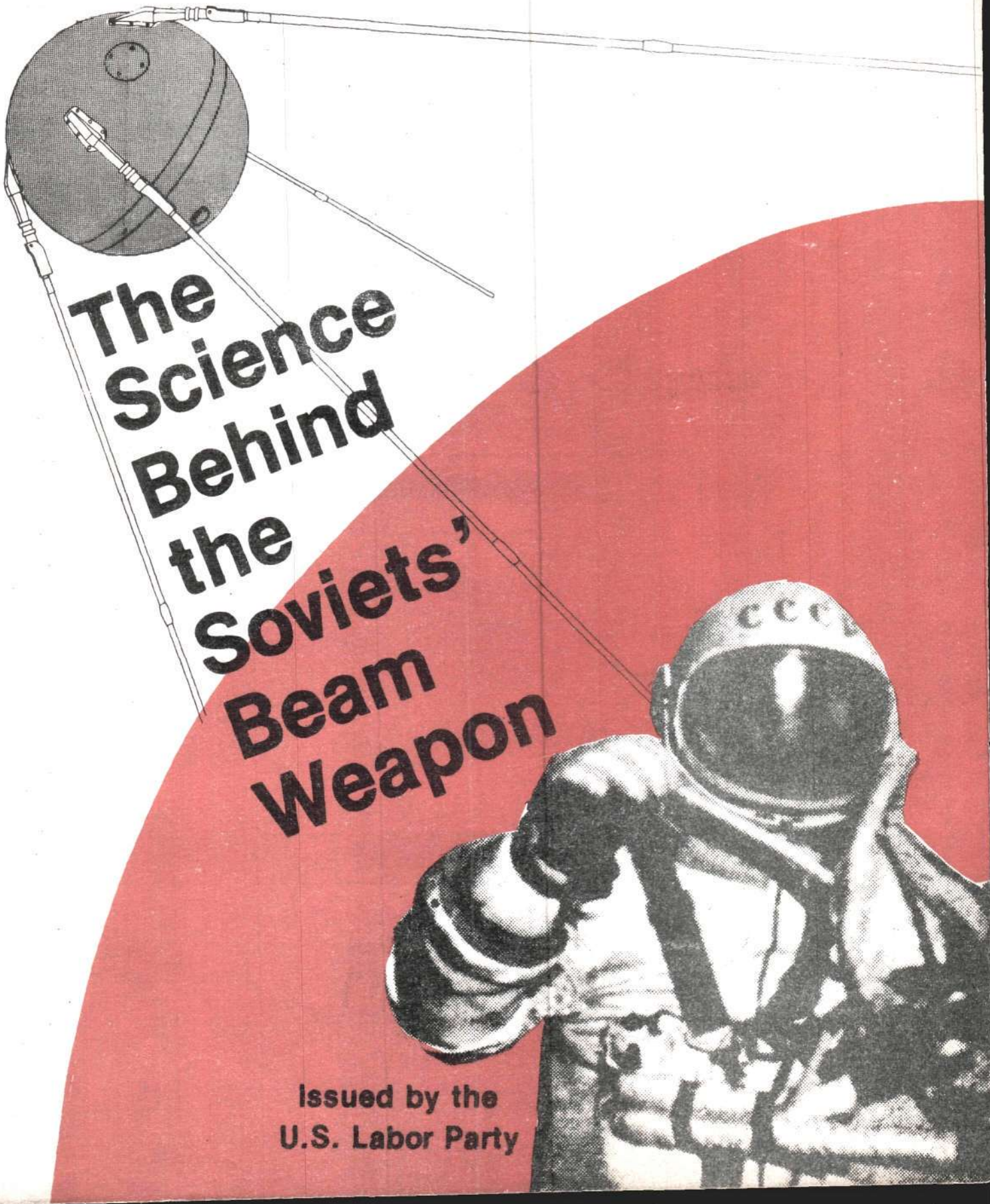
SPUTNIK OF THE SEVENTIES

$1



The Science Behind the Soviets' Beam Weapon

Issued by the
U.S. Labor Party

Contents

Some of the articles in this report originally appeared in *New Solidarity*.

Published by Campaigner Publications
231 West 29 Street
New York, N.Y. 10001
Printed in the United States of America

Edited by M. Minnicino, K. Stevens, T. DeCarlo
Designed by Efthalia DeGroot

New Solidarity International Press Service
Vol. VIII, No. 25, Special Report No. 2
May 31, 1977

X-623

PREFACE

The Science to Survive

Despite public admission by Soviet plasma physicist L.I. Rudakov of basic scientific breakthroughs in thermonuclear fusion research which put the Soviet Union on the verge of developing directed particle beam weapons *in July of 1976*, informed experts in government, the military, and the scientific community allowed this fact of vital Soviet strategic advantage to be covered up for nine months. Now that the May 2 *Aviation Week* magazine has elaborated the work of retired Air Force Intelligence chief Major General Keegan detailing precisely the Soviet capability adduced by the Fusion Energy Foundation from the Rudakov work nine months previous, the issue of U.S. scientific capacity has finally become a center of national debate.

This debate comes not a moment too soon. Spewing a smokescreen of rhetoric and lies about U.S. "superweapon" research and *mutually* assured destruction, the Carter Administration has proceeded to bring the world to the brink of a thermonuclear confrontation which the U.S. cannot survive.

Hence General Keegan's results — elaborated in this pamphlet on the basis of Soviet scientific work *in the public domain* and of the FEF's original work in plasma physics — demand immediate action in two areas. The first is military strategy; the war of national suicide now being prepared by the David Rockefeller-controlled Carter Administration must be stopped. The U.S.'s chief NATO partner, West Germany, has already begun to dissociate itself from this policy, as the *Wehrkunde* reprint in this pamphlet shows. To destroy the Rockefeller threat, however, Congressmen must force hearings on the Keegan findings, reassert their control over foreign policy, and tailor that policy to long-range economic and scientific collaboration with the Soviet Union, among other nations, which will eliminate the danger of world obliteration.

The second crucial area for action is the scientific development policy of the United States itself. As U.S. Labor Party presidential candidate Lyndon H. LaRouche elaborates in this pamphlet, the military preparedness of this nation has undergone a dismal decline precisely as a result of abandoning the principles and practice of industrial progress upon which the United States was uniquely founded. The reason for this is no mystery; as we have outlined fully elsewhere, it lies in usurpation of political-economic policy by the Rockefeller family and their voracious looting in the interests of preserving themselves from literal bankruptcy. In our elaboration of the array of technologies outlined by Keegan from primarily a military applications standpoint, we properly emphasize the tremendous revolutionary industrial implications available to this nation and the world if the political will of the United States forces a recommitment to technological progress in the form of an International Development Bank and its national concomitant, the Third National Bank.

What we are discussing is the creation of the proper political climate to spur equivalent and greater scientific progress in the United States than in the Soviet Union. Despite all sorts of epistemological flaws in the Soviet outlook, it has been the retained principle of progress which has forced and fostered an epistemological rigor in Soviet basic sciences.

The Case of L.D. Landau

This essential point is appropriately illustrated for our purposes here by considering the scientific career of Soviet physicist Lev Davidovich Landau (1908-1962). The work of Landau provides a "crucial experiment" for evaluating Soviet science policies and capabilities both because of Landau's critical position as the leading link between the anti-reductionist initiators of Soviet physical science (most notably V.I. Vernadsky) and the present generation of physicists, and the coherent line of his scientific investigations during three and a half decades. In fact, one of the best pieces of evidence to consider in "documenting" General Keegan's allegations is *The Collected Papers of Landau* (Gordon and Breach, New York, 1965).

From Landau's 1931 paper (with R. Peierls) on the breakdown of quantum mechanics in the relativistic (i.e., high energy) domain to his final published paper on "Fundamental Problems" in honor of the just-deceased Wolfgang Pauli, Landau was consistently ruthless in pointing out that *in reality* there is no such thing as the interaction at a point of extensionless particles. He properly viewed the "renormalization"

techniques which mathematically (in some cases) remove the infinities from computations of point interactions and self-interactions as a mere "technological" trick compared to a theory which could directly account for the actual *geometry* of physical interaction. From this standpoint, Landau developed the perspective out of which flows the present *scientifically* strategic advantages of Soviet research: "Particle" physics in its point interaction form is absurd and the Second Law of Thermodynamics (increase of entropy or disorder) *cannot* be true of the physical universe as a whole or of many of its parts if it holds for any of its parts! ("On the Second Law of Thermodynamics and the Universe," *Phys. Z. Sowjet.* 4: 114, 1933; with M. Bronstein). Therefore, while continuum theories such as hydrodynamics, which are valid in the same domains of nature and to the same extent as are the "laws" of thermodynamics (concerning the distribution of energy among its possible forms for various systems), are not rigorously correct, they are the best approximations we have at present to the actual (but not yet fully describable) higher-order, nonlinear processes of energy stabilization and transformation.

Thus, Landau's work, in constituting a unified approach to the interactions in systems supposedly as different as free particle collisions, fluids, solids, plasmas, and superfluids and superconductors — in each case seeking within existing physics the best possible representation of energy states and associated geometrical configurations and of the limiting circumstances where they break down — directly lays the base for the unified scientific and technological approach required to coherently develop a high energy density, rapidly pulsed particle beam device. Landau's many papers during the period 1940-1945 involving direct application of these principles to military problems and related technologies relevant to General Keegan's concerns (e.g., "Determination of the Flow Velocity of the Detonation Products of Condensed Explosives," *C.R. Acad. Sci. URSS.* 47: 271, 1945; with K.P. Staniukovich) merely underscores that central point.

In his last paper, Landau resummarized the basic problem facing physics: "Unfortunately, the nonlocal nature of the interaction renders completely useless the technique (renormalization of point interactions - ed.) of the present existing theory. Of course the *undesirability of this occurrence* is a poor argument against the nonlocal nature of the interaction:...." (emphasis added.)

In the United States, almost total disregard of Landau's insights has resulted in a total divergence in physics between the two distinct fields of particle and plasma physics. Those few individuals who approach either or both fields from the standpoint of developing new theoretical hypotheses and crucial experimental tests of the relevant dynamic geometric forms of energy transformation are the exceptions who prove the rule of dogmatic attachment to *a priori* particle or field theories. This particle-plasma physics gap underlies the purported rebuttal of Keegan's assessment prepared by Dr. Richard Garwin of IBM for the Council for a Liveable World, which specializes in funding the election campaigns of "arms control-oriented" Senators. Garwin's case boils down to this circular argument: beam generation doesn't require all the energy produced in nuclear reactions, but if the beam energy content is produced by conventional sources, it can be deflected from its target, so particle beam ABM weapons aren't practical. The conversion of the huge energy from a thermonuclear blast into a charged particle beam seems impractical to Garwin and other U.S. scientific defense analysts precisely because they are not committed to going beyond particle accelerators to control of the nonlinear regime of collective acceleration of ions in plasma.

This same *qualitative* distinction between U.S. and Soviet physics extends, as might be expected, to the area of civilian energy research in the case of controlled fusion and related plasma technologies such as MHD. The fact that U.S. and Soviet physics may apparently be interchangeable in perhaps 95 percent of the scientific papers published in no way alters the strategic significance, militarily and economically, of the critical national distinctions arising in research on energy-dense plasmas and beams and related coherent phenomena.

Which Way?

The military circles around General Keegan have initiated a process which is crucial to this nation's survival. They know full well that the policy which the Carter Administration is carrying out will result in the nuclear destruction of this nation. While they have tended to propose a "solution" that maintains the unnecessary state of war between the United States and the Soviet Union, they have sounded the necessary alarm.

It is now up to the American population to mobilize itself. In the next weeks and months, it is the American people who will decide whether the scientific breakthroughs presented in this pamphlet will represent the beginning of a new scientific era, or the senseless obliteration of humanity's highest achievements.

Dr. Morris Levitt
May 27, 1977

How Kissinger and McNamara Wrecked U.S. Military Capabilities

by Lyndon H. LaRouche

WIESBADEN, May 13 — Together with Donald Rumsfeld, Ronald Reagan and a few others, this writer is properly viewed as among the leading candidates to replace an impeached Jimmy Carter as President of the United States. Under those circumstances, and in the context of the present global economic and military crises, it is the writer's duty, as a candidate, to immediately assume the full range of duties of a President "in the wings." He must be, and is, prepared to promptly and efficiently assume all of the duties of the Presidency on virtually a moment's notice.

That announcement might appear a bit far-fetched to persons who do not yet understand how political processes operate under conditions of crisis. Under conditions of grave crisis, leading forces are impelled to repeatedly adjust their thinking in rapid succession, according to the dictates of a search for individuals and forces competent to extricate the nation from deadly problems. If that process does not occur, such a nation is doomed. If it does occur, all the standard rules of "past experience" for political procedures vanish at least temporarily. That is how Charles de Gaulle led the establishment of France's Fifth Republic in 1958; that is the process by which this writer's visible candidacy for President is presently developing.

The following crucial elements of a LaRouche Presidency are already fully developed, ready for immediate executive and congressional action: (1) a comprehensive energy policy; (2) a comprehensive policy for eliminating the terrorism and drug problems; (3) the establishment of a U.S. National Bank, to get the nation out of the present depression; (4) necessary emergency action to prevent waves of bankruptcies and social insecurity during the period of collapse of Chase Manhattan Bank and allied major, bankrupt institutions.

Also, in a major study, *The Case of Walter Lippmann*, the following further elements of a new Presidency are thoroughly elaborated: (1) a U.S. foreign policy consistent with our national interests; (2) a comprehensive and simplified reform of the Executive Branch; (3) a tax reform policy; (4) the policy of implementing the intent of the Constitution concerning both constitutional law and positive law in general; (5) a national basic scientific research and research and development policy.

Meanwhile, this writer, as a prospective President, is acting in his capacity as a private individual to defend the most vital interests of the USA from both the dangers of general war and monetary collapse. He has initiated a major action toward establishing a private bank which shall function as an international central bank at the point of collapse of the International Monetary Fund, Eurodollar market, and key lower Manhattan banks. If successfully established — and numerous bankers and others already agree the measure is necessary — this new bank will act in concert with bankers, industries, and governments to maintain a flow of "hard-commodity" credit for world trade, and will begin the process of real capital formation in technologically advanced industry and agriculture. That will contribute substantially to preventing the financial collapse of Rockefeller and allied interests from leading into a deep and prolonged world depression.

The Military Problem

It is also a principal duty of the President to act as Commander-in-chief of the nation's armed forces. The President must embody such qualifications of strategic command, both for responsibly leading the nation's forces and for developing them according to need. This aspect of the matter has been dealt with by the U.S. Labor Party, with aid of discussions with qualified officers in the USA, France, West Germany, and Italy.

It was through such qualificatons that I was able to

Lyndon H. LaRouche, Jr. is a leading, internationally renowned economist. Presently the National Chairman of the U.S. Labor Party, he was the USLP's 1976 candidate for President of the United States and was renominated to seek the nation's highest office at the party's national convention in December 1976.

Mr. LaRouche is currently involved in international negotiations aimed at the establishment of a new private bank which would serve as the vehicle for creating a new world monetary system to replace the International Monetary Fund. Mr. LaRouche is committed to head such a bank until such time as he is called to serve the United States as President.

warn you accurately, in a nationwide half hour Nov. 1, 1976 television broadcast, of the nature and implications of the military and related adventures a Carter Administration would launch during the first half of 1977.

That danger, of which I forewarned you last Nov. 1, has now materialized. With the complicity of France's President, Valéry Giscard d'Estaing, the Carter Administration has moved to bring the United States and its NATO allies to the brink of war with the Warsaw Pact powers. This has been done in the way I forewarned you would occur if you permitted a Carter Administration to take over the White House, and is occurring for the reasons of which I forewarned you — for reason of the unsalvageable bankruptcy of Carter's patrons, David Rockefeller and his friends.

I can also report to you that the Warsaw Pact command is of the opinion that the Carter Administration's operations in Africa, the South Atlantic, and the Middle East are bringing the world close to the edge of full-scale thermonuclear war between the United States and the Soviet Union. Everything you are being told to the contrary — by Zbigniew Brzezinski's mouthpiece, Jimmy Carter, by James Schlesinger, by Vance, Warnke, Harold Brown, Admiral Turner and others, is either deliberate fraud or an outpouring of their criminal incompetence concerning the present strategic situation.

Under these circumstances, it is my duty to report to you on the military situation as your President should.

What I shall report to you are not in any sense military secrets. Every major government in the world knows these facts, and knows that the other governments know the same facts. It is the ordinary citizens of the United States and Western European countries who are being kept in the dark on these issues — together with far too many of their elected representatives. It is urgent that you and your elected representatives know these facts, so that you and they can act in time — before between 160 and 200 millions of our nation's population die in thermonuclear war.

Most of the basic facts I have to report to you are the judgment shared by the overwhelming majority of qualified general officers and other strategic professionals throughout the NATO countries. I shall also go beyond those bare facts, to explain to you how the United States military establishment and strategic posture degenerated into their present condition. On this second part of my military situation report to you, I can not presently tell you whether or not a majority of professionals fully agree with my observations, but I can say that a representative selection of U.S. military professionals of the highest qualifications do.

In brief, our overall present military-strategic situation is as follows:

The United States and allied military forces have a terrifying capability, sufficiently deterrent that no potential aggressor would launch an unprovoked military confrontation against the United States or any of its allies. Therefore, unless the Carter Administration were to provoke the Soviet Union in the most outrageous and foolish fashion, there would be no danger of military operations against the United States.

However, if the Carter Administration were to force the Soviet Union to go to war, the United States would lose that war, and would in fact cease to exist as a functioning nation. Between 160 and 200 millions of our citizens would die in such a war — without the slightest margin for doubt that the casualties would be in that range. Although the United States' forces can inflict a hideous penalty upon the Warsaw Pact nations, killing perhaps 30 percent of the Soviet civilian population, the Soviet forces have a thin but significant margin of military war-winning capability over the USA and NATO, and a decisive margin of war-winning potential in depth in civil-defense capabilities.

Furthermore, on the basis of an existing Soviet marginal advantage in basic military-applicable scientific research, the Soviet war-winning margin will substantially increase over the period immediately ahead. The best current estimate is that in areas of basic scientific research applicable to military problems, the Soviets are advanced beyond the United States in the order of two-to-four years. As those basic advances in plasma physics and related areas come down the line into finished military product over the period immediately ahead, a possibility exists for a decisive Soviet military war-winning capability.

Furthermore, the Warsaw Pact command is presently committed to a policy of maintaining that technological superiority over the combined USA and NATO forces.

This Soviet marginal advantage would not represent a real threat to the security of the United States were I presently your President, or if a Whig conservative such as Donald Rumsfeld, the former Defense Secretary, were in the White House. From my knowledge of Mr. Rumsfeld and potential candidates of a similar persuasion and competence, I am reasonably assured that such persons would do nothing to place the United States security in jeopardy.

Some misguided persons in the Congress and elsewhere argue mistakenly that the Labor Party overemphasizes its public denunciations of Mr. David Rockefeller and leading Rockefeller protégés, beginning with Jimmy Carter, in the control of the present administration.

Despite such criticisms, it remains a fact that Jimmy Carter has proven himself publicly an emotionally unstable individual, wholly unqualified to understand even the nature of the issues posed to him by leaders of other nations — as was exhibited once again in London most recently. His irresponsible and incompetent remarks concerning the current operational status of the Berlin Four Power Agreement are exemplary of Carter's befuddlement and dangerous bungling.

This unfortunate individual, Carter, is surrounded and molded by Zbigniew Brzezinski — an extremely

reckless incompetent in strategic matters, James Schlesinger — a proven strategic incompetent, dumped by President Ford for excellent reasons, and by Rockefeller's wildly reckless Kennedy Administration "whiz kids" such as Cyrus Vance and Harold Brown. U.S. foreign policy is in fact being made largely by desperately bankrupt David Rockefeller, no genius, and by such Rockefeller associates as Marcus Raskin, and Richard Barnet of the Institute for Policy Studies, Paul Warnke, and Coca Cola's J.Paul Austin.

The Rockefeller crew, whose principal achievement has been to run the world's largest monetary system in history to the edge of the biggest financial bankruptcy in history, is presently engaged in adventures risking general thermonuclear war in a last, desperate effort to cover up the bankruptcy of Chase Manhattan Bank and allied institutions. This Rockefeller crew, and its Trilateral Commission Executive Branch, are pushing the United States headlong toward World War III — and are either hysterically ignoring or publicly fraudulently denying the warnings of qualified military and related professionals in both the United States and other NATO countries.

