practical configuration for indirect drive is the Osaka Cannonball design. Laser beams are directed through small openings in a hollow chamber. The laser light thus becomes trapped within the chamber. The fusion target to be imploded is placed at the center of the chamber.

This configuration has several general advantages over direct drive ablation targets. High absorption and high hydrodynamic efficiency can be achieved because of the confinement of the energy in the cavity. High uniformity in implosion of the fusion fuel is also attained since the multiple-reflection effect of the trapped laser light between the fuel target surface and the inner wall of the Cannonball leads to a smooth distribution of laser energy within the cavity.

The problem found with the relatively long wave-length CO_2 laser at Los Alamos laboratory, where the direct drive configuration was used, should not present itself with the Cannonball. With direct drive, what are called superthermal, extremely "hot" electrons are generated. These can penetrate into the interior of the fusion fuel. When this occurs, the target is preheated and it is impossible to compress it isentropically to the high densities needed to produce fusion. The Cannonball provides the means of controlling the hot electron spectrum through the design of its cavity structure.

Experiments which are reported to have taken place in Osaka on the LEKKO II CO_2 laser, utilized planar Cannonball targets. Single-sided irradiation of the planar target was effected with 30 to 100 joule nanosecond or less laser pulses. The focal spot size was 180 microns in diameter. The beam was directed at an angle of 27 degrees with respect to the normal of the planar target.

In this test, the planar targets did not contain fusion fuel pellets. Each target consisted of three parts, a front disk to act as a tamper, a cavity wall, and a rear foil. The foil corresponds to the pusher on a fusion fuel target, which would otherwise be within the interior of the Cannonball.

Despite the excellent record of the U.S. fusion program in achieving its technical goals, because of congressional chiseling on the Strategic Defense Initiative, funds are being vacuumed into that program from every other, including fusion. The program also suffers under a top-secret classification, which has no point: Japan's parallel program is entirely open.

The hole in the front disk had a diameter of 400 microns through which the laser light was directed. A hollow aluminum cylinder formed the Cannonball cavity. Aluminum was also used for the rear, a two-micron thick foil. The front disks were varied, using in one case ten-micron thick gold, in another ten-micron thick gold with two-micron thick aluminum on its inner surface and, lastly, a nickel wire net. The laser intensity was about 10^{14} watts per square centimer.

A two-micron, single aluminum foil was also used for purposes of comparison of the Cannonball with a conventional ablative target. The Cannonball target was found to have good laser energy absorption—above 50%—and a high hydrodynamic efficiency in the range of 16%. The numbers of hot electrons emitted from the rear of the first type of Cannonball target were found to be less than those seen in the single-foil ablative target. This tendency was even more noticeable for the second type.

Overall, the energetic hot electrons are mainly absorbed by the Cannonball cavity wall. Their energy is thus converted into plasma generation and heating, which then effectively drives the implosive acceleration of the inner surface representing the fuel target surface in this experiment. Furthermore, low energy hot electrons in the cavity also become useful in driving the implosion of the inner surface.

It was found that the formation of the cavity structure of a plane foil can modify the energy distribution of the hot electrons. This modification of the hot-electron spectrum appears to depend on the cavity materials and geometry. Therefore, proper design of spherical Cannonballs can suppress the hot-electron preheating of pellet fusion fuel otherwise seen in direct-drive, long-wavelength laser fusion.

These experiments are a major step forward, opening up the possibility of the industrial use of fusion power in the near future.