FASTC-ID(RS)T-0124-93

FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER

TACTICAL LASER WEAPONS AND OTHER DIRECTED-ENERGY WEAPONS

by

Wang Rongrui

HUMAN TRANSLATION

FASTC-ID(RS)T-0124-93 30 July 1993

MICROFICHE NR: 93C000493

TACTICAL LASER WEAPONS AND OTHER DIRECTED-ENERGY WEAPONS

By: Wang Rongrui

English pages: 13

Source: Laser & Infrared, Vol. 20, Nr. 5, 1990; pp. 26-29

Country of origin: China
Translated by: Leo Kanner Associates
F33657-88-D-2188
Requester: FASTC/TATD/Bruce Armstrong

PREPARED BY:

TRANSLATION DIVISION
FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER
WPAFB, OHIO

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

TACTICAL LASER WEAPONS AND OTHER DIRECTED-ENERGY WEAPONS

Wang Rongrui

North China Research Institute of Electro-optics

The paper briefly introduces the current development status of three directed-energy weapons; among them, the tactical laser weapon may be the first to find application.

Generally, there are three kinds of directed-energy weapons (DEW): laser weapons, radio frequency/microwave weapons, and charged-particle-beam weapons. It is expected that these technologies may be extensively applied in the 21st century among strategic and tactical weapons. In certain aspects, DEW weapons are better than weapon systems employing conventional or nuclear explosions. First, DEW relies on a power source but not an ammunition depot. Such superiority is revealed in combat against numerically superior energy. When the engine is powered with fuel, weapons of this type can be fired almost simultaneously. As predicted by military experts, future weapons may adopt liquid fuel-fed launch vehicles to furnish power for the DEW. Next, such weapons are developed toward killing or damaging soft targets. So-called soft target killing or damaging weapons are designed to explode against the vulnerable parts of an enemy system. Other soft target weapons are also under research. For example, like antiaircraft flak, foam shrapnel can be fired toward the engine of an enemy aircraft in dispersed form. There is another device capable of releasing acetylene gas to wear out the engine on a tank or armored vehicle.

As studied by analysts, currently the particle beam technique and high-power radio frequency/microwave technique still do not satisfy conditions for tactical applications; however, research on laser weapon applications is expanding. Therefore, possibly these weapons will be the first to find applications.

Tactical Laser Weapons

Lasers are becoming conventional devices on the battlefield. Like technologies applied in laser rangefinders and target tracking devices, these technologies can also be applied in weaponry after proportional amplification to higher power. As limited by power and space, within the decade lasers may not be used to shoot down aircraft or to destroy tanks. However, even at the moderate levels of power, lasers can also destroy or impair the performances of sensors, TV cameras and optical designators.

From a report by the U.S. Department of Defense, Soviet Military Power, in fiscal year 1987, the Soviet Union may deploy tactical laser weapons in the near future. In a briefing before the U.S. Congress in April 1987, it was confirmed that the Soviet Union uses laser weapons because a pilot on an American reconnaissance aircraft was temporarily blind at the instant when very powerful laser from a Soviet warship fired. Almost within the same time span, a Swedish pilot on an SAAB35 Draken fighter plane was also temporarily blinded at the instant when a Soviet laser of unknown origin was fired.

1. Laser blinding weapons

Over the past two decades, the Department of Defense in the United States developed some items of tactical laser weapons in a planned program. The U.S. Army had the earliest development of laser weapon prototypes in the early seventies: the movable test unit (MTU) project. This is a 30-kilowatt $CO_0 2$ laser system, which is installed on a U.S. Marine LVTP-7 armored landing craft. Following the MTU project, this is the development project of close-combat laser weapons (C-CLAW). This installation is used to attack enemy sensors.

The U.S. Army C-CLAW prototype is called the Roadrunner, which employs a 1-kilowatt high-pulse-repetition-rate CO_2 laser and a double-frequency Nd:YAG laser. However, the project was terminated in early 1983. The C-CLAW demonstration prototype surpasses the predetermined target in cost and weight. The demonstration prototype machine is 3000 pounds in weight; however, the original target of design is 900 pounds.