For example, during the past week, the magazine of the leading Western Germany military strategy group, the *Wehrkunde Gesellschaft*, published an article correctly stating that official United States strategic policies and postures are entirely incompetent and bankrupt. The *Wehrkunde Gesellschaft* is correct, and no qualified U.S. general officer would disagree privately with the West German military's opinion on this point.

Despite those facts, the Carter Administration is pushing the United States headlong into World War III — with a bankrupt military strategy and an incompetent military posture.

The Kissinger Aspects of U.S. Strategic Incompetence

During the late 1950s, Dr. Henry Kissinger modeled himself for Peter Sellers's portrayal of "Dr. Strangelove" in the well known film of that name. Kissinger's proposal was predicated on a then-existing marginal strategic superiority of the USA and NATO forces, and proposed to use that marginal advantage as a psychological-warfare tool of Mutt-and-Jeff pressure, to force the Soviets to a step-by-step retreat into an entirely indefensible strategic posture at which the USA and NATO would then secure, presumably, a decisive war-winning advantage.

The so-called Schlesinger Doctrine is nothing but a rewarmed relic of the old Kissinger doctrine.

What Schlesinger and others have proposed, and have imposed as NATO MC 14-4 theater nuclear policy, is to apply the 1950s Kissinger doctrine to a situation in which the Warsaw Pact forces have a marginal war-winning advantage!

Schlesinger and allied self-styled strategists propose that the Soviet leaders are so terrified of war that they will react to limited nuclear confrontations by trading away their marginal advantage, and then much more, in successive steps, and in this way give the combined USA-NATO forces a decisive margin of war-winning advantage. In brief, the Schlesinger doctrine — the present policy of the Carter Administration, is based on the assumption that the Soviet leadership is ignorant of simple arithmetic!

If a limited (theater) war between Warsaw Pact and USA-NATO forces involved the Warsaw Pact surrendering a marginal war-winning advantage to the Carter Administration, as the price for avoiding general war, the only possible Soviet response would be to immediately launch World War III, beginning that process by unloading every intercontinental bit of thermonuclear and other ABC throwweight in its possession against the continental United States. Between 160 and 180 millions U.S. citizens would become casualties during the opening hours of war.

Nonetheless, the Carter Administration pursues that as operational strategic policy, hysterically insisting that the U.S. and its military allies can provoke several theater-limited military conflicts with Soviet forces without triggering World War III.

It is true, of course,that the Warsaw Pact command will go to great lengths to avoid World War III. Since a theater military confrontation means instant World War III, the Soviets attempt to avoid theater situations in which the Carter maniacs force the onset of that general thermonuclear war.

That Soviet policy of war avoidance poses the second principal question of the strategic problem: How far can — and will — the Warsaw Pact command retreat to avoid a theater military confrontation? That line is drawn objectively at Cuba-Angola and the Middle East Gulf petroleum-exporting region.

Just as Soviet civil defense capabilities are the decisive margin of Soviet war-winning capabilities in depth, so the global correlation of political forces can determine the potential war-winning capabilities of either superpower in depth. To the extent that a significant portion of the world is non-aligned and that NATO countries have a war-avoidance posture, this political correlation of forces maintains a major element of strategic balance in depth between the two major powers.

If, then, David Rockefeller and Company destabilize the present governments of West Germany, Italy and Japan, and bring a terrorized developing sector under regimes enslaved to Rockefeller strategic economic and political policies, and also incite China against the Soviet Union, that correlation of forces is so aboslutely strategically intolerable to the Warsaw Pact forces that they must be willing to go to general thermonuclear war to prevent that situation from developing.

In brief, military strategy studies and policies center upon the topics of the vital interests and capa-

bilities of potential adversary. Although the interests of nations properly enter into these evaluations, the immediate definition of vital interests is the vital interests of the governing forces of a nation, rather than the nation as such. As we know — or ought to know — the interests of David Rockefeller's Carter Administration and the vital interests of the United States as a nation are direct opposites. The Soviet strategist is obliged to define the Carter Administration as a David Rockefeller administration, and to define the vital interests of the government in terms of David Rockefeller's desperation.

For this reason, any dramatic measures *presently* taken *by the David Rockefeller administration* to develop a strategic war-winning position in depth against the Warsaw Pact will be taken properly as an act of war against the Soviet Union. When a potential adversary's interests impel that adversary toward war, and when the adversary then acts to put a war-winning capability in place,a state of general war between the forces exists in fact, and will become actual war at the choice of the threatened party.

For this reason,the Warsaw Pact is presently placed in the somewhat curious posture of being obliged, in effect, to defend Western Europe, Japan, and the Gulf states aginst the Carter Administration. If Rockefeller and his allies tie up African strategic mineral resources and Middle East petroleum resources as a means for bringing Western Europe and Japan to their knees before the Carter Administration, that action, because of its implications, represents an act of war by the Carter Administration against the Soviet Union. At that point, the Soviet Union is obliged objectively to commit itself to general war against the United States, and will go to war at the moment of its choosing.

One of the mental problems which legislatures and laymen suffer in this connection is that they have not been developed to be able to think like military-strategic commanders. If a strategic commander of any competence knows that he is going to fight a war, he opts to launch that war at a time and in a way that affords him the relatively maximum war-winning advantage. Wherever competent strategic commanders are in charge, mere "incidents" do not cause wars. In such cases, "incidents" cause wars only when the preconditions for war already exist.

The Carter Administration has brought the world to the edge of the preconditions for general thermonuclear war. One significant further shove in the direction being taken by Carter France's Giscard, and Israel's Peres, and everything could go up the pipe.

Naturally, once can not predict at exactly what point war will break out. We can do no more than forecast the situation in the following way. There is a certain broad area of alternative developments in which general war will not occur. There is an adjoining area of alternative developments in which an imminent state of general war exists. Once events move inside the latter area, war is imminent, and the situation has become virtually uncontrollable. The point is to keep out of that latter area of alternative developments unless one intends and is properly prepared to immediately fight general thermonuclear war.

In effect, David Rockefeller's Carter Administration intends, by weight of its current actions, that the United States should fight a thermonuclear war before the end of summer 1977. It is a war which the United States and its military allies are in no condition to fight.

The Folly of the All-Voluntary Army

Even if the United States had a first-line war-winning advantage vis-à-vis the Warsaw Pact, the United States and NATO would nonetheless probably still lose such a war because neither the U.S. Army, nor the French or Italian armies are politically qualified to accomplish their NATO military assignments under conditions of general war. The exemplary point to be made in this connection on the U.S. forces is that the policy of the "all-volunteer army" represents a piece of stupidity, a parody of early eighteenth-century policies fatally discredited at Yorktown and during the French and German army operations of the 1790-1815 period.

What Washington, Hamilton and others demonstrated is that earlier forms of armies, composed in mass of recruits from backward poor farmer and slum population youth, are no match for modern armies or urban workers and highly skilled farmers based in depth on a well trained militia. With this militia policy — e.g., the Philadelphia militia — the ill-equipped, small army of the American Revolution under Washington and Hamilton lost battle after battle, because of inferior means immediately deployable, but won a war.

Similar principles were employed by the First French Republic to shatter the opposing armies of Europe. A direct takeover of the lessons of the American Revolution by Gneisenau and the brilliant Scharnhorst created the German army which defeated Napoléon.

There are three vital principles of military policy involved. First, a modern nation which is unwilling to sustain a universal militia system as the basis for its military capabilities in depth is a nation which is not psychologically qualified to fight through a war. Second, the best fighting forces of a nation are the nation's most productive strata of working people and farmers. It is they who represent the psychological resource of a sense of social world-outlook of the sort indispensable for modern war-fighting. Third, it is the foot soldier who must in the final analysis win wars, and without whom all other military capabilities fall short of actual war-winning capability.

It is the quality of the mass of infantry in depth which determines the potential upon which technological war-winning capabilities are based.

Infantry soldiers of the Soviet Army, which in contrast to the USA's lumpen and farmer-based all-volunteer army, draws on layers of the USSR's most skilled workers through a system of universal conscription.

This was key to the course of the U.S. operations during World War II. Typifying the unpreparedness, during the 1920s and 1930s, the initials for United States Army, U.S.A., were also conventionally interpreted as signifying "Useless Sons Accomodated!" Except for the U.S. National Guard, the United States began World War II without an adequate militia system *in depth*. Without the National Guard, it would have required much longer than three years to bring the U.S. war-fighting potential up to projected strength. The National Guard was the limited expression of Washington and Hamilton's heritage. Had a true universal militia system existed, the U.S. could have reached nearly full potential as rapidly as ships, planes and tanks were supplied.

The same principles were proven by Tito in the wartime Yugoslav partisan warfare, and were proven afresh by Giap in the French Indo-China warfare, and in the prolonged U.S. war in Vietnam. The Yugoslav partisan commanders' reports on the sociological composition of various qualities of combat forces are fresh exemplification of what Washington, Scharnhorst and the French army proved during the 1776-1815 period.

The "Hessian" system, originally developed into its characteristic seventeenth and eighteenth century forms by the House of Orange, seemed to function — as long as it was not pitted against Cromwell's militia-rooted forces — because it faced armies of similar qualities. It degenerated during the eighteenth century into the "set-piece" war-fighting doctrines shattered at Yorktown and by the initial battles fought by forces of the First French Republic and Napoléon.

The early strategic excellence of U.S. military doctrine was weakened under Thomas Jefferson's Administration — for which the United States paid dearly in the War of 1812 — and was dissipated after 1828. The United States military was obliged to relearn the strategic art of war afresh during the Civil War — aided by German immigrants trained in the Scharnhorst tradition. Now, with Kissinger, McNamara and the Kennedy "systems-analysis whiz-kids" who continue the miserable Kennedy tradition, Schlesinger and others have taken U.S. strategic doctrine and military capabilities policies toward the discredited "set-piece" war-fighting doctrines of the early through middle eighteenth century.

The problem is this. The poor sense of social identity of the youth taken from marginal agriculture and urban slums, plus his relatively inferior cultural adaptation to technologically oriented skills, results in troops whose discipline-and-training-induced surface capabilities evaporate psychologically in face of an adversary of matching military-performance capabilities. Just as they have difficulty in assimilating into technologically advanced production, they are also slow learners and respond poorly to tactical improvisation under battle conditions.

However, it is not feasible to maintain the fighting capacities-in-depth of nations in the form of standing armies. The best fighters are in general the best workers, the best farmers, the best professionals. The militia system developed by the American Revolution, and extended by the German Scharnhorst, is the solution. In case of war, the nation uses the militia system to quickly concentrate and deploy mass forces

of the best capabilities around a kernel of professional units, all under a professional officer and non-commissioned officer cadre.

The maintaining of a properly functioning militia system ensures the quality of the professional standing army itself. As for recruits from marginal rural and slum populations, it is by assimilating them into units of a higher cultural level that their cultural level for combat is raised, and they resume civil life with improved self-respect and potentialities.

It is relevant to acknowledge that Kennedy's and McNamara's Vietnam War did much to destroy the militia system in the USA. On this, one should emphasize that one should not put an army through a war it should not have to fight in the first place. Protracted such wars destroy the morale and other essential qualities of an army, and destroy the functioning of a militia system misused in that way. A militia system functions on the basis of the political willingness and preparedness of a population to fight a war.

A "Hessian" force — another name for "all-volunteer army" — functions with apparent effectiveness as occupation forces, or against a vastly inferior, ill-equipped force. Under those circumstances, such an army can function according to drill. The breaking point for a "Hessian" force is that condition of warfare in which a well-matched opponent renders the predefined drill ineffective. Once the element of improvisation becomes dominant, an all-volunteer army becomes distinguished for its routability.

The Fat-Headed Accountant

The chief single cause for the deterioration of U.S. military effectiveness is the unfortunate individual who presided over the Department of Defense from 1961 through 1968 — "Slickum," as President Johnson termed him, Robert S. McNamara, who left the Defense Department in a shambles to continue his career in incompetence as head of the World Bank. To understand McNamara's role at Defense, one should characterize him scientifically as *a fat-headed, overblown accountant.*

Accountants, as accountants, are useful and even necessary within the proper confines of that profession. As persons, some accountants are intelligent and competent away from accounting. However, the sort of accountant who suffers the delusion that the accounting-point-of-view is the properly governing approach to industrial management or military policy is a dangerous lunatic. Such a lunatic was Robert McNamara at Defense — remember the Vietnam "body counts?" Such a dangerous lunatic is McNamara today at the World Bank.

Some people said that Slickum was a genius at Ford Motor. I reject that although, at the same time, I can appreciate why some deceived top people at Ford might have been taken in on the point. In the past, I have studied a number of accountants dabbling in industrial management at close range, observing both their characteristic incompetence in such matters, and also noting how some careless owners and others were deceived into mistaking what an accountant does in management for competence. The point is directly relevant to what Slickum did at Defense, and the worse horrors he has perpetrated at the World Bank. In view of the importance of the point, I illustrate the nature of the "accountant problem" here.

In order to make a specific case anonymous, I shall refer to the corporation involved as the well known "Widget Manufacturing Company." This firm was in financial difficulty. The cause of the difficulty, as a matter of background, was that the owners and managers had frittered away income over preceding decades, rather than reinvesting in developing the firm's productive technology. As such matters turn out, a decade or so of higher distributable earnings left an obsolescence-ridden production and marketing operation, and the obsolescence lawfully expressed itself in reduced earnings and then losses.

In such cases, there are only two workable alternatives. Either liquidate the shebang, or bring in equity or long term debt-capital for capital formation in sufficient amounts to overcome the obsolescence. Once a firm has reached the condition the Widget firm was in, there is no combination of reinvested profits or cost-reductions which can generate sufficient capital to bring operations up to a modern, competitive standard.

The Widget firm included well qualified persons in its management and ownership. However, in the circumstances they behaved as did certain leading Republicans last November and early December in connection with the massive vote fraud for Carter. They avoided the risk of mobilizing to deal directly and effectively with the clear issues, and submitted for "practical political" reasons to alternatives they knew must fail. Not to single out Republicans, there are certain trade union leaders and industrialists who are showing similar gutlessness in permitting themselves to be arm-twisted and blackmailed into supporting the Nazi-modeled "Pacemaker" operation. Similar examples of such vacillation and gutlessness under fire are numerous in all aspects of life.

This vacillation among the competent persons left the matter of determining the firm's policies to sundry accounting mentalities within the management and among the firm's financial backers. Various "brilliant" cost-reduction schemes were launched, each advertised as "the solution" — the proverbial 'light at the end of the tunnel" — and each essentially cutting the firm's operations still further below the breakeven point.

One included element of that program is citable here as exemplifying the same incompetence which McNamara's reign introduced to Defense.

Lo and Behold! As the firm's operations slipped, it exhibited a sizeable slow-moving inventory of finished stock. I recall how the accounting mentalities clucked

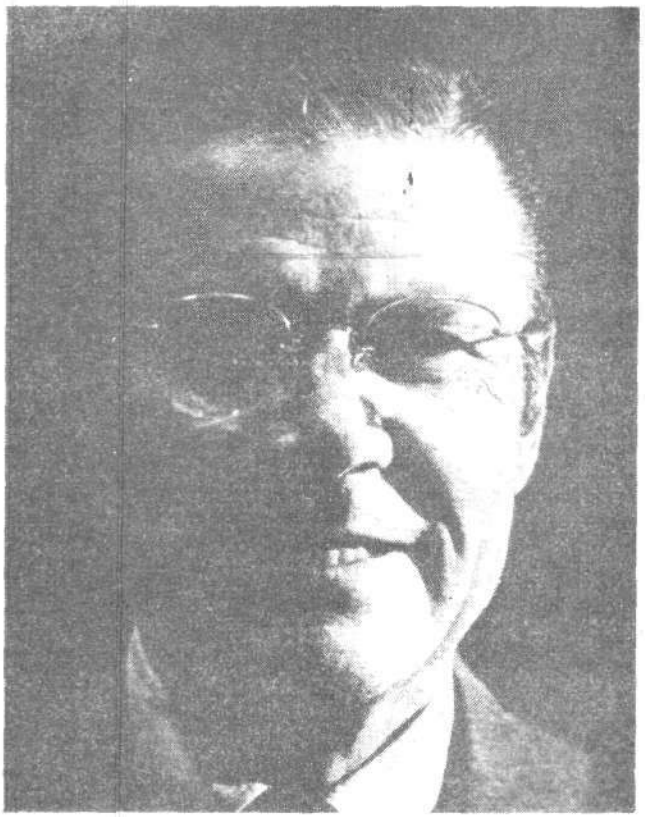
over that marvellous discovery. Their solution: cut back production to give priority to moving the slow-moving stock. All the accounting mentalities, including the financier representatives, clucked more or less in unison — with decimal points — that this would, indeed, be the solution to that problem.

Naturally, as any competent management would have known, the accountant's remedy was worse than the illness. The slow-moving stock was slow-moving because it was slow-moving in terms of market demand. Cutting back new production did not move the slow-moving Widget styles one centimeter-per-year faster; it merely cut overall sales, made the sales-inventory ratios worse, and turned a bad loss into a catastrophe. The solution was the direct approach: increase production on high-demand new styles. It was by increasing total "shelf-position" through high-demand, high-turnover product that a such firm could have improved its inventory ratios, its inventory turnover, and accelerated the movement of the slow-moving items.

In general, that example is not exceptional. It is the intrusion into management matters by accountants with exaggerated sense of importance who have contributed (after foolish bankers) the next-to-greatest and most frequent managerial bungling in American business management. With Slickum's arrival at Defense, the granddaddy of all such bunglers had taken possession of the premises.

I do not know exactly what Slickum did at Ford Motor, but I can make a very shrewd guess. During the period he was at Ford management, there were two, successive processes under way. Up into 1957, the motor car industry, with Ford the worst offender, was engaged in the most insane marketing policies imaginable, tearing the gut out the consumer market, ruining the financial and operating stability of dealerships, and turning this rotten economics back against the production side itself. It was a grand downhill ski-run until the 1957 precipice was reached. The succeeding period, the 1957-1961 recession period, was an orgy of grand old cost-cutting. During that period Midtown and Downtown New York City streets were figuratively jammed with ex-$40,000-a-year corporate vice presidents and division presidents scratching in hope of an $8,000 to $10,000 job. To run up an insane financial bubble in consumer-credit speculation — as the auto industry did between 1954 and 1957 — or to wield a pencil of cost-cutting during a recession, is a sort of work which any mere accounting mentality can conduct without the slightest managerial competence. The accountants who became styled as heros of management throughout the 1954-1961 period were those who got off the financial orgy and onto the cost-cutting at the right point in time. It is most probable that Slickum's reputation at Ford was made on the basis of exactly such shallow-minded charades — since that is the outer limit of the mentality he has since exhibited at Defense and the World Bank.

It is such accounting mentalities that dominate the



Robert McNamara

RAND Corporation, the Hudson Institution, Brookings Institution, the World Bank, the International Monetary Fund management team, and McGeorge Bundy's Ford Foundation. Their policy for bringing the world into financial balance is to drive nations and industries operating below the breakeven point to lower levels of production, while simultaneously willfully raising prices and reducing real wages! To have fascism, one need only place an accounting mentality in charge of economic policies!

(The only good accountants are secretly physicists, engineers, musicians, historians, and so forth — or, occasionally, a good legal mind.)

This devastating incompetence of the accounting mentality is associated with the fact that accounting practice is intrinsically *nominalist*. It counts the numbers of things according to their given labels. It does not know what it is counting, but only the name of the objects being counted, averaged, and so forth. This is the secret of the accountant's function in enabling a client to achieve tax avoidance — change the *name* according to some acceptable legal fiction, and bring the item in question under a different heading: give a tax-exempting name to some item of expenditure, real or implicit. Receive income after the period it qualifies as capital gains. (One of my minor goals for the time I become President, is to simplify the tax laws in such a way as to eliminate that nonsense.) The accountant does not know reality, but only the names he mistakes for reality.

That is precisely what Slickum did with his cost-effectiveness and related accounting-mentality programs and policies at Defense. That is the hideous thing he has done at the World Bank.

Beyond the basics of *interests* and *capabilities*, the business of military strategy is the definition of *flanking potentialities*. A *flank* is not inherently something which is to be displayed on a blackboard tactical diagram. A flank is *some new dimension of war-fighting*, for which (preferably) one's own forces will have a developed capability and the adversary a poor countermeasures capability. Flanks are essentially *psychological* and *technological*. In both cases, one is exploiting some cultural advantage of one's nation and its forces against a relative cultural disadvantage of an adversary. What one does, in principle, is to create a geometry of warfare in some dimension of struggle at which one has a decisive advantage through the cultural capabilities of one's own forces.

