THE GREAT RUSSIAN 'DEATH-BEAM' FLAP

News reports of Soviet advances toward a weapon-sized charged particle beam seem based on good intelligence, fair physics and poor strategy considerations

BY JOHN H. DOUGLAS and DIETRICK E. THOMSEN

Ever since his retirement as head of Air Force intelligence activities, Maj. Gen. George J. Keegan has been openly warning that the Soviet Union is preparing a new type of antimissile weapon but that civilian intelligence officials have ignored his repeated warnings. The supposed weapon would be a powerful beam of charged particles, possibly powered by nuclear energy, which may have been under development for as much as a decade at a secret installation near the city of Semipalatinsk, in Kazakhstan.

A detailed presentation of Keegan's theory appears in the May 2 AVIATION WEEK & SPACE TECHNOLOGY, in an article by Clarence A. Robinson Jr. The article concludes that development tests for such a weapon are now underway, and one official is quoted as saying the system could be operational by 1980. An outline is presented of how Keegan assembled a group of young physicists to check out seven major technological hurdles that would have to be overcome to produce a powerful enough beam. They concluded that none of the hurdles appeared insurmountable. Robinson warns that "the details of Soviet directed-energy weapons have not been made available to the President or to the National Security Council" because of the fight within the intelligence community.

Asked about such weapons in a press conference on May 3, President Carter replied, "We have no evidence . . . that the Soviets have achieved any major breakthrough in the kind of weapon described in the news today. . . . I think that is, first of all, a report that is based on some inaccuracies. Secondly, the assessment of the report in the aviation magazine has been exaggerated."

This flap poses a difficult, but familiar, journalistic problem: Robinson clearly had access to intelligence data favorable to the weapon hypothesis, but little information has been forthcoming from opponents of that viewpoint. The Defense Department issued a denial similar to Carter's, even though AVIATION WEEK editor Robert Hotz says the article was not challenged for accuracy by the "appropriate Pentagon officials" who reviewed it before publication. And although the Central Intelligence Agency is cast in a particularly bad light in the article, a CIA spokesman would tell SCIENCE NEWS only that, "We do not believe the Soviet Union has achieved a breakthrough that could lead to a charged particle beam weapon." He also denied that information was withheld from high government officials.

On this one point, at least, SCIENCE NEWS has been able to gain verification from a trusted, highly placed government source. This source revealed that the National Security Council has been reviewing the relevant technology for two or three months, with the aid of the intelligence community and the Office of Science and Technology Policy. President Carter, then, did *not* learn of the issue from magazine accounts, as Hotz suggests, but based his reply on the review.

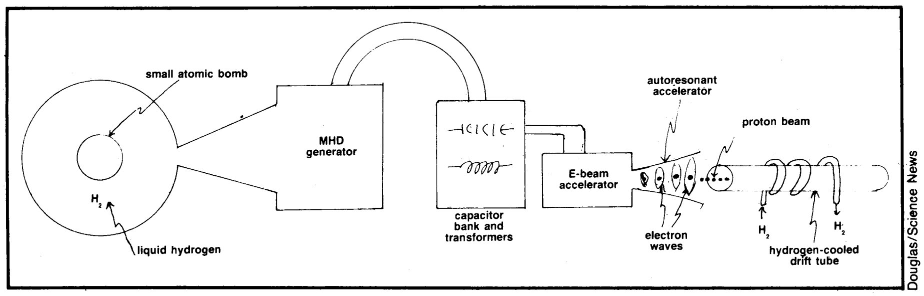
Even without access to intelligence data or classified information about the technology involved, however, serious questions can be raised about the feasibility of a charged-particle beam (CPB) weapon. Even graver doubts can be brought up about its capacity to protect a nation against intercontinental ballistic missiles (ICBMS).