The Stingray laser weapon began to be developed in 1982. This is a vehicle borne protective system with its purpose to destroy enemy's electro-optical system, such as laser range finder and laser target finder. This project was supported by the Army Communication Electronics Command (CECOM). The development project of Stingray is the by-product of the demonstration prototype of C-CLAW, the Roadrunner. It was said that the Stingray is mounted in a rectangular box on one side of the M1 tank turret. The major contractor of the system is the Martin-Marietta Electronics and Missile Consortium, and the following contractors for the Roadrunner/Stingray are as follows: BDM Corporation, United Technologies, and Westinghouse Electric Corporation. General Electric Corporation is responsible for laser development. Since the plate-shaped YAG laser was selected, light beam quality was upgraded by a factor of about

10. The output energy is over 0.1 joule, capable of damaging optoelectronic sensors as far away as 8 kilometers; human eyes even further away can be damaged. The system has a wide visual field search and capture device, enabling the gunner to target several tanks at the same time; also, the laser can fire beams to blind the tank sensors. The prototype of the system began to be tested in 1985; in 1986, system testing was underway throughout the entire United States. As preliminary test results showed, the system can significantly enhance tank survival and combat capabilities. The Army planned to engage engineering research and development in 1988; it is expected to deploy these laser systems in the mid-nineties. The Army has another development project (similar to the Stingray), called as Jaguar and weighing only 33.8 kilograms. Supported by the Army Missile Command (MICOM), the Jaguar is being researched and developed at the Redstone Arsenal; the system is planned to be installed on a helicopter for optoelectronic countermeasures. The Coronet Prince project is closely related to the Stingray project; the design purpose of the system is to protect American aircraft from attack by enemy electro-optical systems. It was reported that the laser technique adopted is identical to that of the Stingray; however, laser output power is even higher. According to the plan, the conceptual prototype was developed in 1988. In 1989, the overall engineering decision will be made. Based on reports, in the United States a system similar to the Coronet Prince was also developed, designated the Compass Hammer. Both systems are in the category of airborne optoelectronic countermeasure (AOCM) systems. According to reports, the US Army has a project (similar to the AOCM project) to protect helicopters, designated the Cameo Bluejay.

Another laser weapon project of the US Army is the Dazer, which is a shoulder-fired laser weapon with functions similar to that of Stingray. First, the project was proposed by MICOM; later, the project was managed by CECOM with the purpose of protecting ground troops from attack by optoelectronic systems, as a fire control system capable of alerting and blocking an attack. The major contractor of the system is the Military Laser Products Division, Allied Signal Corporation. The contract amounted to 360,000 United States dollars. The Dazer was first proposed by the U.S. Army Infantry Center. Built as a 14-inch-long laser gun with a movable support and telescope, the Dazer is powered through a cable connected to batteries in a shoulder pack.

As announced by MICOM, the Dazer will adopt chrysoberyl as the laser working medium and using a Q-tuned quartz acousto-optic switch. The Dazer also includes a cooling chamber and a pump for temperature stabilization. From the chrysoberyl laser made by Allied Signal Corporation, the output wavelength is continuously tunable from 700 to 815 nanometers. For a rod of 6.3 x 76 mm, output energy is 3.3 joules per pulse; the pulse repetition rate is 20 hertz. After the Q-switch is used, the output per pulse is 600 microjoules for 33-nanosecond pulses and average power of 70 watts. Allied Corporation states that the Dazer will adopt techniques similar to the civilian-sector chrysoberyl laser made by the company, but the power supply will be a limiting factor.

Along with developments in laser blinding weapons, the following development trends in the laser weapon marketplace are noteworthy: (1) more and more laser simulators are adopted, such as the well-known multiple integration laser combat system (MILES); in this system, an eye-safe laser is adopted. (2) Related to training and application, another development in the laser market is the selection of lasers that do not damage the eyes. (3) For aircraft pilots and infantrymen, laser-protective glasses are under development. At the same time, an optoelectronic sensor capable of countering laser damage is under development. The new sensor has a switching property: in several microseconds, the sensor can be automatically shut off to lessen the chances of it being damaged by laser weapons. Another scheme is such that the operator can quickly change the damaged sensor head in the event it has been damaged. These are technologies of anti-laser countermeasures alongside the hectic development in laser weaponry.

Some military analysts predict that possibly a homing laser rangefinder, laser target tracker, or a missile using a laser communication launcher may appear within the next decade. Some other experts consider that these systems are not practical. However, all agree that the detector techniques required for guidance of these missiles currently are quite mature. If further development is required, these new anti-laser guided missiles are very similar to anti-radiation missiles. If this type of laser guided missiles is developed, various types of countermeasures (including laser decoying) techniques should be developed.

2. Tactical application of high-energy lasers

High-energy laser techniques are being developed at the DARPA, SDIO and various services of the U.S. armed forces. The development focus of SDIO is strategic laser weapons; however, the focus of DARPA is tactical applications of lasers. Some major laser experimental projects are underway at the high-energy laser system test field (HELSTF or HEL Staff) of the White Sands Missile Test Range. Although most experiments of HELSTF are strategic laser applications, some are related to tactical applications. The most obvious experimental projects include the multiple-application chemical laser (MPCL), medium-infrared advanced chemical laser (MIRACL) and ground-based free-electron laser (GBFEL). The best-known of these is the MIRACL; the project is headed by the Air Force with Army and Navy participation. Based on reports, MIRACL is capable of a laser output of 2.2 megawatts.