Strategy exploits the flanking principle in two categorical ways. First, in the pre-war development of capabilities and in ordering the developed forces for the conduct of an impending war. Second, under actual war-fighting, the same principle of creative innovation is used by commanders to exploit potentialities as they emerge. *The essence of strategic command, as explored by Scharnhorst and Clausewitz, is the development in exceptional military professional leaders of the capability of rigorously predetermining the feasibility of creative discoveries of flanking potentials and committing themselves and subordinates to resolute action in behalf of the realization of those discoveries.*

Several most-relevant points follow from this.

First, the foot-soldier in warfare is not a *unit*. He is a human being of a definite culture, definite sense of personal moral identiy, and associated capabilities of enculturation, training, and experience. No matter how many tens of thousands of men a commander directs in battle, it is the fighting capability of that individual soldier, his level of culture, training, experience, and ability to deploy in concert, which is what the commander is deploying. It is that individual soldier's interface with the adversary which is being deployed.

For example, if the platoon leader and non-commissioned officers of a platoon are casualties, how then will the remainder of the unit fight? Can the unit develop de facto platoon leaders and non-commissioned officer-leaders out of its own ranks? How will they deploy under such improvised leadership? How will they react to an unexpected form of adversary deployment? It is this, in the final analysis, that the commander of the ten thousands commands. His ability to rely on such tactical qualities of the small unit is indispensable to determining the way he coordinates the deployments of the larger wholes.

Second, the relationship between the military and the development of advanced technologies. There is no reason why military production ought to be — intrinsically — in the forefront of the development of industrial technology. However, in great powers (especially), the search for strategic flanks naturally and properly leads always to the search for new technologies — as Napoléon III learned to his sorrow at Sedan. Moreover, the qualified commander knows that his potential adversary is engaged in the same search. Therefore, competent commanders always place a far greater emphasis upon basic scientific research than has been customary on balance among industrialists.

A military command that abandons basic scientific research policies, and goes instead to mere R and D as Slickum's reign defined it, is losing the future war flank to its adversary by default.

Strategy depends fundamentally on a preoccupation with things that as yet have no names, which, therefore, no accountant can know.

Third, line-by-line weapons-systems policies are strategic lunacy. A flank exists with respect to a total force capability taken as a whole. One looks for flanks in the whole of one's own and the adversary's force, and so pinpoints potential flanks, to the effect, "We need a gizmo that..." adding, "Can our scientists discover some hidden principle of nature that we can use for that purpose?"

The accounting mentality rejects all of these three subsumed basic facts of strategy. Systems analysis defines soldiers as mere units, overlooking that most essential quality of the superior infantryman — that he has skills and creative powers that are not in the book or the computerized psycho-profile. Accounting reduces war to a super chess game, in which each type of piece is predetermined, and advantages is obtained by cheating in the movement of the individual piece. *Accountants see war as successful embezzlement;* that is the Schlesinger doctrine; that was failed swindlers Vance and Warnke falling on their face at Moscow; that was the foolish Carter and demented Brzezinski at London and Geneva. Accountants cannot comprehend what does not yet have a name — the known name which therefore intrinsically eludes them in "victory" against a well-matched adversary.

To have a functioning Pentagon, it would be necessary to begin by cleaning out every taint of the influences of Slickum, Schlesinger and Defense Secretary Harold Brown, and painting the faces of accountants a distinctive, indelible purple, so that their opinions on all military subjects might be efficiently ignored at the outset.

The Balanced View

For reasons developed in depth in my *The Case of Walter Lippmann*, under a President representing our nation's Federalist traditions, the adversary relationship between the United States and the Soviet Union can be eliminated on a basis eminently satisfactory to the overwhelming majority of the people of both

nations. However, at this moment, under the preceding administrations and present administration, an adversary relationship exists. We are in fact at the verge of war.

If the war should occur, our nation will cease to exist. The Red Army will ultimately bring political order to the survivors of that smoking rubblefield that was once the United States. That war must be prevented.

To prevent that war, it is necessary to mobilize the majority of the electorate and elected legislative representatives of the nation, to stop the war in the only way possible — impeach the Carter Administration. To tolerate Carter and other David Rockefeller protégés in powerful Executive Branch positions is the same as willfully condemning yourself, your children to radioactive cremation.

For you to act to eliminate this danger, as you must, you must understand the nature of the danger and the reasons our nation fell into its present predicament. Therefore, I have summarized the nature of our present peril and weakness for you. What I have said has the merit of being true, and is also in a form in which numerous others — legislators, experienced military professionals, and so forth — can verify each point I have made to you. You can verify each crucial point I have reported to you here.

You must settle your own mind on this matter. We must act very soon, while it is still possible to prevent Rockefeller from launching his Israeli puppets on a general Middle East adventure or launch Giscard's French-led forces into a general war in Africa. Once those wars begin, it will be most difficult, and then quickly impossible, to prevent World War III from beginning.

If we act to prevent the Carter Administration from triggering World War III, Chase Manhattan and the Eurodollar market will soon collapse of their own bankrupt condition. I will work meanwhile to get the new monetary system launched — and then we can rid ourselves of the horrors of the past period for once and for all.

If the Carter problem is solved, as I have proposed, then let us remember the lessons I have indicated concerning the way in which, from the Kennedy inauguration onwards, our nation was betrayed and imperiled, in part, by those in charge of our military policies and posture. It may well be that we do not need to use those lessons for war-fighting purposes in the future, but the lessons apply to many other dimensions of policy besides war. War is a branch of political strategy. War or no war in our future, political strategy is the foremost responsibility of U.S. national leaders during the decades immediately ahead. The lessons we have to learn on the military side can serve us well in other dimensions of political strategic undertakings.

SPUTNIK OF THE SEVENTIES

The Science Behind The Soviets' "Superweapon"

INTRODUCTION

by Dr. Steven Bardwell

In 1876, an exhibition in Philadelphia celebrated the 100th anniversary of the world's technological achievements since the American Revolution. This exhibition proved to the world that the United States was the leading innovator in new and daring technologies. While England and Germany displayed tooled toilet kits and stained glass windows, the American exhibition showed agricultural machinery, industrial equipment, all powered by the world's largest steam engine, the Corliss engine with pistons three and a half feet in diameter. "Yankee ingenuity" was a fact.

Eighty years later things had changed. During the late 1940s and early 1950s, leading American scientists and engineers advised the U.S. government that missile development and space travel were impossible. In 1957, the Soviet Union launched and successfully orbited the first artificial earth satellite, Sputnik I.

As anyone over 25 years old remembers, Sputnik I was probably the most psychologically shocking event to occur since World War I. How had the U.S. suddenly lost its almost century-old status as the leading *innovator* in technology and applied science? Even more disturbing, how had the Soviet Union — a predominantly agricultural nation — achieved what U.S. scientists had considered impossible?

Twenty years later, the same questions must be asked. According to an informed faction in U.S. military circles centered around Maj. General Keegan, the recently retired head of U.S. Air Force intelligence, the Soviets had made a series of at least nine technological breakthroughs which allow them to deploy a weapon which is, to quote *Aviation Week*, "capable of neutralizing the entire United States ballistic missile force and checkmating this country's strategic doctrine."

How could the Soviets have succeeded in at least seven areas of technology in each of which the "expert" U.S. judgment was: "impossible for several decades"? How can they have established these technologies on a much less advanced industrial base than that of the U.S.?

The answer to these questions is simple: Soviet advances in developing the military technology of the "directed energy beam weapon" were not the result of military research. They are not the result of a large military budget or evidence of a "new arms race." There is no new "missile gap."

Unfortunately, some of Gen. Keegan's co-thinkers have fallen into this fatal misconception as evidenced by the editorial which accompanied the *Aviation Week* article. We are in the paradoxical position that mere military answers to the challenge of the Sputnik of the '70s will ensure not only U.S. failure to develop such technologies, but will ensure a thermonuclear war which the U.S. will lose.

What Have the Soviets Done?

The real story of the Soviet Union's weapons development is not a military one at all, but, rather, a scientific and industrial one. The key to understanding why the U.S. did not develop such a weapon and why the Soviets were able to, lies in the policies of scientific research, energy development, and industrial progress that each country pursued. Each of the technological ingredients which went into making such a "death ray" possible were the result of the Soviet Union's crash program for fusion development, a commitment to basic science research many times larger than that of the U.S., and a continuing,

---

Dr. Steven Bardwell, a PhD graduate in plasma physics from the University of Colorado, is the Director of the Plasma Physics Division of the Fusion Energy Foundation. His recent series, "The Frontiers of Plasma Physics," published in the FEF Newsletter, *pulled together years of plasma physical research to pose the notion of nonlinearity as the guiding conception for all present and future physical research. Over the last several months, he has lectured extensively on fusion and plasma research to both lay and technical audiences. His current research concentrates on the large variety of self-organizing phenomena that appear in almost all kinds of plasmas and the implications of this research for the philosophy of science and contemporary physics.*

aggressive policy of industrial development. It is the welding together of these three areas of basic science, energy policy, and industrial expansion that is crucial.

Based on that general method, the Soviets, as an adjunct of their overall industrial policy, have succeeded in perfecting the following chain of technologies:

1) A welding method which has allowed the construction of a huge steel chamber capable of containing an atomic blast. The dumbell shaped device has spherical ends 70 feet in diameter, with walls 13 feet thick, and is probably housed inside a granite hole.

This welding technology is essential in the construction of the large pressure vessels and machining equipment used in the Soviet Union. It was first perfected as a result of the problems involved in maintaining, by conventional welding techniques, the Siberian rail system. Welding experts in the United States agree that it is currently impossible to weld such structures with technologies available in the West.

2) The chamber is equipped so that it can turn the blast from the atomic weapon exploding inside it into a pulse of electricity. Using a technology called pulsed magnetohydrodynamics (MHD), a burst of electrical energy containing the energy equivalent of millions of pounds of TNT can be released in a fraction of a second. This machine, if it were to fire one bomb a second, would generate twice as much electricity as the whole of the United States! The initial work on MHD generation came from plasma research in the Soviet fusion and fossil fuel energy generation experiments. The U.S. abandoned all work on MHD about a decade and a half ago, until Soviet successes with their experimental U-25 plant resulted in a small, currently running U.S. program. The Soviet U-25 plant is now supplying power for the Moscow subway system.

The electrical pulses from this generator are conducted along hydrogen-cooled transmission lines. The technologies involved in using hydrogen for maintaining cryogenic temperatures have not been used in the United States, nor have conductors been developed which can withstand such high electric fields and currents. The first Soviet work on this subject came out of difficulties that were experienced in transporting electricity over long distances in Siberia. However, again, the continuing research in this field has emerged in fusion development where the transmission of high-intensity pulses of electricity is necessary for initiating and controlling the fusion plasma.

The electrical pulse may then be stored in a capacitor of a design still unperfected in the United States. The so-called pressurized water capacitor, using water under 100 atmospheres pressure, can store energy densities 40 times those of conventional capacitors. The problems of energy storage and the switching in and out of such capacitors were first attacked in the fusion program, both in the U.S. and Soviet Union. According to sources in the U.S. weapons program, U.S. laboratories have had difficult problems in perfecting these capacitor technologies.

3) Once the electrical pulse has been stored in the capacitor, the capacitor is discharged in a controlled way and the electrical energy is used to generate a high intensity electron beam. As was reported in *New Solidarity* in April 1977, the Soviets have made fundamental breakthroughs in their beam-induced fusion research program under the direction of Leonid Rudakov and have perfected a means for generating electron beams at least twice as intense as any in the United States. These beams are used in their fusion program. The diode construction and propagation methods of the electron beams can also be used in the first stage of the generation of a beam for weapon use.

4) Using the intense beam of electrons, plasma processes can be used to generate a beam of atomic nucleii. There are a number of approaches to this process, but the most interesting technology (which the Soviets have perfected and is still several years from success in the West) is a method for generating almost monoenergetic, "cooled proton" beams. This plasma technology makes it possible to generate a beam of protons which fires a burst of energy equivalent to a million pounds of TNT up to 10 times a second!

This technology was proposed by G. Budker in the United States in 1967 and met with uniform ridicule in U.S. labs. It is now opening up the possibility of studying matter anti-matter collisions in scientific experiments and is being tested for use in medical applications, water purification, and military applications.

5) Once the beam is generated, it must be guided to its target. (In military applications, this would be an intercontinental ballistic missile.) This involves a radar capable of siting the beam and a sufficient knowledge of beam-gas-plasma interactions so that the beam can propagate through the atmosphere to reach the missile. The Soviets have had a long program of study of beam-plasma interactions have pioneered most of the conceptions involved in the application of propagating beams. This technology is also being applied to plasma electronics — using beams to generate intense microwaves, for example — and to the study and use of the astrogeophysical plasmas, the ionosphere and magnetosphere. Relevant in this regard are the recent experiments the Soviets have conducted with high intensity, broadband radio transmission, which disrupted Atlantic communication channels repeatedly last fall.

If all these technologies have been integrated by the Soviets, as all available information indicates is the case, the Soviet Union is near to perfecting a weapon which is capable of being deployed to destroy any offensive capability of U.S. ICBMs.

How Was It Done?

It is clear even from this quick description that Soviet investment in these technologies could be afforded by a country poor in capital and technology *only* because such technologies emerged from their otherwise existing industrial and energy policy. This is elementary.

Not so elementary, however, is the role that Soviet basic science research has played in this development. As will be developed in great detail in this series, without a large and growing investment in the research at the frontiers of physics, these breakthroughs could not have been achieved. Especially since the end of World War II, The Soviet Union has had the fastest growing group of theoretical physicists and since roughly the middle of the 1960s, it has had the largest number in absolute terms.

Even more important than the size of this group of researchers is the quality of their training and the freedom of intellectual endeavor in which they work! There are three areas especially where Soviet basic science has excelled, and, interestingly enough, each of these areas has a direct relation to the applications cited above.

The first of these areas is hydrodynamics, the study of the motion of continuous media, classically, fluids, but under certain circumstances including gases and solids, Mikhael Lavrentyev, an applied mathematician who heads the Siberian Academy of Sciences and also the Institute of Hydrodynamics at Novosibirsk, is one of the leading researchers in the theory of shock waves in fluid media. This was the result of a long series of experiments and theoretical study of explosions, in such applications as welding (leading to the explosive welding technique noted above), geologic engineering, and weapons development.

Research in this field is expecially difficult and has lagged in the West, because the field of hydrodynamics, and especially that of shock waves in fluids, is characterized by "nonlinearity" — the property of a system whereby its evolution occurs through the generation of complex structures. Even classical hydrodynamics is famous for its difficulty. The description of explosive phenomena is even more difficult because these self-ordered, highly structured phenomena proceed contrary to the common-sense notion of evolution in the direction of decay and disorder.

It is not that the Soviets have developed any new scientific techniques, but they have unquestionably been bolder and more imaginative in their application of the difficult mathematics required. Thus, they have tried to solve the problems, in a causal, analytic, and rigorous way. When similar problems have been dealt with in the West (which has not been as often), the tendency is to solve the equations with a computer, and ignore the conceptual challenge of the nonlinear behavior of the fluid.

The second field in which the Soviets have excelled is in a theoretical branch of physics called "analytical mechanics." Again, this is a discipline within physics requiring mathematical skill and a willingness to develop new conceptions of the "natural" direction of evolution. There has developed a large school of USSR mathematicians who have perfected the mathematical techniques of Riemann especially and have pursued a theoretical study of the conditions under which a system will evolve in a self-ordering, or disordering, direction.

The mathematical tools developed in this area are applied in the study of large, self-ordering (cooperative) systems, like a laser, or self-accelerated beam. The processes characteristic of the plasma in such a beam weapon, are, also, amenable to these theoretical ideas. Scientists in the United States have lagged behind in this area.

Third, and most importantly, the Soviets are years ahead in their theoretical understanding of plasma physics — the science of the ionized gases which are required for fusion development and for beam weapons. The Soviets devote now about twice as many physicists to studying plasmas as the United States. As *New Solidarity* has reported many times, the quality of the plasma physics research in the Soviet Union is considerably superior to that in the United States. The well known accomplishments of Rudakov in the development of electron beam fusion and the theoretical and experimental work on the Soviet Tokamak program under the direction of Boris Kadomtsev indicate the Soviet lead in this area.

The distinguishing feature of Soviet plasma physics is a willingness to tackle difficult problems in a physically rigorous way. The recent Trieste conference on plasma physics is exemplary: at this meeting several groups of Soviet plasma physicists presented new results on the types of self-ordered structures which magnetospheric plasmas can support. These scientific papers were done as part of the fusion development program and conceived of as a basic research problem.

Better Read Than Dead?

To a certain extent it is *because* of the Soviet Union's lack of industrial elaboration that they have usurped "Yankee ingenuity." Faced with a problem that must be solved but for which the industrial "brute force" tools are not available, a better, more efficient, or cleverer way must be found. Out of necessity the Soviets have pursued basic science and industrial development as aggressively as they have.

But the astute observer will note: this is exactly where "Yankee ingenuity" came from — the same

commitment to progress, the same brash, aggressiveness, and the same willingness to face the challenge of unsolved problems with a combination of intelligence, cleverness and hard work.

It is *this* tradition of the American Revolution that built the United States into the greatest industrial and military power the world has seen — but only, to the extent that this power was motivated by the humanist commitment to progress. The only "national security" which we have ever had, grew out of, and was maintained by, that commitment to progress.

What does it mean, then, that James Schlesinger calls on all Americans to give up a belief in progress and growth, that James Carter calls on all Americans to support an energy policy which forbids the development of new energy technologies like fusion? What does it mean when this Administration proposes a budget which decreases the country's investment in basic science and then pursues policies which are leading directly and rapidly to a thermonuclear confrontation with the Soviet Union?

Some would call this treason.

I. Soviet Welding Breakthroughs

by Dr. Steven Bardwell

Of all the technologies required to perfect a directed energy beam weapon, it is welding that most clearly demonstrates the interconnections between an aggressive energy and industrialization policy and weapons development. In fact, without the Soviets' 20-year commitment to the development and the rapid industrialization of Siberia, the beam weapon they are on the verge of perfecting would likely have been impossible.

The amount of energy required for a working anti-ballistic-missile beam weapon is tremendous — more energy, in fact, than most countries produce *for all applications* would have to be diverted to the beam weapon while it was operating! The only presently available way of generating such quantities of energy is by means of atomic explosions. The problem is how to control the large, sudden burst of energy from the bomb.

The Soviets have taken a direct, simple approach — put the bomb in a big explosion chamber, where the explosive force will be contained; then the energy released by the bomb can be extracted at will. What is required is then technology for fabrication of a steel chamber, roughly 20 meters (70 feet) in diameter, with walls between 3 and 4 meters (10 to 13 feet) thick.

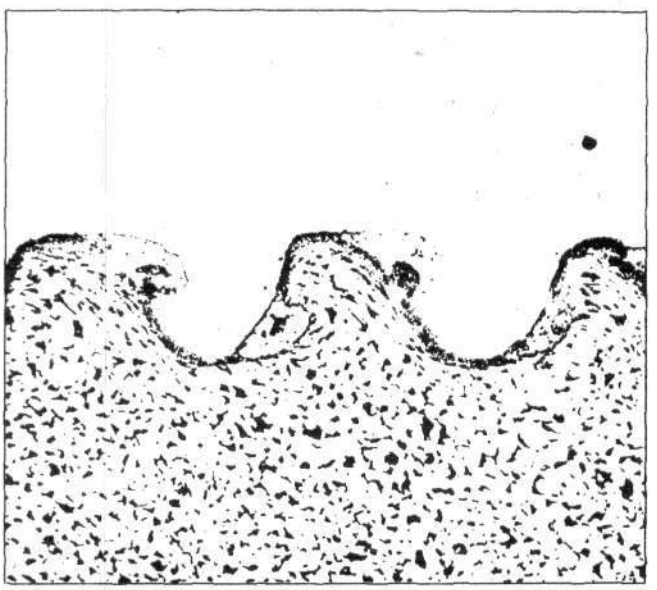
According to *Aviation Week* magazine, sections of just such a chamber have been fabricated in a secret Soviet research center, and have been taken into a granite cavity hollowed out near the research center. The unanswered question is: How did the Soviets weld a sphere of this size?