As the installation at Semipalatinsk is described by Robinson, based on information from Air Force intelligence sources, the presumed CPB test unit might look like this: At one end would be a 57.8-foot-diameter steel sphere buried in an underground chamber. In this sphere, it is suggested, small nuclear bombs could be set off to generate a plasma that would in turn be converted into electricity. Electrical energy would be stored and reemitted by a bank of capacitors and transformers to run an electron beam accelerator. These electrons would be sent in waves (called cyclotron eigenmodes) down another accelerator, where small bunches of protons would be added and carried along like so many surfboards. Finally, an evacuated underground "drift tube," perhaps a kilometer long, would be used to test the propagation and destructive power of the proton beam.

Anyone familiar with the open literature concerning the technology involved in each of these devices would immediately raise the sort of questions Gen. Keegan apparently encountered—practically every step is either at or beyond the known "state of the art." But a harder look suggests that none of the steps seems impossible, either.

Take the nuclear-explosion-to-electricity step, for instance. More than three years ago, some leading Soviet physicists published an unclassified article showing how it could be done using a magnetohydrodynamic (MHD) generator. (E. P. Velikhov et al., *Atomnaya Energiya*, April 1974, p. 258—translated and distributed in the United States by Consultants Bureau, Plenum Publishing Corp.) They proposed creating a plasma by exploding a laser-ignited pellet of deuterium and tritium, wrapped in a lithium blanket, assembled in a large metal sphere. In principle, the same sort of process could involve a small fission bomb immersed in liquid hydrogen.

Or, consider the other end. Speculation on how to form a very energetic proton beam using electron waves as carriers goes back several years (SN: 7/12/69, p. 35). A detailed calculation of the specific "autoresonant accelerator" concept discussed in the Robinson article was published in the United States in 1973 (M. L. Sloan and W. E. Drummond, PHYSICAL REVIEW LETTERS, Nov. 11, 1973, p. 1234). The authors conclude that "ample power flow (10^{11} to 10^{12} watts) is available



A speculative schematic reconstruction of the secret installation at Semipalatinsk.

Continued on page 334

. . . Particle beam weapons

for the acceleration of hundreds of amperes of multi-GeV ions."

One of the most intriguing strengths of the Keegan hypothesis is his prediction that large quantities of hydrogen would have to be vented in the process of using a CPB device (both as exhaust from the generator unit and from cooling the drift tubes). This early prediction has apparently proved to be correct, for Robinson reports that explosions from hydrogen discharges have now been seen and that large amounts of hydrogen with traces of tritium (presumably related to the nuclear explosions) have been detected in the upper atmosphere.

Even if one assumes that all the steps contemplated in the CPB installation are theoretically possible to build and that the Soviets are indeed in the process of trying to hook them together, experts consulted by SCIENCE NEWS still raise purely scientific doubts about the project's overall feasibility. Why, they ask, should one bother trying to power the beam by an atomic explosion? That amount of energy simply isn't necessary—conventional explosives or jet-powered generators could do the trick, *if* you could actually produce the proton beam. And Soviet ability to produce the beam is what the scientists question most.

Unlike nuclear explosives technology, high-energy accelerator work is not only unclassified but has long been a field involving much cooperation between Russian and American scientists. Conventional accelerators produce particles energetic enough to meet the needs of a CPB weapon, but the current density is almost negligible and the installations are roughly the size of football fields. A few recent experiments have been launched to accelerate denser currents, but the beams produced so far are still orders of magnitude away from the required combination of energy and density. To be useful as a weapon, a beam must be able to initially burn a hole in the atmosphere—heating the air along a column long enough to create a temporary vacuum for the passage of the rest of the beam.

Leading American physicists say that simply hasn't been done—either in the Soviet Union or in the United States. And, they say, cooperation between the two countries has been constant enough and open enough that the capabilities of each party are well known to the other. As for alleged superiority of Russian scientists in beam technology, they point out that when the largest Soviet accelerator had trouble coming on line, American scientists were called in to help.