The Air Force and the Strategic Defense Initiative Organization (SDIO) have a joint development project on excimer medium-power Raman-frequency doppler laser device (EMRLD) at the Air Force Weapons Laboratory of Courtland Air Base, an experimental project valued at $130,000,000 is underway. It was stated that the EMRLD is currently the largest excimer laser in the Western world; its goal is to generate a repetition 100 hertz and 5 kilowatts in output power. Although this laser is being developed for strategic applications, analysts predict that some techniques of the project will be eventually used in tactical systems. The prime contractor of the EMRLD is Afuke [transliterated] Research Laboratory; Rockwell International is a major subcontractor.

With support from SDIO, the Air Force has another experimental project, the Alpha laser project, under construction in a weapons laboratory. The Alpha laser relies on hydrogen as the fuel. As recently revealed in heat flow experiments, optical elements can be installed now for full-scale laser experiments.

II. Radio-Frequency Weapons

Radio and microwave weapons are also referred to as high-power microwaves (HPM) weapons. Using high power in firing, these HPM weapons act as a super jamming device to disable electronic systems; the operating principle was conceived of by American radar scientists during World War Two. But these weapons are now becoming a reality because of developments in firing device technology.

In the three currently major directed-energy technologies, investments in radio-frequency/high-power microwaves weapons are at the bottom, only accounting for 1 or 2 percent of total investments. It was stated that the technologies required for a super jamming device have been available. At present, DARPA has selected the probing medium-power radio-frequency/microwave weapon. The three branches of the armed forces believe that the high-power microwaves system will operate at the power that is six orders of magnitude over the currently available jamming devices. However, the systems explored by DARPA operate at approximately three orders of magnitude above currently available jammers. The reason for this selection by DARPA is consideration of the limitations of present-day technology; with respect to weight, dimensions, and power, the high-power microwaves weapons are not suitable for tactical applications.

At present, the specific effects of medium-power microwave is at an early research stage; the harmful effects of medium-power microwave have not yet been discovered. However, deeper exploration is underway in some special realms, and attempts to develop outstanding microwave systems. With the exception of attacking a target by a frequency-band firing device, the purpose of current jammers is to interfere with radio and radar operations; however, the purpose of high-power microwaves weapons is to affect the electronic equipment as such. But it is at present impractical to build a high-power microwaves weapon with power sufficient to disable enemy electronic equipment but of a size to be installed on a tactical platform. Thus, tradeoffs are required in effective energy, dimensions, and weight. Today, the Air Force is thinking about a high-power microwaves system with output power between hundreds of megawatts and a gigawatt. However, Air Force research on medium-power and high-power microwaves is at the elementary stage; the concept began to be included in a project only in 1986. At first, the emphasis was to research the effect on neighboring systems due to high-power microwaves, with the purpose of designing a better protective system against high-power microwaves. Although the entire project is defensive in nature but applications to weapons will be considered. In addition, another method of disabling and jamming is the non-nuclear technique of electromagnetic pulse.

As revealed in SDIO research, with regard to the effects of high-power microwaves, the missile reentry flight vehicle is a very difficult target, but there are currently relatively few studies on strategic applications of high-power microwaves. There are different demands by various branches of the armed forces on high-power microwaves: the Army wants a compact high-power microwave device capable of being installed in an armored vehicle. The Air Force wants to have a system that can be installed on an aircraft platform. The Navy requires a high-power long-range system, but with no strict limitations on weight, volume, and power. As predicted by market analysts, the Navy may possibly be the first to use high-power microwave tactical systems capable of disabling microelectronic circuitry. There are possibly three functions for microwave and radio-frequency weaponry: (1) By using a method similar to present-day anti-jamming systems at power levels exceeding enemy communications and radar systems. However, unlike the currently available jamming systems, these super jamming devices can completely overwhelm a target. (2) If high enough power can be generated, microelectronic circuitry of enemy electronic systems can be irreparably disabled. (3) If power can be further increased, the target can be heated under the same principle of the household microwave oven.

It is noteworthy that there are obvious limitations in radio-frequency/high-power microwave weaponry. First, for effectiveness, the power of the radio-frequency/high-power microwave weapons should be increased, but these power levels will seriously jeopardize nearby electronic systems. Moreover, the same methods of protection against electromagnetic pulses from nuclear explosions to damage electronic systems can be adopted in safeguarding electronic systems from disablement by radio-frequency/high-power microwave systems. At present, in the latest military electronic designs of most countries, protection against electromagnetic pulses has become the general rule. In addition, there are numerous limitations on the microwave thermal effect because the skin effect of metal can shield an object from heating by microwaves.