Explosive Flux Welding

All the welding experts contacted by the U.S. Labor Party Research and Development staff, both in industry and universities, agreed on one conclusion — *nowhere* in the West do the technologies exist to weld a sphere with walls 3 meters thick. However, many of them qualified their statement by saying that *the Soviets might be able to do it!*

In general, the Soviets have developed a number of technologies specifically for the fabrication, machining, and welding of very large metal parts. Of these technologies, explosive flux welding is the most ingenious, and it is very likely the technology which the Soviets used to assemble the explosion chamber for a beam weapon.

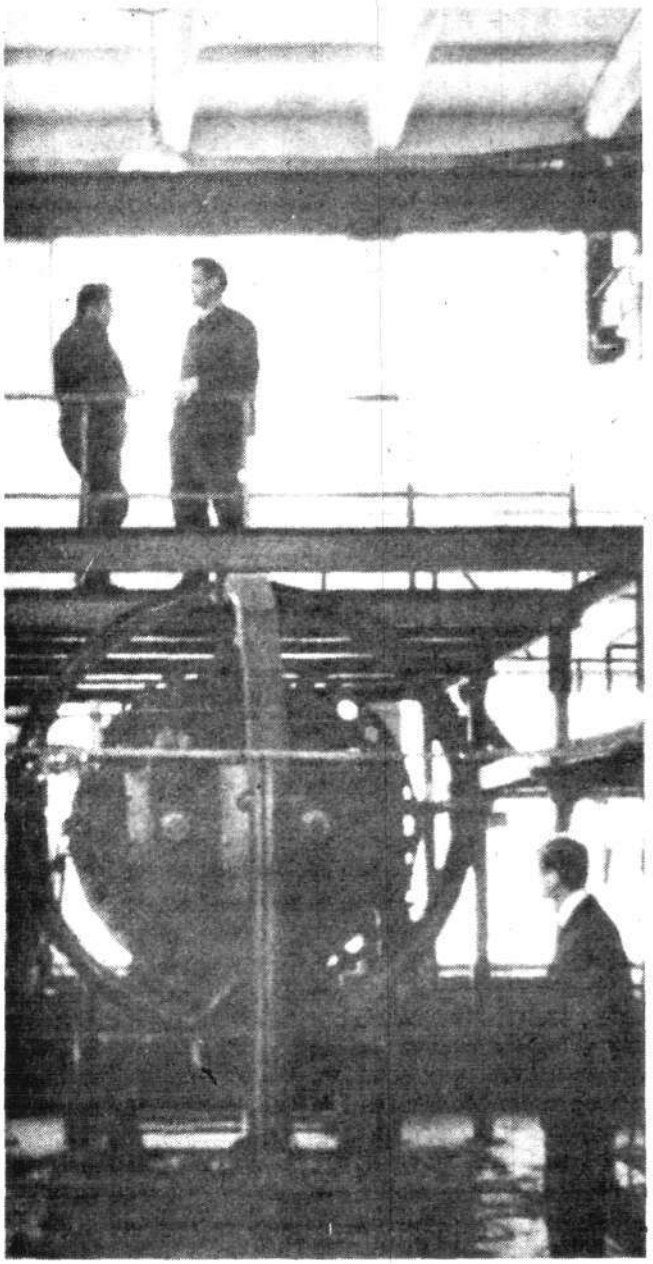
The story of explosive welding is intimately bound up with the career of a Soviet scientist, Mikhail Lavrentyev, the director of the Institute for Hydrodynamics at Novosibirsk, in Siberia, and founder and permanent president of the Siberian Academy of Science. Throughout World War II Lavrentyev was in-



Microphotograph of the interface of an explosive weld between an aluminum-bronze alloy and steel. The highly symmetrical waves of the interpenetrating metals are formed when the metal surfaces are forced together at tremendous velocities with pressures of millions of pounds per square inch.

volved in theoretical and experimental study of explosions. The immediate application of the work was war-related, but after 1945, he and a growing group of students continued their work on explosive phenomena for civilian applications.

At the Institute for Hydrodynamics, two lines of research were pursued which converged on the development of explosive welding and its unique capabilities. On the one side, Lavrentyev's group pursued a wide range of practical and experimental studies on explosive phenomena, with successful applications to river and avalanche diversion and engineering projects. In the course of experimental work on the physical effects of explosive shock waves on metals, it was accidentally discovered that two pieces of metal, if forced together by an explosion, do not bounce apart, but rather are welded together in a bond which is stronger than the weaker of the two metals!



An explosion welding chamber at the Institute of Hydrodynamics in Novosibirsk.

This has been described as accidental in most historical accounts of Lavrentyev's discovery. It was an "accident" that could only have happened, *and then been perfected*, in the course of a research program motivated, as Lavrentyev's was, by a crash program for the practical use of a new energy source, in this case explosions.

The first uses of the new technology were in the service of the Soviets' attempts to rapidly industrialize Siberia, where a major problem had been the maintenance of the long rail lines in an area of intense cold. Faced with the *necessity* imposed by Siberian development, what could have remained an experimental oddity was rapidly perfected as a technique for resurfacing Siberian rail lines; by means of a series of small explosions a continuous ribbon of steel was welded on top of the rail. After this success, the Soviets developed a large range of uses for explosive welding, most importantly as a way of welding large surfaces of metal. Explosive welding is the only known technique which would allow a 3-meter-thick sphere to be assembled. Lavrentyev has continued his involvement with Siberian development — he was the first scientist to move to Novosibirsk and he was the major organizer for the establishment of Novosibirsk as a Soviet science center and focus for the industrialization of Siberia.

The Science of Welding

The second and equally important line of attack on the study of explosive phenomena was theoretical study of shock waves and their propagation, which Lavrentyev's group pioneered. Lavrentyev himself is an applied mathematician whose specialty has been the study of the highly nonlinear effects which characterize shock phenomena in fluids.

The successes the Soviets were able to achieve in practical use of explosive phenomena, specifically in welding, came out of the theoretical work in hydrodynamics. The Soviets' work in hydrodynamics, and especially shock waves — both fields in which they are recognized world leaders — was successful because it is based on a philosophy different than similar research pursued in the United States.

In the U.S. research has proceeded along very narrow lines of inquiry, each motivated by a highly specialized problem. With this approach, solutions are usually found by numerical (computer) calculation from equations so complicated that no physical or mathematical insight is generated. This means that the "solutions" found are difficult to generalize. The field of hydrodynamics has become unfashionable in American circles; in fact, hydrodynamics is not even taught as part of the standard physics curriculum.

In the Soviet Union, in part because they lacked the larger, faster computers to solve hydrodynamics problems, the question of fluid phenomena had to be treated by different, usually classical, methods of mathematical physics. Faced with a problem which they could not solve by the brute force of a computer, the Soviets solved the underlying *conceptual* problem. This is "Yankee ingenuity" at its best: if you can't do it the old way, find a cleverer, more imaginative one. This attitude has not only allowed the Soviets to maintain undisputed mastery in the field, but has also generated a body of conceptions and synthetic approaches which lead to wide generalizations and new practical applications.

Explosive welding is an excellent example of the problems posed by shock wave phenomena in matter, which the Soviet methods are equipped to solve. The accompanying micrograph of an explosive weld between an aluminum-bronze alloy and steel indicates the important features of the hydrodynamics of the welding process. As the two metals are forced together under pressures of millions of pounds per square inch, the metal surfaces act like fluids and microscopic wave-vortex jets of metal (not molten!) are forced from each piece of metal. The resulting interpenetration of the two metals creates a cold-weld stronger than the weaker of the two metals welded.

Like all fluid phenomena, explosive welds are characterized by highly ordered and structured phenomena. The metal, acting like a fluid at these energy densities, changes the disordered motion of the explosion into a coherent regular vortex structure, which the photograph shows quite clearly. What kind of science is appropriate for understanding these ordered phenomena? The only body of physics which has had even limited success in providing deep, generalizable insight into self-ordered phenomena is classical hydrodynamics! The sort of mathematical physics pursued in the United States has offered only hints, in very limited context, of why these coherent phenomena occur or how to take advantage of them.

It is the estimation of a number of scientists that the self-organized behavior so clearly shown in an explosive weld, and characterizing more generally all physical processes involving large energy flows, actually portends a fundamental challenge to presently understood physics. The Soviets have made no such fundamental breakthrough in theoretical physics, but they have not avoided the evidence which poses this challenge.

The overwhelming tendency among scientists in the United States has been to "explain away" so-called anomalous self-ordering behavior. This is the critical difference between Soviet science and American science over the past 20 years. In the face of evidence which, most scientists sense intuitively, challenges the foundations of physics, does one react by blocking out that evidence? Or does one pursue the rigorous, conceptual implications of *presently* existing science, and then compare these implications with the experimental evidence of self-ordering phenomena?

II. MHD: From Nuclear Explosion to Electricity

by Marsha Freeman

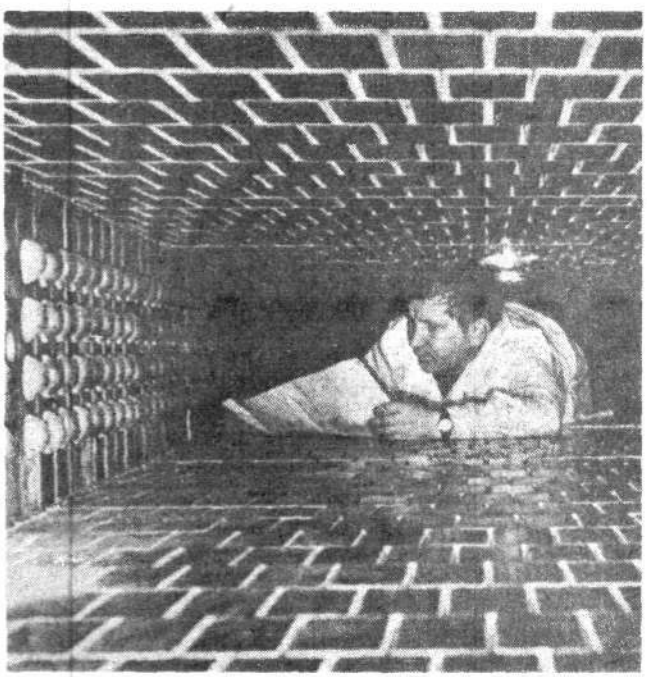
Based on their advances in theoretical plasma physics, the Soviets have undeniably "Sputniked" the United States in both fossil-fuel-based and fusion-based magnetohydrodynamics.

In 1962, at the First International Conference on MHD in England, two prominent Soviet scientists announced that the USSR had embarked on a program to develop commercial MHD. A.E. Sheindlin, the head of the Soviet Institute of High Temperatures, outlined a four-phase program which would bring the Soviets to commercial demonstration by the early 1980s. Academician E.P. Velikhov, the deputy director of the Kurchatov Institute of Atomic Energy and one of the most reknowned plasma physicists in the Soviet Union, presented some fundamental analysis of the thermodynamic and electromagnetic instabilities which could be expected under certain conditions in MHD plasmas. Both presentations have since been dramatically realized.

Soviet scientists' initial interest in MHD was for direct conversion of fusion energy to electricity (to be explained below), and the MHD work at the Kurchatov Institute has continued to focus on thermonuclear energy as the source of heat for an MHD generator. The Institute of High Temperatures' MHD program has had the parallel goal of demonstrating commercial feasibility of MHD using fossil fuel as the heat source. This latter program, now nearing the successful completion of its third phase, will bring a 1,000 megawatt commercial demonstration plant on line by 1982. It will be the only such plant in the world.

It should not be surprising to U.S. scientists and military intelligence personnel that the Soviets may also have developed an MHD generator fueled by pulsed fusion explosions, nor will such persons be unaware of the possible military implications. The operation of an anti-ballistic-missile particle beam would require a tremendous source of pulsed energy, invulnerable to attack and independent from commercial power grids. Since only thermonuclear explosions could satisfy those requirements and still provide the magnitude of energy needed, it would be necessary to develop a controlled way of converting that energy to electricity. It appears that the Soviets have effectively solved that problem.

In the case of fusion-based MHD, the Soviet Union has undoubtedly pursued both military and commercial applications simultaneously. Likewise, the unique success of the Soviets' fossil-fuel-based program demonstrates their commitment to carry through a 20-year scientific and technical perspective. Furthermore, it should be crystal clear — especially since it has been said directly by Velikhov and others — that it



Interior of the Soviet U-25's MHD channel. Electrodes are along the sides.

Marsha Freeman is a member of the U.S. Labor Party's Research and Development staff and of the Fusion Energy Foundation. Her articles, published principally in the newspaper New Solidarity, *have repeatedly scooped other science writers on the implications of Soviet work in magnetohydrodynamics (MHD), the Soviets combined basic research and high-level technological development projects in Siberia and other fields to predict several months ago the dangerous significance of the Soviet-U.S. "technology gap" documented in the* Aviation Week *exposé.*

is the Soviets' theoretical understanding of plasma behavior that is the basis on which all of their MHD work, both nuclear and fossil fuel, has been done. This is incomprehensible to many scientists in the United States only because U.S. work on MHD has never been done on such a rigorous scientific basis.

Originally the West was actually ahead of the Soviets in MHD. The U.S. MHD fossil fuel program was initiated by a handful of corporations, as early as prior to World War II. Researchers at Westinghouse, General Electric, and Avco Corporation began by experimenting with small generators, but by the mid-1960s only a government-supported program could have scaled up the experiments and solved the problems associated with a commercial program. The U.S. government chose to fund MHD research only in military and space applications, and the commercial generating designs were scrapped. These non-commercial applications, aiming for a short burst of energy for space propulsion or weapons and radar pulses, did not pose the problems involved in generating electricity for long durations that would have to be solved for utility use of MHD. As a result, when the Soviet Union announced in 1971 that their phase three pilot plant, the U-25, was now running, the United States was left on the short end of the technology gap.

Magnetohydrodynamics

The conventional thermal method for generating electricity is to burn a fossil fuel (oil, coal, or natural gas) and use that heat to boil water to produce steam. The steam then turns turbines that rotate through a magnetic field, producing an electric current. Because the fuel burns at over 3,000 degrees, but the turbine material can handle temperatures of only approximately 600 degrees, a good deal of the heat energy is dissipated and simply lost. As a result, thermal power plants operate at a rate of efficiency between 30 and 40 percent.

The development of fusion reactions and the study of the properties of plasmas (ionized gases) led scientists to postulate the following: instead of converting heat to mechanical energy (to turn turbines) that would then interact with a magnetic field to produce a current, a hot ionized gas could be pushed directly through a magnetic field, generating current essentially with no moving parts. The plasma, or working fluid, could be produced either by fusion reactions or by burning fossil fuels at extremely high temperatures. Electricity would be produced directly by the interaction between the electrical potential of the plasma and the external magnetic field.

In fossil-fuel-based MHD, the gas produced from burning the fuel does not completely ionize, so a "seed" — a metal with a low ionization temperature, such as potassium — is introduced to increase the ionization rate and the electrical conductivity of the plasma. Most commercial MHD designs are "open cycle," where the plasma, which has dropped about 1,000 degrees after going through the MHD duct, is then put through a further steam-turbine cycle similar to a conventional thermal generator. By thus using the plasma's heat "twice," efficiency is raised to between 50 and 60 percent.

In the case of coal-based MHD, the potassium seed, in addition to enhancing the ionization rate, also chemically bonds with any sulfur in the coal, therefore providing a pollution-free combustion process. Researchers at University of Tennessee Space Institute announced in May that 95 percent of the sulfur was removed by their MHD generator, and that they had developed ways to recycle the potassium seed.

The Soviet Lead

Early in May the Soviets' U-25 MHD pilot plant met the second criterion necessary to complete phase three — it ran continuously for 250 hours. It had already met the first test by producing a short period of current at 25 megawatts. The next and last criterion is testing with a superconducting magnet, which will be on its way in June from Argonne National Laboratory in Illinois. The use of superconducting magnets will be important to bring the "enthalpy extraction rate," the rate of efficiency of electricity extraction from the plasma, up to commercial standards. At present, the U-25 is operating at an enthalpy extraction rate of less than 10 percent. Between 20 and 25 percent is considered necessary, corresponding to a 50 percent or higher rate of thermal generation efficiency.

So far, the U.S. generator at the Avco Everett Research Labs has reached a 14 percent enthalpy extraction rate, which is now the best measurement internationally. In addition to the increased field strength of a superconducting magnet, increased efficiency depends on the electrode material, and the temperature and electrical conductivity of the plasma, which are the subject of continuing development efforts in the Soviet and the U.S. programs. Success has in large part depended on an international exchange of information and experience between the two countries.

After some data is generated from the magnet tests, the Soviets will be ready to begin phase four, the construction of a commercial demonstration plant of 1,000 megawatts, which will give them commercial feasibility by the early 1980s.

The Soviet natural-gas-based MHD generators will importantly augment their planned production of electricity through the use of nuclear energy at twice the efficiency of thermal generation. The Kurchatov Institute has already built small MHD generators for short-duration electricity production, which are being used for geological work in the Pamir Mountains in South Central Russia. Because MHD does not require

any moving parts or cumbersome equipment it can readily be applied where a mobile power source is preferable.

It would seem perfectly lawful, except perhaps to the naive, that since the Soviets are at least five years ahead of the United States in fossil-fuel-based MHD, they would likewise be significantly ahead of the United States in both fusion-based and weapons-applicable aspects of the technology.

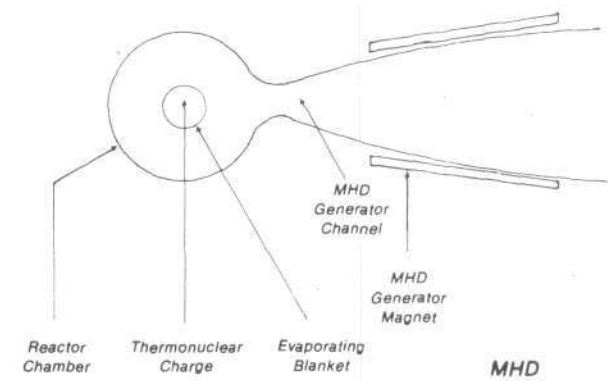
Pulsed-Fusion MHD

In a paper appearing in the April 1974 issue of *Atomnaya Energiya* titled "MHD Conversion of Energy From Pulsed Thermonuclear Reactors," Academician Velikhov and others clearly outlined the options for design of MHD generation from pulsed fusion reactions. These include either a conduction-plasma MHD generator or an inductive MHD generator. In both cases, it is assumed that the thermonuclear explosion will produce approximately 10 billion to 1 trillion joules of energy, or the equivalent of 2.5 to 250 tons of TNT. The working fluid for the reactor chamber in either option would be an alkali metal vapor, probably lithium, potassium, or sodium, which would surround the thermonuclear charge as an evaporating blanket. This blanket would be vaporized as a result of the fusion explosion and would be the conducting plasma sent through the MHD channel. Then the condensation of the liquid metal blanket would cool the chamber walls.

The conduction design is essentially the same as that described above for fossil-fuel MHD generators, with the vaporized metal as the plasma surrounded by a magnetic field, and with electrodes in the duct to collect the electricity (see *Figure 1*). The average electrical power generated during the pulse would be about 10 GW (gigawatts, or 10 billion watts), with maximum utilization of the internal energy of the plasma as it flows through the MHD channel at 25 GW, or about 5 percent of total current U.S. electricity production.

But there are problems with the conductive design, including heat losses to the chamber walls and the difficulty in ensuring that the plasma flows smoothly, which may require special technical apparatus. Moreover, there are problematic materials requirements for the internal electrodes and for the strength of the

Figure 1: Diagram of a conducting MHD generator for a pulsed thermonuclear reactor.