Potentially, however, CPB weapons would have some attractive features and, given tremendous effort, might be built. The devices would have particular advantages over high-energy laser weapons, which are apparently under active development in both the United States and the Soviet Union (SN: 7/3/76, p. 11). Laser beams are subject to rapid dispersion in the atmosphere and do not penetrate clouds. A beam of charged particles would be deflected only slightly by the earth's magnetic field and could easily penetrate clouds. Making a missile very reflective would help defend it from a laser beam, but particles could penetrate almost any conceivable material or configuration and wreak havoc as they passed.

If the technology should ever prove feasible, however, a whole new set of strategy questions would have to be asked about whether CPB weapons would be worth deploying. Even at this premature stage of development, the potential usefulness of such devices as a defense against ICBMs can be seen to be very low.

Perhaps the most devastating critique of the CPB weapon concept is presented in a paper dated May 13 by Richard L. Garwin of the IBM Research Center, Yorktown Heights, N.Y. SCIENCE NEWS has obtained a preliminary copy of the paper, which will appear in a forthcoming issue of REPORTS, a publication of the Council for a Liveable World. Garwin was one of the most influential critics of previous proposals for antiballistic missile (ABM) systems, arguing that they are easier to counter than they are to build and are generally not very cost-effective.

In his paper, Garwin estimates that a 3-centimeter-diameter beam of 5-GeV protons would have to transmit at least 10 megajoules of energy to a target made of aluminum in order to melt it. Assuming 30 percent efficiency in an accelerator, some 30 megajoules of electrical energy would be needed to drive each burst of protons. Using existing plasma devices with efficiencies of about 10 percent, he says, one could theoretically produce the needed electricity by detonating about 100 kilograms of conventional explosives (four orders of magnitude less than a small atomic bomb). The result would be a short burst of current of 1,000 to 10,000 amps lasting a few microseconds. (Other physicists say a millisecond beam would be needed, requiring more energy.)

From such "back of an envelope" calculations one can quickly draw some interesting conclusions about CPB devices. First, they do not require nuclear power, and Garwin concludes that speculation about using small atomic bombs to drive the beam "makes absolutely no sense." Other physicists generally concur. Second, since a beam destroys *only* what it hits directly, a device must be able to repeat these bursts frequently as corrections are made for misdirection. Developing the crude CPB weapon just described into a sophisticated "rapid repeater" would be no mean trick.

One way to produce as many as 1,000 shots a minute would be to use a 500-megawatt electrical generator connected to a capacitor bank, which would store the energy for release in short bursts. The generator would have to be the equivalent of a medium-sized power station, but for short operation, Garwin says, 5 or 10 large jet engines could be used to supply the primary power. The capacitor bank, however, would be *very* heavy, and this sort of device would be limited to ground installation.

A defense planner would thus face the following dilemma: In space he could try to build a relatively compact CPB device using explosive charges, but the technical problems of assembly would be formidable. On the ground he could erect a more versatile, conventionally powered device, but tracking would be more difficult because of distance, bending of the beam in the earth's magnetic field, and limits of resolution of conventional radar. The task is about like trying to shoot at a bullet coming toward you on a foggy day while your gun hand is shaking and the wind is blowing.

Technical problems of this magnitude have, of course, been surmounted in other weapon systems. The next question that arises then, is what countermeasures could an enemy take against such a defense. Garwin poins out two that are almost painfully simple. To jam sensor satellites and disturb the local magnetic field of the earth, an attacker would only need to explode a nuclear device above the atmosphere just before he launched his ICBMs. A charged particle beam would be deflected and a neutral beam (more difficult to make anyway) would be ionized and dispersed as gas from the top of the atmosphere was blown up in its path.

The second countermeasure involves the use of decoys or reflectors extended from an ICBM while it is in space. Since a direct hit must be scored, the CPB would have to be pointed successively at each decoy or reflector in turn. A beam device installed on a satellite could, theoretically, hit a missile during its vulnerable launch period, but such satellites, in turn, would be very vulnerable.