Currently, besides compensating for reduction of radar signatures of launch vehicles and aircraft by using high power level, medium-power microwaves can also damage a target by illuminating it with very high repetition-rate pulses. Therefore, it is proposed to use microwave-absorbing materials, and it is possible to use the thermal effects of microwaves for effective kills.

The weakest point of radio-frequency/high-power microwave weaponry is its vulnerability to anti-radiation missiles, which is its natural enemy. However, radio-frequency/high-power microwave weapons can generate powerful electromagnetic signals; to some extent, this can naturally guard attacks by anti-radiation missiles. This is so because such weapons can generate high output power so that the warhead of the attacking missile can be detonated before reaching the target. In addition, such weapons can affect the microelectronic circuitry of the enemy guidance systems to disable the anti-radiation missile. It has been said that the purpose of DARPA radio-frequency research is to explore the optimal pulse shape and the pulse repetition rate in order to defeat anti-radiation missiles.

III. Particle Beam Weapons

Another aspect of tactical directed-energy weaponry is represented by particle beam weapons, which are at the initial research and development stage. Most methods of generating particle beams make use of linear induction accelerators. For practical tactical use, present-day devices are too bulky, too heavy, and too long.

As reported by the U.S. Army Trajectory Research Laboratory, at present the structure of a small cyclic linear induction accelerator is under study. The pulsed electron beam can be continuously cycled to steadily raise the beam energy. An outstanding feature of particle beam weapons is that it is not required to stay on the target like lasers, because the capability of particle beams in penetrating the target is high. In addition, its aiming is completely by relying on an electromagnetic method; this is easier and more precise than the mechanical method (reflective mirror) in scanning the target with a laser beam. However, a shortcoming of particle beams is their unsteadiness, with wobbling so that difficulties crop up over long-distance aiming in the case of particle beam weapons. Since neutral particles react vigorously with air molecules so that the particle beam can be used only in near-vacuum conditions. Although negatively charged particles do not react with air molecules, yet the stability problem still persists. The following phenomena will occur when a charged particle beam passes through the atmosphere: since the particles are charged, the moving electrons generate magnetic fields that compress the electrons into narrower beams; this feature of negatively charged particles is superior to neutral particle beams and laser beams.

The instability is a key technique in the development of particle beam weapons. At present, studies are underway to compensate for this instability under different atmospheric conditions, and computer models for predicting the path of particle beams; initial successes were attained. From predictions, particle beam weapons may possibly be the first kind to have tactical applications in point-defense weapons. In the late sixties, the Navy began a project (Chair Heritage) for building these weapons; the project includes the use of charged particle beams to carry out point defense of a warship against attack by an incoming missile. A prototype of Chair Heritage uses a rocket engine as the power supply generator in supplying electricity to the particle beam producer. It was estimated that this prototype can fire 100 times a second, with an effective firing range of 1 to 3 kilometers; the fuel capacity of the generator is 20,000 gallons; almost half a ton of fuel is consumed per second. At that time, however, since there were too many unknown factors, the Navy felt uncertainty and terminated the project. At present, DARPA inherited the technology used in Chair Heritage; together with the Navy, a project of charged particle beam technology has been gotten underway. Now, some experimental accelerators have been built; the largest accelerator is a 300-foot-long advanced test accelerator (ATA) built by LLNL to study the propagation of particle beams in gases, and to study functions and features of particle beams striking materials. At present this accelerator is used by SDIO in conducting free-electron laser experiments. It appears that for some time in the future, studies on charged particle beam weapons will continue in laboratories, mainly the development of such technology under active urging by the Navy.

The key technique in building tactical particle beam weapons is the high-power switch for fast pulsing of particle beams; at present, the conventional cyclotron and spark gap switch cannot be used; a type of magnetic switch is under study. This kind of magnetic switch applies a method of saturable induction in order to achieve a high repetition rate.

Generally speaking, weapon development follows a trend toward high speed and miniaturization. From this aspect, directed-energy weapons have an advantage that conventional weapons are unable to attain; finally, directed-energy weapons can be effectively used.

Brief background on the author: please refer to this publication, Jiguang Yu Hongwai [Lasers and Infrared], No. 5, page 19, 1989.

LITERATURE

1. Defense Electronics 21/8, 47-57; 77-86 (1989).

2. Defense Electronics 21/6, 69-80 (1989).

3. Guowai Jiguang [Lasers Abroad], No. 5, 1-4 (1989).

4. Wang Rongrui, "Development trends in military laser weapons and equipment," (Internal report, 1989).

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E051 HQ USAF/INET	1
E404 AEDC/DOF	1
E408 AFWL	1
E410 ASDTC/IN	1
E411 ASD/FTD/TTIA	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
P050 CIA/OCR/ADD/SD	2
1051 AFIT/LDE	1
P090 NSA/CDB	1
2206 FSL	1

Microfiche Nbr: FTD93C000493
FTD-ID(RS)T-0124-93