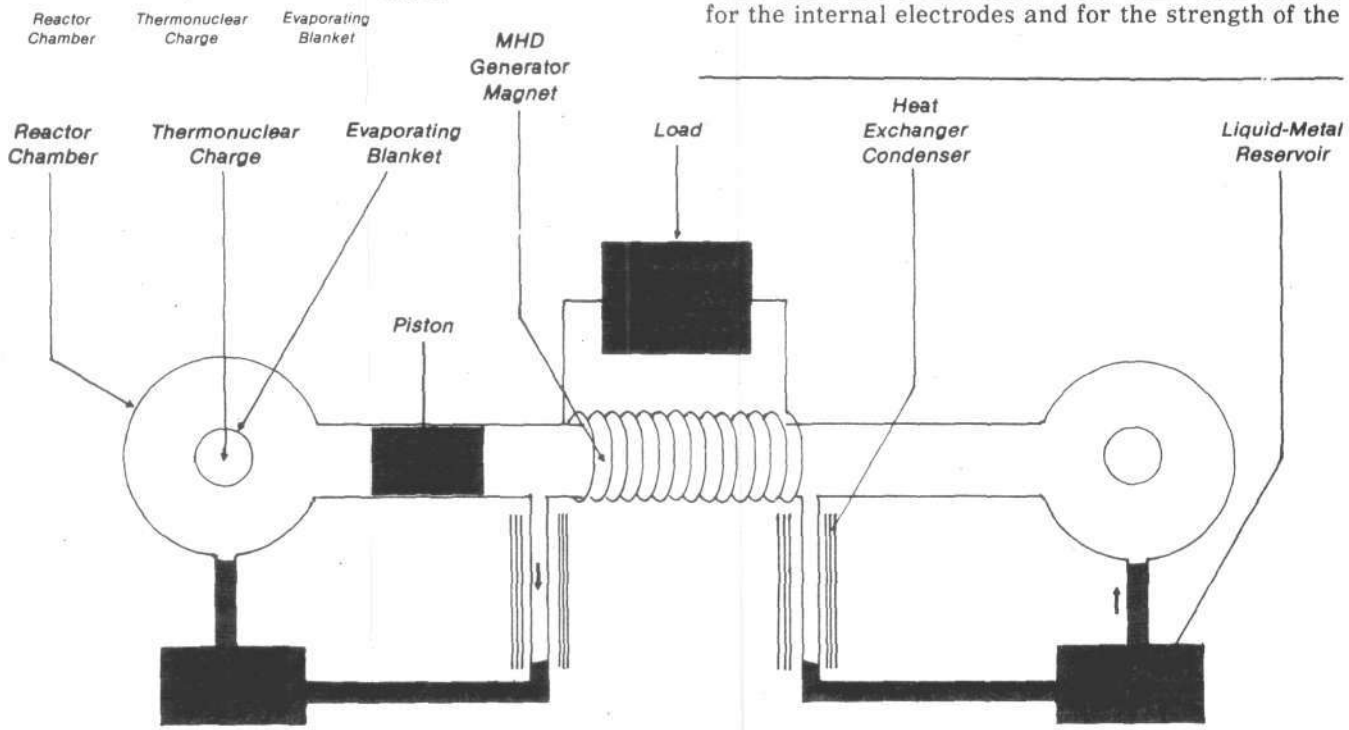


Figure 2: Conceptual diagram of an inductive MHD generator for a pulsed thermonuclear reactor.

external magnet in their interaction with the conductive plasma.

Due to these difficulties, Velikhov put forward the alternative of the inductive MHD generator, which he posits would be a more "logical idea" for pulses of power (see *Figure 2*). The inductive design entails a dumbbell-shaped apparatus with two explosion chambers separated by the MHD channel. It is, therefore, a closed-cycle system in which the liquid metal vapor is caught and condensed, and then recycled through the liquid-metal reservoir back into the reactor blanket to be revaporized. The metal vapor itself is not directly the conductive medium, but is needed to provide the mass in the plasma to propel a metal piston. This piston is in one end of the chamber, and when the explosion occurs the lithium plasma pushes it through the channel into the other chamber. On the way it is partially slowed down by the magnetic field surrounding the channel. The energy of this field greatly exceeds that of the piston, which is a metal conductor with a higher conversion efficiency (converts heat-energy to electricity more efficiently) than the plasma. The moving piston compresses the magnetic field of the magnet and transfers its energy directly to the magnet. Velikhov has projected that this inductive design would produce an average electrical power of approximately 15 GW, with efficiencies of conversion comparable to a steam turbine generator.

From Velikhov's work it is very clear that the Soviets are serious about the development of pulsed-fusion MHD and have done the theoretical analysis and experimentation necessary to assure its feasibility. A report done for the Rand Corporation by George Rudins in 1974, *U.S. and Soviet MHD Technology: A Comparative Overview*, also indicates that military-related MHD work has probably been going on at the Kurchatov Institute and that various types of liquid metal systems have been tested.

According to the *Aviation Week* article, some U.S. scientists have rejected as "improbable" evidence indicating that the Soviets have solved the problem of "flux compression," i.e., inductive MHD. But former Air Force Intelligence head General Keegan and his team of physicists, after a careful survey of the open literature, found that the Soviets had "long since solved that problem."

Switching and Transmission

A number of discussions on Soviet beam weapons development have raised the problem of storage, switching, and transmission of the electrical energy generated. There are several points which are relevant in this regard.

1) An accurate assessment of whether such hardware is necessary for the functioning of a beam weapon is unclear. The explosive MHD generator provides short pulses of electrical energy without the necessity of storage in a capacitor. The technical question of the timing and shape of the pulse is difficult if not impossible to answer without experimentation on the tremendously high energies involved. Thus, to make a statement about the "impossibility" of a beam weapon of this size because of the lack of capacitors and switching for energy storage is irrelevant.

2) The question of whether the Soviet Union or the United States is ahead in the technologies of switching or storage is one that we are unable to answer. Several Rand reports discuss this question, and consultations with a number of U.S. experts have also dealt with it. *In terms of* the energies required for a beam neither country has published any data within three orders of magnitude of these energies. However, the Soviet Union seems to be somewhat ahead in pressurized water capacitors and in the area of superconducting transmission lines for civilian (long-distance) use. The exact relevance of these technologies to the beam weapon is unclear.

3) In any case, the on-going intense research in these technologies, in both countries, has come almost entirely as a byproduct of fusion research projects.

APPENDIX TO I AND II

Project PACER: Unravelling the Myth of "Uncontrolled" Nuclear Fusion

by Charles B. Stevens

The very same week that *Aviation Week* detailed the intelligence data — satellite pictures, spectrographic measurements, etc. — that indicated that the Soviet Union had developed a fusion-powered, directed beam, anti-ICBM weapon, a system which most leading U.S. scientists and intelligence analysts had written off as "impossible," "a Buck Rogers fantasy," Carter's Special Energy Advisor James Schlesinger testified before Congress that as to the U.S. achieving practical fusion energy, "scientists have been predicting a breakeven point for fusion in five years for the last 25 years — if we ever breakeven I'll be surprised."

On May 6, a leading fusion researcher who also works on hydrogen bomb development, began his presentation at the Fusion Energy Foundation's New York conference with the following comment: "When I am asked when will the scientific feasibility of releasing net amounts of fusion be attained, I reply that in 1952 at Eniwetok the net release of 10 billion kilowatts of fusion energy (equal to more than the total electrical output of the United States on that same day in 1952) was achieved. The only remaining question is that of developing systems which make practical the use of fusion energy, though at the same time these systems may involve the most advanced scientific and technological problems to ever confront man."

Project PACER

Energy chief Schlesinger cannot plead ignorance or simple lack of information in defense of his congressional testimony. As the former director of the CIA and Secretary of Defense, hydrogen bomb development and fusion research were his day-to-day concerns. In fact, prior to the Rockefeller-engineered "Arab" oil boycott when Schlesinger directed the Atomic Energy Commission (later the Energy Research and Development Administration), scientists at the AEC's nuclear weapons laboratory at Los Alamos had completed initial studies that showed that practical generation of electricity and nuclear fission fuel could be attained by exploding small hydrogen bombs in underground cavities.

Technical progress in making cheap, clean bombs, and experience gained in underground tests throughout the 1960s, demonstrated that, contrary to the initial calculations made in the 1950s, economic, environmentally safe generation of energy using thermonuclear weapons was more than feasible. Schlesinger promptly placed these proposals under security wraps, although no classified weapons-related data was involved.

In 1974 and early 1975, at the urging of Dr. Robert Seamans, the director of ERDA, these proposals, known as Project PACER, were further analyzed and made public. Dr. Seamans' backing did not prevent the proposals from being quickly buried once more without even a minimal investment of a few hundred thousand dollars for continued conceptual investigation. The sole reasons given were not technical, but political. Once again, the scientists involved suspected, Schlesinger was responsible.

The Soviet PACER

While Rockefeller policymakers and project funders in the U.S. forbade even miniscule funding of "conceptual" work on the relatively crude, but effective PACER proposal, it is now apparent, given the *Aviation Week* report, that the Soviet Union was carrying out a crash program for the development of an *advanced* PACER system. The first public indication of such a program came at the 1974 Culham International Atomic Energy Agency Workshop on Fusion Reactor Technology. Included in the proceedings of this conference, published as a supplement to the journal *Nuclear Fusion*, Dr. E. Velikhov, director of the Soviet fusion research program, presented the Soviet design for an electron beam-driven pellet fusion reactor.

The reactor design, according to Velikhov's report, consisted of two sphere-like chambers which have inside diameters of approximately 10 meters, linked by a cylindrical tunnel. Every 10 seconds a thermonuclear explosion equal to 25 tons of TNT or about 20 barrels of oil would be set off by electron beams alternately in each of the spherical chambers. The fusion blast would vaporize several tons of lithium in the chamber and this would drive a large metal piston in the tunnel between the two chambers through an externally generated magnetic field. In this way, the energy of the blast could be converted to electricity with efficiencies of over 50 percent. The Velikhov design projected a total electrical output of over 5,000 megawatts of electricity, about 5 times the electrical output of a conventional nuclear fission reactor.

Given this design for electron beam pellet fusion power plants, it is not difficult to conceive of the possibility of small hydrogen bomb power systems working in the same way. The system would involve blasts equivalent to several thousand tons of TNT. Such a system was researched by the U.S. Labor Party's Research and Development staff, who, prior to the *Aviation Week* report, had calculated that the minimum size for such a hydrogen bomb-powered system would be approximately 18 meters in diameter, the same figure reported by *Aviation Week*.

Obviously, the life cycle of the chambers would not be long in the case of hydrogen bombs, lasting possibly through thousands, instead of the hundreds of thousands needed for an actual power plant. But with advanced technological development, even this may be possible. In any case, only a small number of cycles are needed for weapons applications research and limited experimental utilization.

Why Use the Bomb?

The director of one U.S. weapons lab, when interviewed recently, denied any connection between the U.S. PACER proposal and the system reported in *Aviation Week*. Another prominent scientist, who advises the Democrat Party and the Pentagon on nuclear weapons, admitted that it was quite probable that the USSR had developed the pulsed H-bomb power system reported in *Aviation Week*, but denied that this could be used as the power source for an intense proton beam accelerator. A third leading weapons scientist pointed out that an H-bomb was not needed to power a large beam weapon since the energy could be "built up" over a long period of time in a capacitor bank.

The question remains: Why use the bomb at all?

First, the Democrat Party-Pentagon advisor was correct, albeit in a negative sense. Merely using a pulsed H-bomb power system for generating intense proton beams would be wasteful. The thermonuclear blast itself offers a unique source of energy. Just one possibility would be to use the intense flux of neutrons from the thermonuclear blast as the pump for a gamma-ray laser, also known as the graser. As its name implies, this laser would have numerous weapons applications, just one being an effective anti-ICBM directed energy beam. But of far greater significance from a basic science standpoint is that the graser could be the most important scientific advance of the 20th century.

Other applications of an H-bomb power system would be the development of the x-ray laser; utilization of the radiation from the initial blast for generating much smaller and observable fusion microexplosions, ideal for studying the processes involved in thermonuclear fusion; the study of extreme high-energy plasmas; and particle beam experiments, including the possible generation of large amounts of anti-matter. It has been suggested by such plasma researchers as Heinrich Hora in 1975 that beam production of anti-matter together with the utilization of the anti-matter for initiation of fusion microexplosions could produce overall net energy gain.

Second, it has already been noted in the Nagle-Teplitz article, "Energy Parameters for Ground-based Laser-Powered ABM Systems," submitted to *Nature* in November 1975, that in order to develop any effective, directed energy anti-ICBM system one would necessarily have to utilize a substantial portion of a country's total electric power output during the periods the weapons are operated. The pulsed H-bomb system described in *Aviation Week* fits the bill.

Cheap, Clean, Safe Fusion Energy Now

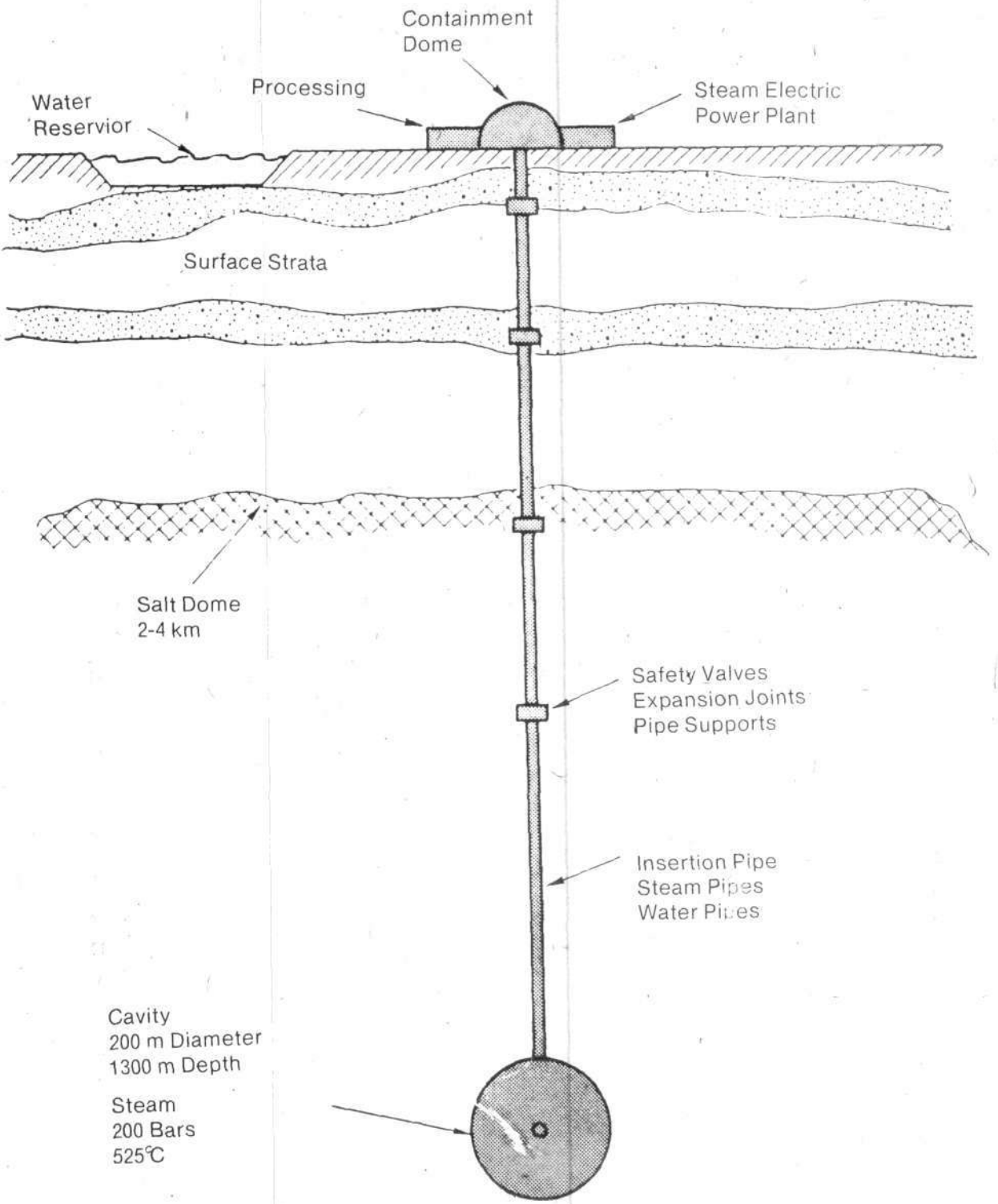
The basic outlines of a PACER power system are shown in *Figure 1*. Five, 20-kiloton TNT-equivalent hydrogen bombs are exploded per day in the 200-meter diameter cavity 1300 meters below the ground. The bombs are introduced through pipes. Through other pipes, 286,000 tons of steam circulate in a closed loop. The H-bomb explosions are sufficient to maintain the steam at 500 degrees centigrade, and to support a power output of 2,000 megawatts of electricity which is produced by steam circulating in a second closed loop running through a turbine.

The H-bomb also produces a sufficient number of neutrons to convert 9.5 kilograms of either uranium 238 or thorium 232 which is suspended in the steam and filtered out after conversion, into either plutonium 239 or uranium 233. PACER breeds enough fission fuel to keep 18,000 megawatts of Light Water Fission Reactors running during the time between each explosion.

Less than 5 percent of PACER's direct energy output involves fission reactions producing radioactive products since the main source of energy for the system is the advanced fusion reaction of Deuterium—Deuterium — a heavy hydrogen molecule. Less than 400 grams of radioactive fission products are present in the entire system at any given time; and that is continuously filtered out with the fissile fuel which is bred. This is less than 1 percent of the radioactive inventory which is present at any given time in a 1000 megawatt Light Water Fission Reactor (LWR).

The economics of PACER are even more impressive. According to the most recent 1977 studies done by R and D Associates and Los Alamos Laboratory, the capital costs of PACER would be between $500 and

Figure 1. Schematic Diagram of PACER



$800 per kilowatt, about half the cost of a LWR and equal to the cost of a coal or oil-driven power plant in current dollars.

Fuel costs are virtually nonexistent. One liter of sea water for the Deuterium, plus a few grams of thorium, both costing only a few cents, would produce the equivalent energy of 23 barrels of oil which cost $276 at present world prices. The cost of the bomb and construction of the cavity are a small fraction of the overall costs. Each bomb costs on the order of $25,000. Construction of the cavities is commonplace in the Gulf Coast and in Europe where they are used for the storage of gas and oil.

Thus, even with the most outlandish financing arrangements (20 percent interest loans and so forth), PACER returns 56 percent of its total capital costs in the first year of operation with energy and nuclear fuel taken at current prices.

The Major Questions

The Pacer system utilizes primarily off-the-shelf technologies — no new technological or scientific problems are involved. The only significant problem involves the dynamics of the 200-meter diameter cavity carved out of rock salt.

Previous tests with underground explosions, both nuclear and conventional, have shown that the cavity could withstand hundreds of thousands of explosions without breaking up or moving. The steam, as well, protects the salt wall from most of the radiation generated by the bomb blast. A large portion of the blast shock is reflected and contained within the cavity with less than 1 percent of the energy of the bomb going into a seismic shock. Both this seismic decoupling and the greater output of neutrons from a small Deuterium — Deuterium bomb are the result of weapons development work in the 1960s and were not known when a PACER-type system was first suggested in 1957.

Because of the nature of the geological formation in which the cavity is constructed, the rock salt wall is always under compression and acts similar to prestressed concrete. It is never driven beyond its elastic limits. Field tests would be necessary to verify the initial tests of the 1960s and more recent calculations and laboratory measurements, but everything known about the straightforward physics of the materials involved indicates that the cavity would hold up for more than the 30 year life of an average power plant.

The salt, furthermore, is virtually indissoluble in 500 degree Centigrade steam. The small amount which is melted on the surface of the cavity wall "heals" any cracks created within 20 minutes.

The 1977 studies on the PACER system are nevertheless quite conservative in their initial projections. But if, for example, the cavity can withstand 200 kiloton equivalent TNT blasts, a tolerance which still requires testing, the fuel-bomb costs could be decreased by a factor of 10. Bomb costs do not significantly increase with increase in size. The main cost in an H-bomb is the fission trigger, probably consisting of less than 1 kilogram of plutonium. But each bomb blast in a PACER system creates about 10 kilograms of fissile material. PACER not only promises to lead to substantially decreased costs for electrical energy, but can decrease that cost by factors of 10.

The studies also note that the system would be limited to certain geological formations, but its main output would be fission fuel for Light Water Fission Reactors. Ten PACER systems would produce sufficient nuclear fuel to run all existing reactors and those under construction in the world, putting out at the same time 80,000 megawatts of electricity for area industrial and agricultural development projects.

III. The Relativistic Electron Beam Angle

by Charles B. Stevens

It has been suggested by many concerned scientists that the focus on radar development during World War II actually delayed the onset of the solid state electronics revolution which has given us such wonders as hand-held computers, wristwatch TVs, and literal eye-of-the-needle radio transmitters. This, these scientists say, was due to the fact that researchers' attention was focused on electronic tube development.

Yet history has turned the tables, for the relativistic electron beam (REB) diode, the great-grandson of the Fleming valve and Crookes tube, is already leading directly to the harnessing of nuclear fusion energy and beyond the frontiers of 20th century mathematical physics.