Garwin concludes: "The above should provide good reason to doubt the utility of work being done toward [particle beam] ABM weapons, the depth of understanding of those who emphasize a threat in this regard, and the good sense of those government officials who would be responsible on either the U.S. or the Soviet side for spending large amounts of funds in the development of such a capability."

Several intriguing questions, however, remain:

- Why should the Air Force suddenly allow substantial leaks of classified information in a sensitive intelligence area? Those who know Keegan say he fervently believes the Russians are ahead of the United States in developing CPB weapons. A more cynical view is that *if* America's ICBMs were suddenly indisposed, the next logical line of defense would be two weapons systems highly touted by the Air Force but now facing stiff congressional opposition—the low-flying cruise missile and B-1 bomber, which would be harder to track.

- What is the significance of the "Rudakov connection"? Last year, a leading Soviet physicist, L. I. Rudakov, gave a talk on electron beams at four U.S. laboratories and one conference, and suddenly the *American* scientists were not allowed to discuss openly what he said. Speculation on why has run the gamut from warnings of an "Idi Amin bomb" (a nuclear weapon cheap enough to be built by small countries) to the "shopping trip" theory (the idea that Rudakov was telling a little, but wanting to find out a lot in return).
- Assuming the Semipalatinsk facility has anything to do with CPBs, why would the Russians spend so much (reportedly $3 billion) on a project whose applicability as a weapon appears so shaky from the outset? On the strength of this interest alone, some American physicists are trying to get funding to push similar work, which has languished in this country.
- Finally, what is likely to be the effect of this flap on high-energy physics, once the most open and cooperative of fields? That openness might well become the first and only victim of a CPB weapon. □

BOOKS

BOOKS is an editorial service for readers' information. To order any book listed or any U.S. book in print please remit retail price, plus 25¢ handling charge for each book to **BOOK ORDER SERVICE**, Science News, 1719 N Street, N.W., Washington, D.C. 20036. All books sent postpaid.

ACTS OF GOD, ACTS OF MAN—Wesley Marx—Coward, 1977, 276 p., photographs, $8.95. Brings together a great many case histories that show how frequently man's incautious enterprise, construction, or government-sponsored control measures have aggravated rather than lessened the consequences of natural disasters.

ALTERNATE REALITIES: The Search for the Full Human Being—Lawrence LeShan—Evans, 1976, 232 p., $7.95. Experimental psychologist presents a synthesis of his continued probing into valid modes of human perception of being and existence—a process that involves inventing as well as discovering reality.

ASIMOV ON NUMBERS—Isaac Asimov—Doubleday, 1977, 265 p., illus., $9.95. Collection of essays dealing with numbers used in counting, mathematics, measurement, the calendar, astronomy, and the earth.

ATLAS OF CRYSTAL STEREOGRAMS—Richard M. Pearl—Earth Sci Pub Co, 1976, 80 p., photographs, 119 stereograms, paper, $3.75; optional: folding Taylor-Merchant stereopticon viewer: $1.25. Collection of stereoscopic drawings of crystal geometry with descriptions, and introduction to the subject of crystal classification.

THE BIOLOGY OF INSECTS—C. P. Friedlander—Pica Pr, 1977, 190 p., drawings, charts, $12.50. Considers the group as a whole, traces the various specialist adaptations of form and function, and discusses the impact of insects on the rest of the biosphere.

BUILD IT BETTER YOURSELF—*Organic Gardening and Farming,* Editors—Rodale Pr, 1977, 956 p., 425 photographs, 700 drawings, $16.95. Step-by-step instructions for the do-it-yourself builder of farm, garden and homestead projects, from planting flats to nontip sawhorse.

THE COMPLETE BOOK OF FLYING—Lyle Kenyon Engel and Monty Norris—Four Winds, Schol Bk Serv, 1977, 300 p., photographs, $9.95. After discussing the basics of flight and aerodynamics, the book takes reader, lesson by lesson, through typical flying course.