Both aspects of the REB diode are crucial to the Soviet development of a proton anti-ICBM beam weapon: the first, in its potential in developing a portable power supply; the second, in its potential to provide the means to generate an intense beam of high energy protons.

Electron beams are actually commonplace in our day-to-day life. A good color television uses a 30,000 volt electron beam to produce the image on the screen. *Figure 1* gives the basic outlines of a diode — actually a triode because of the intervening grid — in a well known form — the electronic tube. As electrons flow from the cathode through the grid to the anode plate, a small negative potential on the grid interrupts the electron beam flow. In this way the tube can act as an amplifier, amplifying an electrical signal transmitted to the grid. In REB diodes the electron beam modulates itself through its generation of intense magnetic fields and energy-dense plasma structures.

As tubes are made with electron beams of increasing power levels, modulation of the beam by a grid leads to the transmission of bursts of microwave electromagnetic radiation. It was in the development of higher-power diodes for microwave radar that scientists were led, in the West almost accidentally, to relativistic electron beams.

Power of a World

Some measure of the distinction between the electron beam in your home TV set and the REBs used by scientists in fusion research can be derived from the fact that during the time that the beam flows (usually much less than a millionth of a second), it has more electrical power than all of the world's industry combined. Instead of the thousands of volts in your TV, the REB has millions. Instead of a fraction of an amp, millions. Instead of a few watts, trillions.

The first problem in building an REB is to find some means of feeding it this level of electrical power. This is accomplished by slowly building up energy in a bank of capacitors and then suddenly dumping the charge into the REB diode. As the intense electrical pulse travels from the capacitor bank to the diode it can be shaped and further intensified. In so-called pellet fusion research the resulting beam is used to

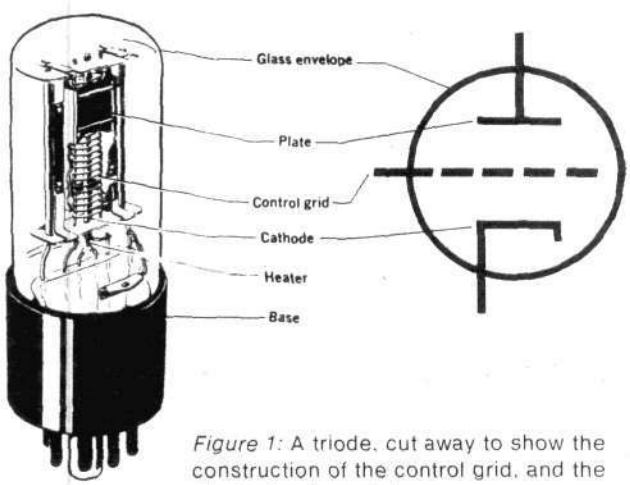


Figure 1: A triode, cut away to show the construction of the control grid, and the triode circuit symbol.

Charles Stevens, a member of the U.S. Labor Party's Research and Development staff and the Fusion Energy Foundation, is a leading reporter on international developments in fusion research. Stevens was primarily responsible for the only reports which competently predicted the Soviet electron beam fusion research breakthroughs and the commentaries on the Soviet physicist L.I. Rudakov's disclosures concerning those breakthroughs.

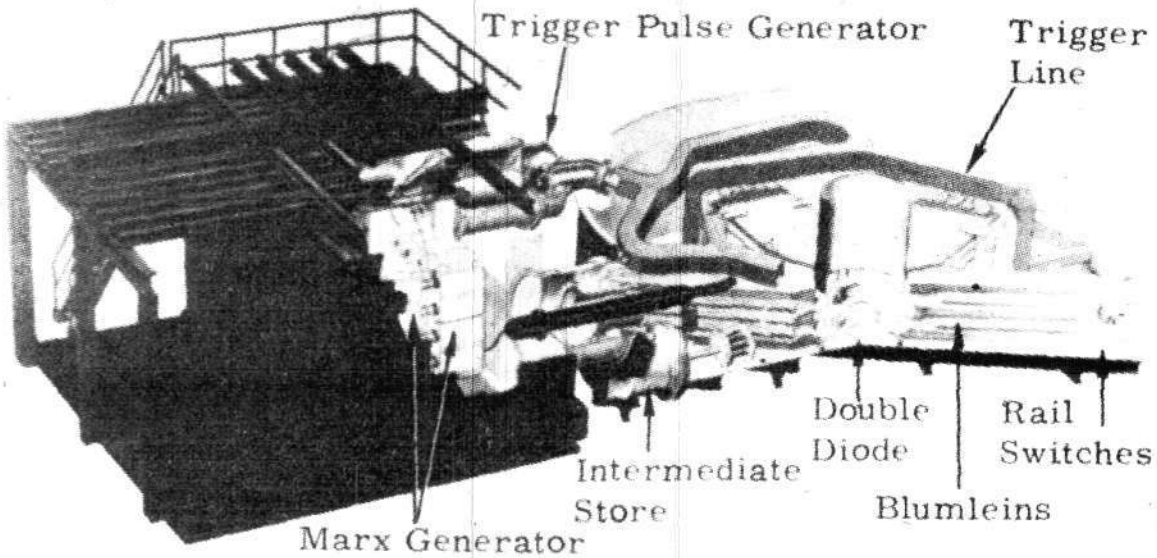


Figure 2: A schematic of Proto-1 at Sandia Weapons Laboratory.

compress and heat a small pellet of fusion fuel, triggering thermonuclear fusion.

Figure 2 is a diagram of Proto-I, the REB machine utilized at Sandia Weapons Lab in Albuquerque, New Mexico for electron beam pellet fusion research. Proto-I develops an electron beam of 3 million volts, 800,000 amps, and 2.4 trillion watts, lasting 24 billionths of a second, in the diode. The beam is focused to a few millimeters in the diode, giving power densities of several trillion watts per square centimeter, which of course normally burns a hole through the anode plate.

Laser beams have attained much higher power densities, on the order of ten million trillion watts per square centimeter. But in the generation of intense laser beams over 99 percent of the energy invested into the laser is lost as heat, while REBs are 50 to 70 times more efficient, losing only 30 to 50 percent of the energy invested. By utilizing particular diode geometries and pulse shapes, new types of plasma structures are generated in the diode which efficiently focus the REB to higher power densities, and even lead to the efficient transformation of the energy in the REB into electromagnetic radiation, as was done by Soviet fusion scientist L.I. Rudakov.

Besides efficiencies greater by orders of magnitude, REBs have also attained total energy outputs thousands of times greater than short-pulse, high-power lasers. Both of these factors are crucial for the development of fusion reactors.

First, the total energies needed to achieve high-energy-gain fusion pellet microexplosions are known to be on the order of a million joules. High-power lasers have only attained outputs of a few thousand joules, while REBs have reached multimillion joule discharges.

Second, to attain net energy production the fusion energy released in the pellet microexplosion must be greater than the energy invested to create the beam. For existing lasers this means that gains much greater than 100 in pellet-fusion energy over beam energy are requisite, while REBs have only to attain gains of five to ten. (It should be noted, however, once gains of greater than five are obtained, the first microexplosion's energy can be used to drive even a second, larger microexplosion. But obviously, the more efficient the system is to begin with, the greater the total gain from such "cascading" amplification.)

Soviet researchers, led by L.I. Rudakov, are currently building a 5 million joule REB at the Kurchatov laboratory in Moscow which will be the experimental core of a fusion reactor in 1980. While the USSR is spending over $100 million just on this facility, called the Angara V, the Carter Administration has cut back all U.S. REB fusion research to just a couple of million dollars and postponed the construction of the next major U.S. REB fusion facility at the Sandia lab.

Beating the Alfven Limit

Electrons in an REB travel at over 99 percent the speed of light. It is for this reason that they are called *relativistic* electron beams. At these velocities, according to Einstein's theory of Special Relativity, the electrons' masses increase substantially. For over 40 years such high-speed beams have been produced by physics researchers, but only at currents (i.e., number of electrons in the beam) much less than an amp. Since the strength of the magnetic field produced by an electrical current, including a free one such as an REB, depends directly on the current, the REB, with up to million amp currents, produces a gigantic magnetic field. The magnetic field wraps

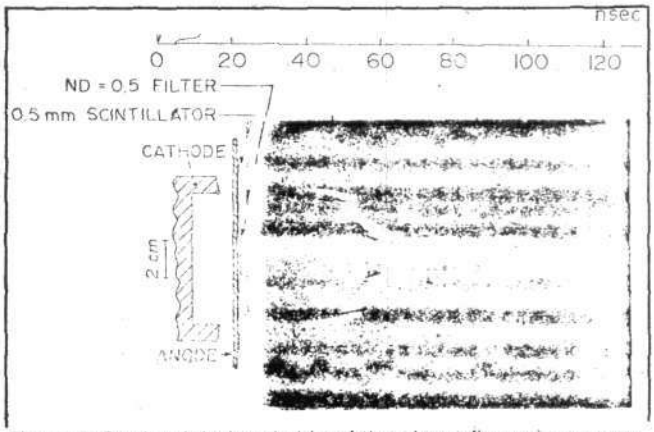


Figure 3: On the right-hand side of the above figure is a cross-section view of an REB diode. It produces a hollow ring of electron beams which crack the Alfven limit. On the left is a streak photograph of the radiation output of the REB as it transits the diode gap. Time is shown in units of nanoseconds in the scale above the photo. Note that the ring of beams collapses at about 50 nanoseconds into the discharge.

around the beam like a coil, and at sufficiently high current densities the magnetic field will first "pinch" the beam to even greater current densities, producing still greater magnetic fields, and then even turn the beam around on itself.

Given the above considerations, simple calculations show that there exist current densities at which the REB does not propagate (i.e. at which it is turned around on itself by the magnetic field). This is termed the Alfven limit, and it is measured by the ratio of the energy in the field versus that in the beam current.

In the early 1960s researchers in the West, seeking higher-power beams for microwave radar applications, were experimentally confronted by the REB pinch effect and the Alfven limit. At first these researchers went to great pains to circumvent what they termed an "anomalous" effect. Extremely large, externally generated magnetic fields were applied to the diodes in the opposite direction to the magnetic field generated by the REB in an effort to cancel it out. But as higher power levels were attained, the REB simply overpowered the relatively miniscule "external fields" and the anomalous pinch reappeared with a vengeance.

A handful of curious U.S. researchers, at small research and development companies such as Physics International, Maxwell, Field Emission Corp., and Ion Physics, and in the corners of the larger weapons labs, in particular the Naval Research Laboratory in Washington, D.C., decided to pursue this anomaly.

A 1974 Canadian government report on fusion research gives the following background on REB development in the mid-1960s: "The magican (sic) was J.C. Martin of AWRE Aldermaston (the nuclear weapons laboratory in Great Britain — ed.) who mysteriously enough has not published in the open literature... It has been somewhat typical of the field that the experimental achievements in (beam) gun operation have outshipped (sic) the theoreticians' understanding; to a lesser extent, the same is true for beam propagation."

Actually "Charlie" Martin has written extensively on the subject, and every leading researcher in the field has large bundles of his *handwritten* notes.

It was not until the Soviets began a well publized REB fusion effort in the early 1970s that, just as in the case of laser pellet fusion, a similar but much smaller program was initiated in the West. And given the recent experimental results achieved by John Luce of California's Livermore Laboratory and those discussed by Rudakov during his recent visit to the U.S., the theoretical lag is even greater today than in the early 1970s.

Hollow Cathodes

What "magician" Martin demonstrated was that the Alfven limit could be beaten with hollow cathodes. As can be seen in *Figure 3*, which shows a cross-section of a hollow cathode-diode (from a front view it would simply be a ring), a hollow cylinder of electron beams propagating from the edge of the hollow cathode travel across the diode gap to the anode plate. About 50 nanoseconds (one nanosecond is a billionth of a second) into the discharge, the cylinder pinches the beams together to extremely intense levels within a few nanoseconds. (In fusion experiments the target pellet is placed on the anode.)

In the West, REBs were almost exclusively developed for generating high levels of radiation (x-rays) to simulate nuclear weapons effects. The full story of the Soviet development of REBs has yet to be revealed, but judging from their recently announced experimental successes in fusion-related areas and their extensive public basic research efforts in REB, it is doubtless the story of one of the largest crash scientific efforts in the 20th century. Just one further indication of that fact is the persistent rumor that in the middle of Moscow there is a secret REB lab, larger than any other single experimental facility in the world.

The intense energies contained in focused or self-pinched REBs are a potential tool for the production of large amounts of "anti-matter" — such as positrons. These particles appear identical to electrons except for being positively charged. When electrons and positrons collide, both are annihilated and converted into energy. Conversly, intense energy can generate such positron-electron pairs. The generation of large quantities of positrons could open up tremendous new areas for experimental research into the basic structure of matter, including, for example, the resolution of the paradox that although matter and anti-matter are observed to be created in equal amounts in the laboratory, in the universe almost no anti-matter occurs naturally. The eventual "practical" or technological implications of such research

could eventually overshadow even the present profound impact of electron beam technology on fusion power generation, let alone its application to the Soviet beam weapon.

From a simpleminded interpretation of the energy-density-throughput criteria established by Soviet physicist Kapitsa, the REB would appear not even to be in the same ballpark with intense laser beams since laser beams can readily achieve power densities millions of times greater. Yet the unique plasma structures, discussed in the V.N. Tsytovich 1976 *Physica* review and the article by Dr. Winston Bostick in the recent *International Journal of Fusion Energy*, produced by REBs and the efficiently achieved total energy outputs give the REB the advantage in readily attaining extremely dense, high temperature fusion microexplosions. This results in power densities thousands of times greater than that of laser beams, in the core of the fusion microexplosion. Several researchers have suggested that under these conditions, large amounts of anti-matter can be produced.

It is the capability of attaining fusion microexplosions to which M. Currie, former director of the U.S. Defense Research and Engineering office, was referring when he pointed out in 1976 that the Soviets could leap-frog sophisticated U.S. technology in short-duration pulsed-power generation by concentrating on the "front end," the fusion microexplosion.

The most profound aspect of REBs is the fact that despite their mundane appearance (see *Figure 1*), they readily produce what is virtually incomprehensible to prevailing conceptions of matter-energy. The propagating beam itself produces gigantic electromagnetic fields, which, according to the Luce experimental results and indicated by Rudakov's description, act on the beam such that self-subsisting structures are formed. These structures can in the first approximation be viewed as filaments in which the electrons spiral along the lines of their own self-produced magnetic fields and reflect back straight through the middle of the coil.

This leads to the well-ordered production of gigantic electric fields. By properly configuring these filaments, fields much larger and more efficient than those previously generated by man can be attained. In this way (collective acceleration), high current proton beams can be readily and efficiently produced. At the Naval Research Laboratory for example, the Gamble II REB is utilized to produce million volt proton beams with currents of tens of thousands of amps. However, the U.S. base of REB research is currently a few score scientists and a scanty million dollars.

IV. Collective Ion Acceleration: How the Beam Works

by Dr. Steven Bardwell

Since at least 1960, the Soviets have stated publicly that the development of a high-energy ion beam is one of their top priority technological goals. Such a beam, they estimated, could be the basis for a "technological revolution."

There is good evidence that the Soviets were attempting to develop such a beam for civilian uses until about 1967 when the first experimental results were made available on the generation and control of a partical beam. The experiments were so successful that it was clear to the Soviets that such beams had military applications and at this point a concerted, but much more secret, program of research was initiated.

It is ironic that, with this information in the catalogue of any complete library, American scientists should still have given General Keegan the assessment that is "impossible" to develop a high-energy particle beam for weapons application. One high intelligence official is quoted as saying: "One of the problems is that some U.S. intelligence officials and scientists have difficulty in understanding the concepts involved. The technology is simply beyond their comprehension."

As *Aviation Week* sarcastically implies, it is a well-known secret that the U.S. is years behind the Soviets in the mastery of plasma technologies. This is the most basic fact behind the inability of U.S. intelligence to accurately assess Soviet work.

The link, in personnel, expertise, and scientific progress, between the beam weapon and fusion-related plasma research, is clearest in the case of the technologies required to accelerate the beam itself. Suppose, on the basis of the evidence presented in this pamphlet, that the Soviets can tailor an *electron* beam with energies in the range of thousands of tons of dynamite. The problem is to convert that electron beam energy into a proton beam. This is desirable for much the same reason that a high caliber weapon is more effective than a shot gun — it is easier to guide and control a heavier bullet than a multitude of much lighter ones, even if the energies of the two are the same. Since the electron weighs about .0005 as much as a proton, the proton beam weapon is preferable.

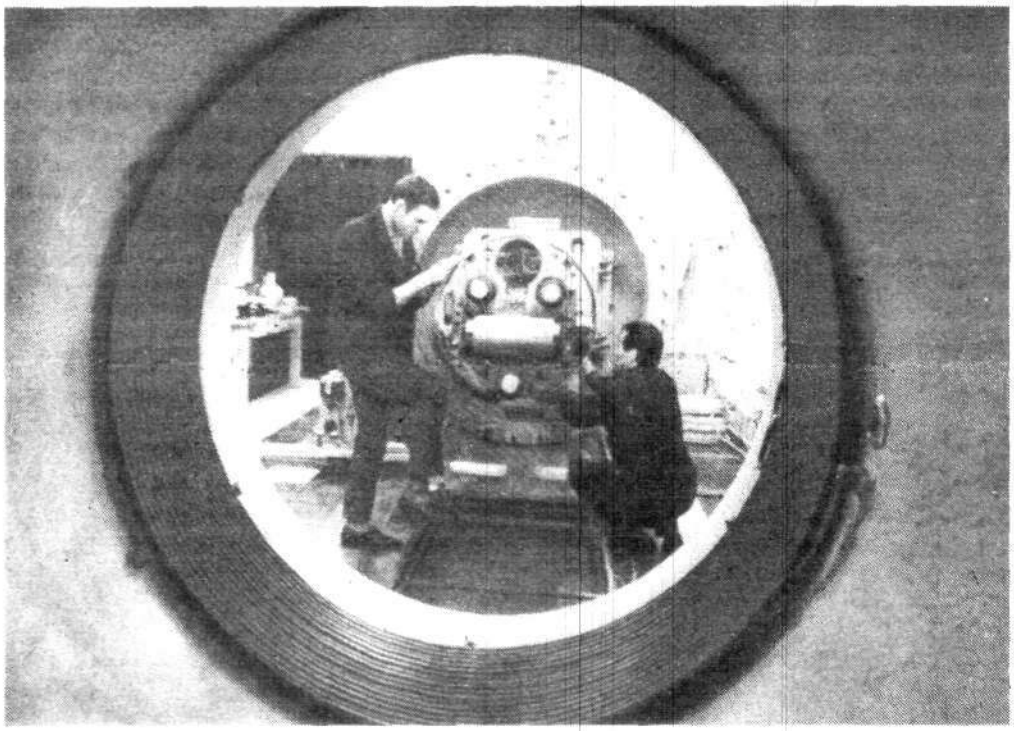
Accelerating the Proton Beam

The Soviets have pursued a number of approaches to the problem of accelerating and controlling a beam of protons. But two of these are especially well documented: the team studying "collective acceleration" under A. Plyutto at the Sukhumi Physicotechnical Institute in Georgian SSR, and the group studying "cooled proton beams" under the direction of Gersh Budker in Novosibirsk.

The first successful demonstration that an intense, relativistic electron beam could transfer its energy to a beam of protons was done by the Plyutto group. The phenomenon they discovered is so bizarre that it is not understood. To appreciate the strange properties of "collective acceleration," first imagine an analogous situation in a fluid: When a jet of water is shot into a body of still water, the organized motion of the jet very quickly disappears. The body of water absorbs (as heat energy) the energy of the jet of water.

But a plasma behaves differently. When a beam of relativistic electrons is shot into a plasma, there is an interaction between the electrons and the plasma whereby the electrons preferentially transfer their energy to the heavy particles (the ions) in the plasma. The beam drives up a "pancake" shaped disk of ions that precede the beam as it propagates through the plasma. This self-accelerating bunch of ions can absorb, in overall terms, the energy of the beam very efficiently. More importantly, the energy of the individual ions can be up to 30 times that of the electrons that initially entered the plasma. Imagine putting a hose into a swimming pool, and getting out a high velocity jet of water at the other side of the pool (traveling 30 times faster than the water coming out of the hose)!

The description of this sort of self-organizing phenomenon presents contemporary physics with a serious challenge: Physical theory today is based (both rigorously and in a conceptual sense) on the "common sense" perception that physical phenomena in general run down. The natural direction of all phys-



Academician Gersh Budker

Personnel at the Institute of the Physics of Semiconductors prepare to start an accelerator.

ical processes seems to be towards greater uniformity and greater disorder. How is a process, such as collective ion acceleration, in which the energy in the system becomes highly ordered, to be described by this physics?

The Soviet plasma physicist V.N. Tsytovich, in an article published in early 1976, for example, identified collective acceleration of ions (and the pancake structures he called "acceleratons") as one of a number of striking features of plasma behavior which seemed to demand new concepts in physics.

The reaction of the mainstream of plasma physics in the U.S., when confronted by the problem of self-organizing phenomena in plasmas, has been a quite hysterical avoidance of the problem, of the form of labeling these phenomena "anomalous," of attributing their formation to quirks of experimental set-up, and the like. These phenomena have not been studied as some coherent body of effects which, in fact, have the greatest practical importance and scientific significance.

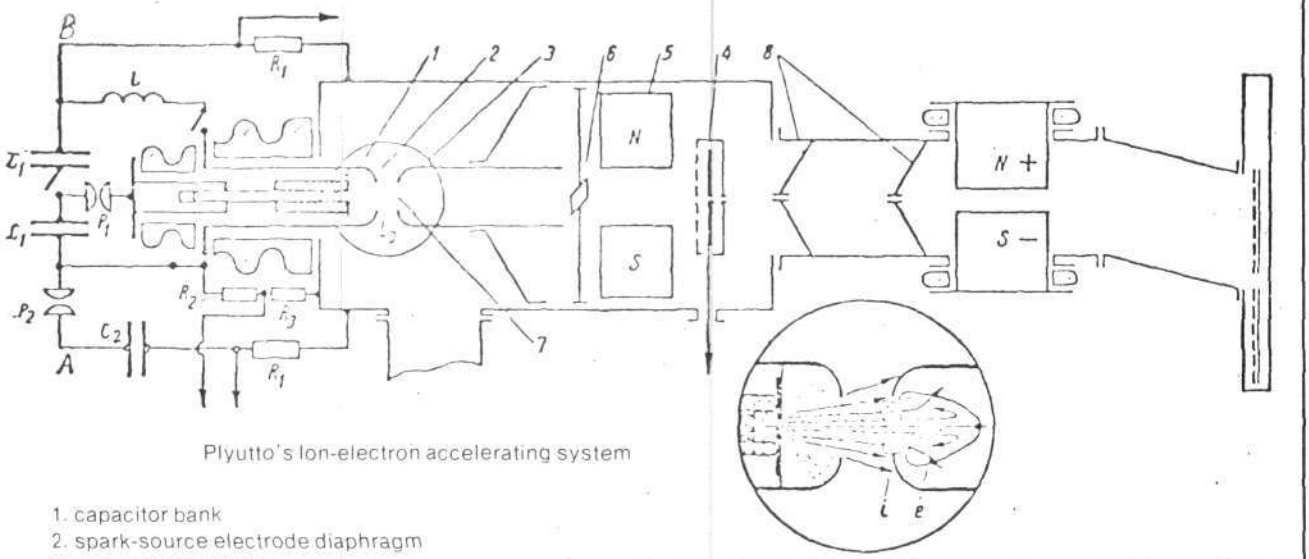
The phenomenon of collective acceleration has still not been satisfactorily theoretically described in either the Soviet Union or the United States. But the Soviets are making use of it nonetheless.

The group at the Siberian research center under Gersh Budker has pursued a different concept for solving the problem of beam acceleration. In Budker's accelerator, the chief object of research has been focusing and concentrating the beam of protons. This group has used plasma phenomena to create a beam of "cooled protons," so-called because of the small amount of random (heat) energy left in the beam after its focusing.

The problem that the Novosibirsk group was attempting to solve in the control of proton beams is due to the electrical repulsion that the protons exert on each other since they have like charges, a repulsion which results in the beam spreading out as it travels. If this natural spreading of the beam is not overcome, the energy in the beam becomes so diffuse as to be useless.

In 1967, Budker proposed a method which used electrons to control the repulsion of the protons. At a 1967 scientific meeting in the United States, Budker described in detail the concept which his group had been working on for "cooling" proton beams and was laughed at by American scientists. One researcher at the Brookhaven National Laboratory, after he heard the recent reports of Budker's successful experiments in Novosibirsk, commented: "We have egg on our face. When Budker described these ideas ten years ago, we thought he was crazy." Attempts are now underway at several laboratories to duplicate Budker's successful application of his focusing idea.

Basically, Budker proposed to use the mutual attraction of the ions and electrons to have the electrons take up the thermal (disordered) energy from the protons. His experiment generates a pulse of electrons which accompany the protons being accelerated (that is, he is accelerating a *plasma*). Since the electrons are much lighter than the protons, they



Plyutto's Ion-electron accelerating system

1. capacitor bank
2. spark-source electrode diaphragm
3. accelerating anode
4. collector
5. electron-beam deflection magnet
6. beam aperture
7. electrode aperture
8. collimating diaphragm of mass spectroscope

A. unipolar voltage
B. a-c voltage

ℓ accelerating gap

preferentially absorb the proton motion perpendicular to the beam direction. There is a tendency for all the particles in the accelerating plasma to have the same random, equalized *energy* distribution in the direction perpendicular to the beam: thus, the lighter electrons will be moving much faster than protons with the same energy in that direction. These electrons will then leave the beam, carrying the perpendicular "thermal" energy with them.

The result of this interaction between the electrons and protons is a very rapid removal of the random heat energy from the proton beam, and a concentration of the proton beam by factors of a hundred. With focusing of this sort, the major technical control problem of a beam weapon can be solved, at least in theory. Since the beam must travel hundreds of miles to intercept a missile, a spread in the beam of more than a fraction of a percent can disperse the energy of the beam. Budker's method of beam focusing is critical for a working beam weapon.

There are two features of Budker's research which are exemplary of the Soviet research effort which resulted in the development of the beam weapon. First, the original impetus for Budker's work came out of the need for a "cheap" particle accelerator which could be applied for medical treatment, sewage treatment (similar to experiments being conducted in the United States in this area), and industrial processing. Particle beams, if they could be generated cheaply and in a highly controlled fashion, would be invaluable in each of these areas. It is very likely that the military application of this technology emerged from successful experiments first undertaken in the context of an aggressive industrial development research program.

Secondly, the fact that Budker is using *plasma* physics in what is usually called "particle physics" is very striking. In the U.S., there is almost an hermetic division between particle physics, which deals with the interactions of single, high-energy "elementary particles," and plasma physics, which deals with the collective interactions of some of these particles. No such division exists in the Soviet Union. This is the reason American scientists thought Budker was crazy.

It is interesting to note that there is one American group pursuing the connection between plasma and elementary particle physics. Under the direction of John Luce, at the Lawrence Livermore Laboratories, their work on collective acceleration is among the best in the U.S. Most significantly, however, this group is the proverbial "exception to the rule." The theoretical work that Luce has been involved in has been contrary to the mainstream of U.S. plasma physics research, dealing with the highly organized structures that the plasma creates. His work on these self-ordered phenomena in accelerators, electron beams, and lightning are all exemplary.

The Soviets' success in weapons development is the result of a very broad "interdisciplinary" scientific research program exemplified in both of these approaches to beam acceleration, *and* the result of the industrial focus then given to this scientific effort. When a country begins to give up a commitment to progress, basic science research and industrial research, even military weapons development becomes "impossible."

V. Beam Guidance and Propagation

by Dr. Steven Bardwell

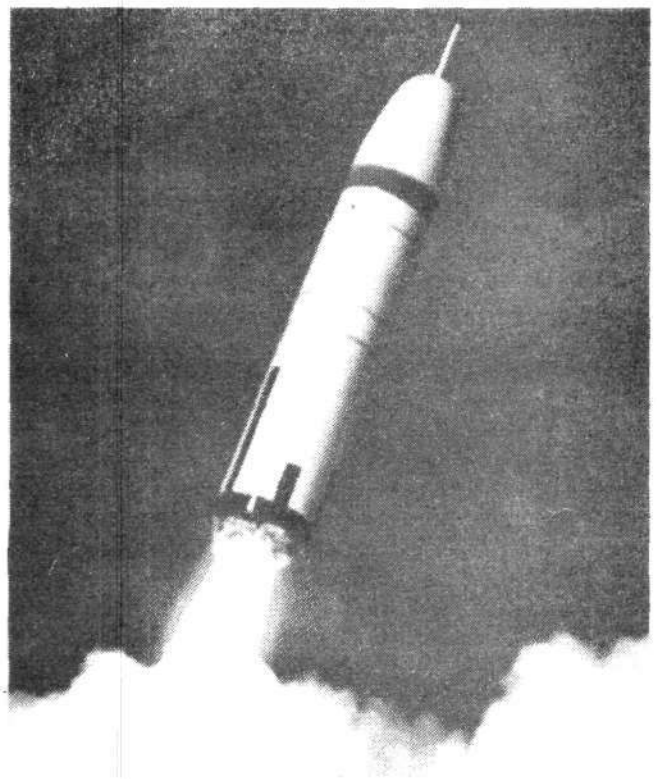
The final, and perhaps most difficult, problem that must be overcome in the development of a charged particle beam weapon is the guidance and propagation of the beam itself. The difficulties in this process of using the beam energy to destroy an incoming missile are, in fact, what seem to have led most U.S. researchers to discount the possibility of the Soviets having a charged particle beam weapon. There are several interconnected features of the guidance and propagation of a beam which must be unraveled.

In the first place, and contrary to some published rebuttals of Major General George Keegan's documentation of the beam weapon, guidance of the beam is not a classical problem of "shooting at a fly with a BB gun in a tornado." As is clear from the earlier discussion, a charged particle beam weapon does not shoot at a target individually. Rather the tremendous energies carried by the charged particles can destroy any missile in a target area roughly a half-mile on a side. Thus, the beam must be aimed not at a specific target, but only at the "window" through which any missile must pass to hit a known area. In the case of a city such as Moscow, an adequate ICBM defense could be effected by aiming the beam weapon at the region of the upper atmosphere which any missile targeted to hit Moscow must pass through. Since ICBMs are not maneuverable, when they approach one of these "windows," the beam can spread its energy over a large area to destroy all the missiles in the window at that time.

The most frequently voiced objection to a beam weapon is that such a collection of ions could not be propagated through the atmosphere. The claim is made that either the atmosphere would interact so strongly with the beam as to diffuse its energy, or the magnetic field of the earth would deflect the beam from its intended path. These objections are based on little experimental evidence. There are no experiments in the public literature on the energy densities being discussed for a beam weapon. From past experience it is known that with a system as nonlinear as a plasma, simple extrapolation from low to high energy regimes is misleading. At this point, it is very difficult to predict whether such a beam could propagate through the atmosphere, but clearly the Soviets are considerably ahead of the United States in the theoretical studies required to competently predict the plasma behavior of the beam. On an intuitive basis, one is much safer with the guess that the plasma will behave in an ordered way and that the beam will propagate, than in predicting that, on the basis of past experience at lower energies, the beam will not propagate.

Most importantly, there is a large body of evidence of Soviet research on areas peripheral to the beam weapon indicating an outlook and approach to the questions of high energy processes in the atmosphere considerably in advance of those in the United States. On the experimental side, the Soviets have been engaged in an intense research effort on the general question of the interaction of radiation (both electromagnetic radiation in almost all areas of the spectrum, and particle energy) and the ionized layers of the atmosphere (the ionosphere and magnetosphere). These experiments in creating "artificial auroras," in broad-band radio wave propagation, and high-energy laser propagation are quite well known in their separate fields, but represent a broad-based research effort on the part of the Soviets.

More indicative is the impressive scope of Soviet theoretical research on ionospheric interactions. To control a beam of ions for weapons use, it is absolutely



A U.S. long-range ICBM takes off. Could a Soviet beam weapon bring it down?

critical to understand the plasma interactions that go on in the atmospheric plasmas the beam must traverse. Research reported by several groups at the March meeting, Third International Conference on Plasma Theory in Trieste, Italy, may be the most striking evidence of Soviet work in this area. At this conference, the Soviets reported a number of new results in the propagation of relativistic electron beams through a gas and plasma, the generation of various kinds of electromagnetic radiation by electron beams, and the self-organizing phenomena which characterize energetic discharges from the ionosphere.

This latter research, by V.I. Petviashvili, showed convincing data that there is a close association between solitons in a magnetized plasma (like the magnetosphere), vortex phenomena, and the pulsed high-energy radio waves that are characteristic of discharges in the ionosphere and magnetosphere. To take one example, Petviashvili's group showed data that could describe the major characteristics of the one-minute nightside, magnetospheric radio bursts as smoke-ring-like vortex solitons due to the nonlinear propagation of magnetosonic waves.

The study of these high energy, coherent phenomena is absolutely necessary if propagation through (and, ultimately, control of) the ionosphere is to be achieved. The Soviet research in this area, like most areas of plasma physics, is considerably ahead of that in the U.S.

The potential for practical and military application of this research is dramatized by experimental research in progress at Stanford University under the direction of Robert Helliwell. This group has performed experiments in which the injection of as little as 10 watts of coherent, radio wave energy into the ionosphere can precipitate 100,000 *megawatts* of energy out of the ionosphere. The ionosphere seems to function as an unstable amplifier, in which a small coherent signal can "slave" tremendous amounts of backround, initially random energy.

In this context it is even conceivable that the Soviet ABM particle beam system is based on generating the proton beam in the ionosphere itself, i.e. *in situo*. The idea would be to convert the earth-bound, pulsed fusion energy to either radio or microwave frequency electromagnetic radiation which would then be readily transported to the ionosphere where it would interact with the ionospheric plasma to produce beams of high-energy protons.

The question most pointedly raised by the Soviet developments is exactly the control of such processes.

On the Political-Strategic Debate in the USA

by Hans Ruhle

Excerpted from the May 1977 issue of Europäische Wehrkunde.

A time of government changeover is always and everywhere a period of insecurity. Rarely in the recent history of the Western world, however, has a government changeover been accompanied by so many personal and conceptual question-marks as has the transition from Ford to Carter. Nobody seemed to know what direction this political voyage is supposed to take — except Jimmy Carter himself.

And not just that. The kind of half-baked and apolitical stuff that coursed out of the mouth of a promising presidential candidate across the Atlantic stole the power of speech away from many otherwise verbose contemporaries. And once the election was over, a flabbergasted Europe had to once again concede that the USA remains the land of unlimited possibilities. A country where a nobody, not representing a convincing personal alternative, without a pressing or even partially determined political program, and against the opposition of a major portion of his own party leadership, could become President. A country where, event in the 20th century, the classic "American Dream" of the rise of an unknown could not only be dreamed of, but realized.

Since then the new government has been in office for a few months. But not that much has changed. To be sure, Carter, his Cabinet, and his "kitchen cabinet" have formulated clear positions in a few political areas, but even intimate observers of the American scene still find it impossible to identify any concept behind the statements and measures put forward thus far — and to thereby allow American policy to assume a relatively consistent and predictable path. This insecurity necessarily affects security policy particularly strongly. Not only because the national fate of numerous allies depends on the course of American security policy, but also because even relative security in the present system of mutual deterrence can only be achieved if American policy is to large degree predictable — in the sense of rational calculability.

And thus we come to the point: the political-strategic debate in the USA. For the unusual and uninterrupted frenzy of this debate could and can be explained by the initial incompetence of candidate Carter and the present security-policy eclecticism practiced by President Carter. This appeared and still appears to signal that the conceptualization phase for the new American security policy has not yet been concluded — and thus that further influence can be exercised on its formulation.

The currently discussed themes are not new, nor were they during Carter's candidacy. For years, some of them were regular items in the tables of contents of nearly all influential journals. But until now they had a largely independent dynamic. Now, however, since the problem became that of helping out a President who was "green" as to security policy, and to program him for the upcoming SALT talks, all caution was set aside.

What was proper for the academicians was certainly all right for the secret services. Nuances no longer played any role. The issue was taken on directly: "Who leads?" — the USA or the Soviet Union? As could only have been expected, the viewpoints on this global question remained in dispute. This generally unfruitful debate should therefore not be emphasized and analyzed. Rather, the major points of this debate will be isolated and given historical explanation. In conclusion, an attempt will be made to come to a general evaluation on a higher level of political abstraction.

"Civil Defense": the New Debate

Since the early 1960s, when the USA established the concept of "mutually assured destruction" for the prevention of a nuclear war, civil defense in the USA played practically no role any longer. It was assumed that a guaranteed second strike capability, which could wipe out a potential aggressor as a "viable 20th century nation," would not only fully suffice for nuclear deterrence, but must make any expenditure for active or passive protection of the civilian population appear wasteful. Of course, in 1967 McNamara undertook active protection of the American civilian population against China's "primitive nuclear weapons" through the construction of an anti-missile

system, but by 1969 Nixon gave this concept up again. Consequently, in the SALT I treaty the USA gave up any preemptive limitation of damage, and bypassed any active protection of its civilian population. Passive civil defense, on the other hand, especially protection of the population from foreign attack through the construction of bunkers, etc., has not been a serious matter of debate in American policy since the 1950s.

Since America could not realistically attempt to protect all of its citizens, none were to be protected. It is true that in academic and semi-political circles there has been a long-term discussion on passive defense of the civilian population, which has involved much less a strategic conception than debate over its physical possibility or impossibility.

It is entirely in this sense that the so-called "new debate" in the area of passive civil defense is being conducted.

As a result of statements by former American Secretary of Defense Schlesinger, according to which a Soviet counterforce attack against all American land-based intercontinental rockets would possibly kill "only" 800,000 people, new speculations were provoked, starting in 1974, based on calculations and countercalculations as to the number of victims which would result from a Soviet missile attack. Yet this new debate would likewise have petered out without much interest and without practical consequences after a time had new information on the state of passive Soviet civil defense not been made known. In an interview with the *New York Times*, the retiring chief of U.S. Air Force Intelligence, General Keegan, pointed out that the Soviet Union

— had produced 35,000 protective buildings partially hardened to 1000 psi for the protection of military personnel and material as well as for the military intelligence networks. Only 75 are in or near Moscow.

— had brought the entire chief of staff apparatus for the three armed forces in reinforced underground bunkers, and in addition had at its disposal an equally reinforced, fully equipped alternative headquarters. In addition, the entire nuclear chain of command, from the Soviet General Staff, to the regiment commanders overseeing nuclear weapons — from Vladivostok to East Berlin — runs through reinforced installations.

— had constructed such a large number of huge bunkers near its industrial centers that more than 60 million workers could survive a nuclear war.

— had set up, on the edges of approximately 40 major urban centers, underground supply bunkers the size of several football fields.

— is preparing 25 percent of the industrial workers in ongoing training programs for leadership functions in civil defense situations.

— had bunkered 10,000 positions with anti-ballistic missiles and is presently in the process of adding to them 4,500 tactical early-warning and radar-defense systems.

— now has a comprehensive civilian defense organization, led by Lieutenant General Altunin and 78 generals, which is considered an independent armed forces division.

Upon inquiry by the Congress, the Joint Chiefs of Staff to be sure rejected several of the general assertions by Keegan (not discussed here) as incorrect; however, they were unable to refute the data on the cited concrete civil defense measures. The less so, as Keegan did not remain without support. T.K. Jones, a former member of the American SALT delegation, and presently with Boeing, went so far as to claim that 98 percent of the Soviet population could survive a nuclear war. The Soviet economy would recover in two to four years from a nuclear war; the American economy would need 12 years for this under present conditions. At the time, Jones' calculations appeared barely credible, but the fact that Paul Nitze backed them up in his January *Foreign Affairs* article at least assured Jones' work an open discussion.