THE CONDENSED CHEMICAL DICTIONARY—Revised by Gessner G. Hawley—Van Nos Reinhold, 1977, 9th ed., 970 p., $32.50. Expanded in the area of energy and its sources, this authoritative compendium of technical data and descriptive information covers thousands of chemicals and chemical phenomena, from *abaca* to *"Zytron."*

. . . NGF

workers. These include a macrophage growth factor, made by fibroblasts (cells present in connective tissue); a fibroblast growth factor, made by the pituitary gland of the brain; and an ovarian growth factor, also made by the pituitary gland. Like NGF, these factors are proteins. However, their amino acid sequences differ from NGF's and from each other's. They also appear to exert different biochemical effects on their target cells. For instance, fibroblast growth factor induces DNA synthesis and cell division in a target cell, reports Denis Gospodarowicz of the Salk Institute for Biological Studies in San Diego. And while Cohen is still not sure how epidermal growth factor exerts its effects, he is sure that it does *not* act on microtubules as NGF does. Thus, "the relationship among these factors, if any, is still unknown," Young concludes.

Finally, should NGF and these other growth factors be classified as hormones, or should they be put in a tissue-enhancing category all their own? Gospodorowicz, who isolated the ovarian growth factor in 1974, reports that "it is distinct from known pituitary hormones." As for NGF, its actions are quite different from those of conventional hormones, Levi-Montalcini has found. And as Angeletti reported in the January BIOCHEMISTRY, the amino acid sequences of NGF from different sources are more similar to each other than they are to the protein hormone insulin, which they resemble to some degree. So are NGF and other growth factors hormones or not? "It's a very hazy area," Cohen concedes.

Meanwhile, more startling insights into NGF keep emerging from labs around the world, and they may well, like pieces of a jigsaw puzzle, finally bring NGF's true value to nerves and other tissues into focus and finally disclose its role in relation to other growth factors and conventional hormones. For instance, Young and his colleagues report in the April and May PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, that NGF is only a partial product of a parent molecule that is 10 times larger than it is, and whose amino acid sequence is grossly different from NGF. As soon as they isolate this compound, researchers may then be in a better position to understand the origin of NGF and what it does for the body. In other words, it may have an even larger role than nerve growth and development.

Also, before NGF's true impact on life is fully appreciated, emerging information about NGF may benefit medicine, and in some unexpected ways. A case in point:

George J. Todaro, Robert N. Fabricant and Joseph E. DeLarco of the U.S. National Cancer Institute reported, in the February PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, that they have found receptors for NGF on cancerous pigment cells taken from several patients who died from malignant melanoma. Such receptors, they add, are not present on fibroblasts, epithelial cells and numerous other cell types. These findings suggest, as some past studies have, that cancer cells, especially melanoma, need NGF for some purpose. But the more provocative aspect of these results is that they might lead to better diagnosis and treatment of malignant melanoma.

In other words, if NGF receptors were found on a sample of pigment cells taken from a person, they might well indicate the presence of malignant melanoma, and possibly in its earliest stages. This sampling for NGF receptors might provide an early diagnosis for this form of cancer. In contrast, an antiserum to NGF or to its receptors might be devised, injected into a malignant melanoma patient and deprive cancer cells in the patient of needed NGF and lead to the cells' demise. Thus such an antiserum might make an effective form of treatment against malignant melanoma. In fact, the NCI researchers have reason to believe that such an antiserum might be even more effective against malignant melanoma after it has invaded the body than before because they have found even more NGF receptors on invasive cells than on noninvasive ones. So the first clinical uses for NGF may well emerge in the cancer arena rather than in the neurobiological one.

Thus, Levi-Montalcini, who watched with wonder the birth of her "miracle" molecule from the womb of malignant tissues, may well live to see NGF and NGF antibodies slay those very same tissues. The world of NGF is indeed baffling, but ripe with promise. □