General Keegan has had the last word in this debate for the time being. A few weeks ago he issued an imploring appeal to a group of journalists. Repeating once again his data on Soviet civil defense, he called upon them to openly contradict him: Keegan on his concern and on the reason for his decision to go to the public with his information: "The time has come to warn our population and its leaders." That this is so becomes clear from the official yearly report of the American Defense Department for fiscal 1978, which states: "During the last six months, the actual extent of Soviet civil defense has become known to us.." Apparently, for many years we had underestimated the problem of active, but even more, of passive Soviet civil defense. And this was so even though there has long existed Soviet as well as American literature on this subject, literature whose contents could have been sufficient, indeed were sufficient, to examine the effects of Soviet civil defense on the stability of the strategic system. Now, after a Soviet defector had confirmed "the entire extent of Soviet civil defense," and had demonstrated what previously could not have been known from secret service activities, it suddenly became clear that the Soviet Union was in the process of destabilizing the system of mutual nuclear deterrence based on the mutual vulnerability of the superpowers. For if the Soviets were to succeed in protecting decisively important military installations, its civilian population, and essential portions of its productive installations, then the American second-strike capability would be neutralized, and a strategy based on American retaliation would be obsolete. Now, for the first time, the problem of Soviet civil defense was discussed in American debates in the context in which it belonged: within the complex of problems as to the preconditions and functional conditions for a strategy of mutually assured second-strike capabilities. Within this complex of problems, the issue of Soviet civil defense coincided with a viewpoint which insured its proper weight within the

strategic debate. This view is expressed in a quote from the CIA, which former U.S. Secretary of Defense Rumsfeld quoted favorably in his 1976 yearly report: "The Soviets are striving for the acquisition of a 'war-winning capacity,' a decision which rests on the concensus that the survival of the Soviet Union as an integral national entity must be assured in the case that deterrence fails. This corresponds to the principle (*Lehrsatz*) of Soviet military doctrine, according to which a nuclear war could be conducted and won, and therefore, in the development of strategic-nuclear potentials, the emphasis must be on developing counterforce capabilities. The strategy of "Mutually Assured Destruction" as a desirable and lasting basis for stable strategic-nuclear super power relations has never been accepted by the Soviet Union. The Soviet political and military leadership sees it much more as a reality with which they must live for the next decade." Thus the discussion of Soviet civil defense led necessarily into a general debate over whether the Soviet Union even thinks or plans in categories of nuclear deterrence — whether therefore, a strategy based on mutual vulnerability, and on mutually guaranteed destructive capabilities, even made any sense whatsoever.

The Threat Analysts in Open Contradiction

For months, America's secret services went for banner headlines. Scarcely a day passed by that a member, sympathizer, or opponent of these otherwise so silent networks did not issue a public statement. The issue was the extent of the Soviet threat. True, certain skeptics claim that the entire debate on the national security situation was bogus, built up to create an alibi for Carter to back off from his promises made during the election to reduce the defense budget. However, these voices have become more and more quiet and infrequent. Even if the initial motivation for the debate was an attempt to save Carter's face, the debate took on such proportions and depth — became principled in the best possible sense — that the reasons for its introduction became predominant.

The leaders in the debate were, and still are, as noted, the secret services. This is unprecedented in recent American history. Yet it is no accident. For many years, there have existed considerable differences between the American secret services. That they are now being discussed out in the open might have many reasons. One, however, is certain, and is important enough to legitimize the publicity: thorough disagreement in the evaluation of the threat.

That was not always the case. Until the end of the 1950s there were, just as among the secret services of all countries, occasional rivalries of numerous origins. The analyses of the threat, however, were generally undisputed. This changed at the beginning of the 1960s, when during the Kennedy Administration some of the so-called "Whiz Kids," that younger generation of intellectuals — to which the newly appointed American Secretary of Defense Brown belonged — were flooded into the CIA. The old battlehorses of the military secret services not only established a natural distance from those self-confident eggheads, stomping around with their systems analyses and use-cost-risk evaluations, but soon enough there were opportunities for controversial, objective discussion.

The most important accusation by the DIA (Defense Intelligence Agency), the central military secret service, as well as of the secret services of the three armed forces divisions, was that the CIA (Central Intelligence Agency) underestimated the extent of Soviet arming in general, and the tempo of Soviet arms development in particular. Of course the CIA rejected these accusations year after year on the occasion of the "National Intelligence Estimate." Today, however, we know that the accusations were justified.

In the summer of 1974, Albert Wohlstetter (who in 1959 made strategic history with his article "The Delicate Balance of Terror") published previously confidential material on the threat evaluation of the American Administration, which was essentially influenced by the CIA, and compared this to the actual development of the Soviet arsenal. The results were downright sensational. Wohlstetter demonstrated that for the period between 1962 and 1972, American evaluations were practically always below — and usually considerably so — the actual Soviet development...

The Soviet Union is certainly at a considerable general technological disadvantage in relation to the USA: however, in the last few years the USA has learned that this has only conditional impact on the area of weapons technology. In particular, the Soviets are increasingly attaining the ability to knock out the land-based missile potential of the USA in a nuclear first strike through the high loading capacity of their land-based inter-continental missiles, and have decisively reduced the numbers of American nuclear options as a result.

The SALT proposal presented to the Soviets in Moscow contains, alongside a number of honorable, although admittedly naive components, an effort to limit Soviet superiority in the area of loading capacity of strategic-nuclear systems. That the Soviets rejected the entire American package should not be surprising. In the last few years, through an expenditure of approximately 80 to 100 billion marks, they have considerably modernized their land-based ICBM potential through the introduction of new carrier systems (SS-17, SS-18, SS-19). To now demand that they reduce these systems again was — to say it cautiously — politically foolish. If this SALT proposal had any point — and presumably this was the point — then it was only to demonstrate to the world that the Soviet Union is possibly ready to enter into temporary

arms limitations in the sense of freezing agreements, but, not to undertake disarmament measures.

With this, stress was laid on political-strategic propaganda which for years had claimed that the Soviet Union will not be satisfied with military parity — on whatever level — but is aiming unambiguously for superiority. Military superiority, however, is a foreign element in a system of mutually stable deterrence, which in its essence is a system of equality. The consequence is clear and was drawn by the American Administration. Fred Ikle, the recently retired head of the American Arms Control and Disarmament Agency, a man who cannot be categorized as a military 'hawk' in the classical schema of the American strategic scene, formulated this conclusion. The Soviet Union, stated Ikle a few weeks ago, has never accepted the American concept of mutual deterrence. It has not, as was presumed in the USA, simply reacted to American actions in the political-strategic sphere. Rather, the Soviets have always had an independent view of political development, and of its political-military interconnections.

The Future of American Security Policy

Whatever current one follows in the present American strategic debate, each leads unavoidably to the core of American security policy. And there, where the apologists of "Mutually Assured Destruction" have long strategically "ordered" the international system from their standpoint without consideration of the theory and praxis of Soviet military policy, one becomes increasingly uneasy. Justifiably. It is still one of the unholy inheritances of the McNamara period that the American Administration certainly believes in an overall expansive Soviet foreign policy, whose conceptual and material translation into the military dimension, however, they continually deny. Thus, it is argued that since, in the nuclear age, war between the superpowers can no longer be a means of politics, any single effort for military superiority is superfluous. Only a system of stable deterrence, it is argued, makes any sense, and furthermore only on the foundation of mutually guaranteed second-strike capability. To be sure, the Soviet Union has never positively welcomed this conception, but nevertheless the planners in the Pentagon presumed that Soviet military strategy was identical with the American. Not because the Soviets wanted it so, but because according to the viewpoint of accredited American military strategy, no alternative existed for a "rationally" thinking and acting Soviet Union. There was never any doubt in Washington as to whether a politically dynamic Soviet Union, by virtue of its ideological role, would see a static military concept as "rational." Al this was fine as long as the Soviet Union acted in a way that suited a system of stable mutual deterrence. This registered in the USA as entirely conforming with the idea that the Soviet Union was working its way up from its inferior status to parity with the USA. The rude awakening occurred — and that is where we stand today — when new information in the area of Soviet civil defense as well as on the forced expansion of Soviet strategic nuclear weapons potential could only lead to the conclusion that the Soviet Union is striving for military superiority. Now it has suddenly been realized in the USA that for several years Soviet weapons development has been equated with conceptual explanations which Moscow silently indulged in, but never affirmatively answered. Above all, one is forced to recognize that the Soviet Union not only follows a dynamic concept in the political sphere, but commands a dynamic military strategy. A military strategy that is to set in motion the "victory of Communism on a world scale" through the achievement of global military superiority. The fact that the Soviet Union, via its visible striving for military superiority, has obviously not accepted the system of mutual deterrence means no more and no less than the total failure of American security policy. The participants in Washington are still defensively denying this viewpoint. The fight of the secret services to circumvent the results of this view and the consequences to be drawn from it illustrates this. Yet the present controversy may end in the short term, in the midterm those will be proven correct who simply represent the viewpoint which the Soviet Union has always expressed: that the Soviet Union, which has undertaken to convert the world to its faith, cannot see security only in its own superiority.

Bibliography

Abourdjana, H.D.; Kitsenko, A.B.; and Pankratov, I.V. "The Nonlinear Theory of the Interaction of the Charged Particle Beam with a Plasma in the Magnetic Field." *The Third International Conference on Plasma Theory, Kiev, April 1977.* (6)

Brown, T.S., et al. *Project FC, Study Project for a Canadian Programme on Controlled Thermonuclear Fusion.* Canada, 1974. This report has very good discussions of electron beams, energy storage and switching, and fusion research in general. (1)

Budker, G.I. "An Effective Method of Damping Particle Oscillations in Proton and Antiproton Storage Rings." *Soviet Journal of Atomic Energy* 22 (May 1967): 438-440. (6)

——— *Proceedings of the CERN Symposium on High Energy Accelerators, 1956,* p. 68. Both this and the above article from the *Journal of Atomic Energy* present Budker's original ideas on collective acceleration for application to particle accelerators. (6)

Carlson, R.J.; Linse, V.D.; and Wittman, R.H. "Explosive Welding Bonds Metals, Large Areas," *Materials Engineering* 68 (1968): 70. There is no really adequate survey of explosive welding techniques, but this article stresses its unique capability for welding large areas of metal. (2)

Crossland, B. "Review of the Present State-of-the-Art in Explosive Welding." *Metal Technology* 3 (1976): 8. (2)

Friedman, M., and Herndon, M. *Physical Review Letters* 28 (1971): 210. (6)

Friedman, M., and Herndon, M. *Physical Review Letters* 29 (1972): 55. (6)

Helliwell, R.A.; Katsufrakis, J.P.; Bell, T.F.; and Raghuram, R. *Journal of Geophysical Research* 80 (1975): 4249. (6)

Hubbard H.W. and Hammond R.A. "PACER: A Practical Fusion Power Concept." In *The Proceedings of the Intersociety Energy Conversion Conference of the American Institute of Chemical Engineering, Heat Transfer and Energy Conversion Division, 1976.* New York: American Institute of Chemical Engineering, 1976. Short report by R and D Associates on the PACER Project. (3)

Kassel, Simon. "High Current Particle Beams. I. The Western USSR Research Groups." *Rand Report R-1552-ARPA.* Santa Monica: Rand Corporation, 1975. An excellent overview of the Soviet work in the area of collective acceleration. The report contains no references to military application. (1, 6)

——— "Soviet Development of Flash X-Ray Machines." *Rand Report R-1053-ARPA.* Santa Monica: Rand Corporation, 1973. (4)

——— "Soviet Progress in Physics: Review of Current Research." *Rand Report R-793-ARPA.* Santa Monica: Rand Corporation, 1971. A summary of some of the more exotic Soviet research in various areas of high energy physics. (1, 6)

Kassel, Simon, and Hendricks, Charles D. "Soviet Development of Needle-Tip Field-Emission Cathodes for High-Current Electron Beams." *Rand Report R-1311-ARPA.* Santa Monica: Rand Corporation, 1973. (1, 5)

Kassel, Simon, and Hendricks, Charles D. "Soviet Research and Development of High-Power Gap Switches." *Rand Report R-1333-ARPA.* Santa Monica: Rand Corporation, 1974. Good overview of Soviet work. (4, 5)

Kazakhstanskaya Pravda. (June 27, 1973) p. 3. Reported in "High-Current Particle Beams. I. The Western USSR Research Groups." *Rand Report R-1552-ARPA.* Santa Monica: Rand Corporation, 1975. (6)

Kitsenko, A.B., and Pankratov, I.M. "The Nonlinear Theory of the Excitation of Monochromatic Electromagnetic Waves in a Magnetoactive Plasma by the Relativistic Beam of Charged Particles." *The Third International Conference on Plasma Theory, Kiev, April 1977.* (6)

Los Alamos Scientific Laboratory Report LA-5764 MS. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151. The 1974 report on Project PACER is a collection of papers and letters giving detailed studies on and the history of the PACER concept. (3)

Luce, J.S., *Annals of New York Academy of Science.* 251 (1975): 217. (6)

——— "Collective Field Acceleration of High Energy Ions," In *Energy Storage, Compression, and Switching,* edited by

W.H. Bostick, V. Nardi, and O.S.F. Zucker, pp. 163-173. New York: Plenum, 1977. These two articles summarize the work of the foremost American investigator in the field. (6)

MacKeown, G. "Explosive Welding." *Military Engineer* 69 (1977): 100. (2)

Martin, J.C. "Short Pulse High Voltage Systems." In *Energy Storage, Compression, and Switching*, edited by W.H. Bostick, V. Nardi, and O.S.F. Zucker, pp. 3-14. New York: Plenum, 1976. This paper, by the father of the relativistic electron beam in the west, gives a good overview of the technology involved and lays the basis for understanding why explosively driven MHD generators are crucial for higher power electron beams. (5)

Newcombe, G. "The Bimetal Concept, Part II." *Welding and Metal Fabrication* 42 (1974): 400. This article has excellent microphotographs and data on explosive welds. (2)

Petviashvily, V.I. "Non-onedimensional Solitons and Anomalous Effects in Plasma." *The Third International Conference on Plasma Theory, Kiev, April, 1977.* (6)

Plyutto, A.A.; Belensov, P.Ye.; Korop, Ye. D.; Mkheidze, G.P.; Ryzhkov, V.N.; Suladze, K.V.; and Temchin, S.M. *JET Letters* 6 (1967): 61. (6)

Plyutto, A.A.; Suladze, K.V.; Temchin, S.M.; and Dorop, Ye. D. *Soviet Atomic Energy* 27 (1967): 1197. These are the articles announcing the results by the Plyutto group. (6)

"Powerful Soviet Radio Signal Protested." *Aviation Week and Space Technology* 105 (August 30, 1976). (6)

Proceedings of the Conferences of the Center for High Energy Forming, University of Denver, Denver Research Institute, 1969 and 1973. Denver: Denver Research Institute, 1969 and 1973. (2)

Reid, S.R. "Prediction of the Wavelength of Interface Waves in Symmetric Explosive Welding." *Journal of Mechanical Engineering Science* 18 (1976): 87. (2)

Robinson, Clarence A., Jr. "Soviets Grasping Strategic Lead." *Aviation Week and Space Technology* 105 (August 30, 1976). (6)

Rudins, George. *U.S. and Soviet MHD Technology: A Comparative Overview*. Santa Monica: Rand Corporation, 1974. A very comprehensive evaluation of Soviet and U.S. programs including a critique of the differing overall approaches to both programs. Rudins includes an extensive bibliography of over 100 sources which include most of the major theoretical and experimental work in the field. (4)

Sedikh, V.S., and Bondar, M.P. "Basic Parameters of Explosive Welding and Strength Characteristics of Welded Joints." *Welding Production* (USSR) 2 (1963): 1. (2)

Sedikh, V.S.; Derbas, A.A.; Bichenkov, E.I.; and Trishin, Yu. A. "Explosive Welding." *Welding Production* 5 (1969): 4. These two articles are the most recent Soviet literature available on explosive welding. (2)

Teno, J. and Sonju, O.K., "Explosively Driven MHD Generator Power Systems for Pulse Power Applications." In *Energy Storage, Compression, and Switching*, edited by W.H. Bostick, V. Nardi, and O.S.F. Zucker, pp. 151-156. New York: Plenum, 1976. The only article on explosive MHD generators in western scientific literature since 1963. This report shows why it is not necessary to have switches or capacitor banks with explosive MHD and, therefore, why nuclear bomb charges can be used for the highest power outputs. (3, 4)

Tsytovich, V.N. "The Interaction of a Relativistic Electron Beam with a Gas and Plasma." *Proceedings of the 7th Eindoven Conference.* In *Physica* 82C (1976): 141. Tsytovich summarizes Soviet thinking on the challenges presented by collective effects in plasmas and includes a long and interesting discussion of collective acceleration of ions. (1, 6)

Velikhov, E.P.; Golubev, V.S.; and Chernukha, V.V. "MHD Conversion of Energy From Pulsed Thermonuclear Reactors." *Atomic Energy* 36 (April 1974): 330-332. (3)

Velikhov, E.P.; Volkov, Yu. M.; Golubev, V.S.; Lobanov, N.V.; Rutberg, F.C.; and Yakushev, A.A. "Plasma MHD Generator for Modelling Energy Conversion in Pulsed Thermonuclear Reactors." *Atomic Energy* 39 (December 1975): 1043-1047. (3)

Zucker, O.S.F., and Bostick, W.H. "Theoretical and Practical Aspects of Energy Storage and Compression." In *Energy Storage, Compression and Switching*, edited by W.H. Bostick, V. Nardi, and O.S.F. Zucker, pp. 71-94. New York: Plenum, 1976. Excellent review of all problems involved in energy storage, compression, and switching. (4)

KEY

The numbers in parentheses at the end of each entry refer back to the following:

(1) Introduction: The Science Behind the Soviets' "Superweapon"
(2) I. Soviet Welding Breakthroughs
(3) Appendix: Project PACER
(4) II. MHD: From Nuclear Explosion to Electricity
(5) III. The Relativistic Electron Beam Angle
(6) IV. Collective Ion Acceleration: How the Beam Works
V. Beam Guidance and Propagation

ISSN: 0146-4881

U.S. Labor Party Directory

ALBANY NY (518) 463-2909
BALTIMORE MD 824 Calvert St. 21218 (301) 752-7374
BOSTON MASS Rm. 230 120 Boylston St. 02104 (617) 426-7598 Box 1543 South St. Station
BUFFALO NY Rm. 926 Ellicott Sq. Bldg. 295 Main St. 14203 (716) 847-2100
$CAMDEN NJ (609) 665-3083
$CHARLOTTE NC Box 1606 28201 (704) 332-4834
CHICAGO ILL Rm. 252 Monadnock Bldg. 53 W. Jackson St. 60604 (312) 663-3692, 939-9518
CINCINNATI OHIO Box 8973 45208 (513) 871-1759
CLEVELAND OHIO Rm. 806 750 Prospect Ave E. 44115 (216) 621-1550,51
DETROIT MICH Suites 608,610,611 2011 Park Ave 48226 (313) 964-2550
DENVER COLO Box 11402 Highland Sta. (303) 744-8526
GARY IND (219) 398-2691
GRAND RAPIDS MICH (616) 774-2070, 774-7187
GREENSBORO NC 902 W. Market St. 27401 (919) 275-2452
HARTFORD CONN P.O. Box 6335 Sta. A 06106 (203) 522-9077
INDIANAPOLIS IND (317) 359-6190
LANCASTER PA (717) 392-4261
LANSING MICH (517) 482-8757
LORAIN OHIO (216) 288-9411
LOS ANGELES CA (213) 385-5190
MILWAUKEE WIS Box 10195 53210 (414) 444-6315, 447-1763
MUNCIE IND (317) 284-2495
NEWARK NJ 2nd floor 25 Halsted St. East Orange 07018 (201) 676-1800
NEW YORK NY National Office Box 1972 GPO 10001 (212) 563-8600. Regional Office 231 W. 29th St. 10001 (212) 563-8648, 695-9806
OXFORD OHIO (Miami U.) (513) 523-8319
PERTH AMBOY NJ (201) 826-2841
PHILADELPHIA PA 1st floor, 2114 Arch St. 19103 (215) 561-5565,66,67
PITTSBURGH PA Suite 2, 1725 Murray Ave, 15206 (412) 421-7136
PORTLAND ORE Box 14403, 97214 (503) 238-0162
RICHMOND VA Box 25803, 23260 (804) 353-7189
ROBESON COUNTY NC (919) 422-8326
ROCHESTER NY 156 Denver St. 14609 (716) 288-3158
SAN FRANCISCO-BAY AREA CA Box 4498, 94101 (415) 776-0414
SEATTLE WASH 2nd floor 71 Columbia St. 98104 (206) 622-7922,23
SPRINGFIELD MASS Box 445 Forest Park St. 01108 (413) 736-2113
ST. LOUIS MO Box 3011 63130 (314) 725-6073
SYRACUSE NY 1427 South State St. 13205 (315) 425-9648
TACOMA WASH (206) 759-7924
TOLEDO OHIO 1004 Front St. 43605 (419) 698-2781
TRENTON NJ (201) 676-1800
WASHINGTON DC 617 K Street NW 20001 (202) 347-5359
WATERTOWN NY (315) 232-4168
WILMINGTON DEL (302) 798-0548
YORK PA (717) 392-4261