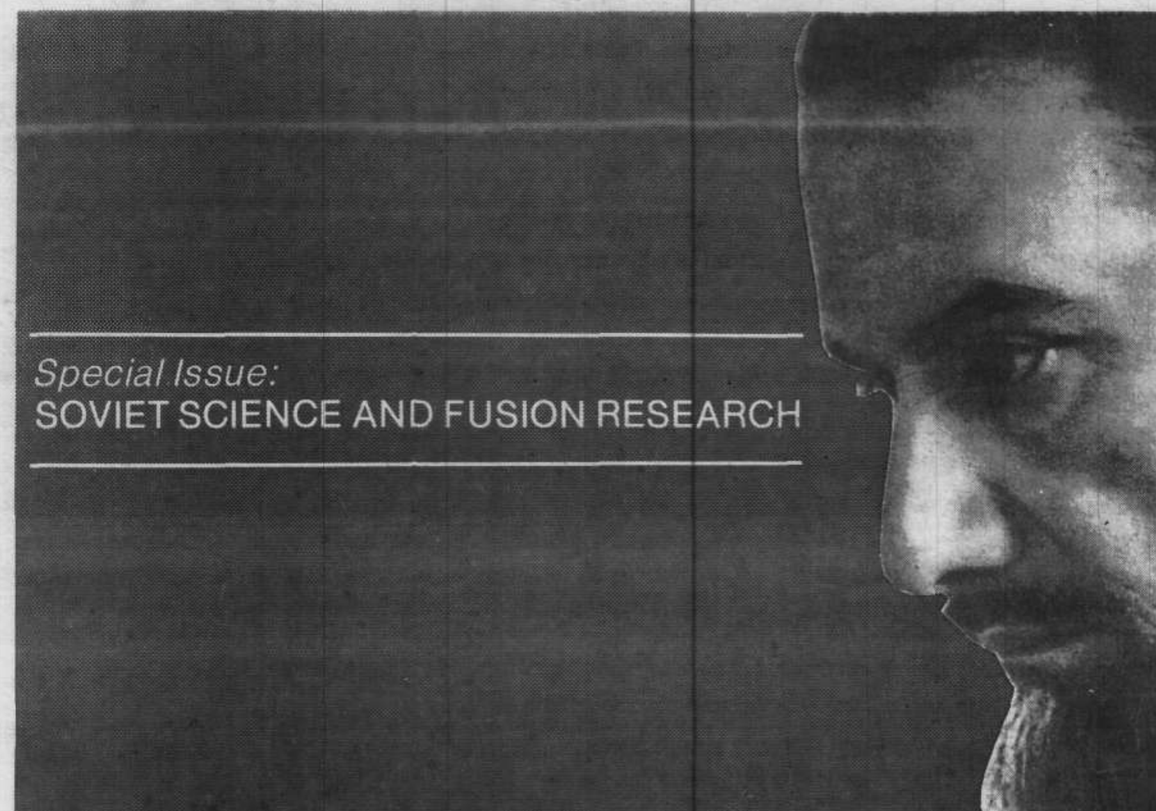
Fusion Energy Foundation



Newsletter

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A CLEAR CHOICE

The bankruptcy of U.S. scientific institutions has become all the more obvious in contrast to recent Soviet breakthroughs in fusion research and the concerted effort of most of the world's governments and peoples toward a policy of coordinated international and scientific development. Iraq, Algeria, and other Third World countries have promised access to low-cost oil in return for industrial development, scientific training programs, and aid to devastated countries. The Soviet Union has begun an unprecedented program for international technical cooperation and has openly predicted fusion reactors in the early 1980s.

Demoralized by a decade of Zero Growth propaganda, the steady attrition of this nation's R and D personnel and the decimation of the country's productive capacities, American scientists can do no better than hope for a magical rescue by a new Science Advisor to the President.

For these, and other reasons to be further elaborated on, this issue will be devoted to recent Soviet initiatives in fusion research.

The basis for revitalization of U.S. science lies in vastly broadening the scope of basic scientific research in conjunction with a re-orientation toward broad developmental objectives. To achieve this, we must cultivate creative approaches to fundamental problems. Primary technical objectives, (which will push scientific knowledge to its theoretical frontiers), include the development of controlled fusion, understanding human developmental and aging processes, controlling plant and animal biology for greater yields, and intervening effectively in global climate patterns.

The National Science Foundation, however, insists on developing curricula glorifying backwardness and "survival" ethics and sponsoring RANN research on increasing "productivity," i.e., how to slice the bread or steel thinner. National Academy of Sciences' agronomists point out that research vital to agricultural productivity — now barely funded — warrants a Manhattan Project, then collapse into praise of 2000 year-old Chinese labor-intensive practices. After a year of hoopla about the breeder reactor and a ten-fold increase in fission plants, ERDA announced on June 30 that its only energy program is a 25 per cent cut in energy consumption. Privately ERDA-CTR officials admit that the present narrow, bureaucratic fusion research program will probably fail; publicly, fusion and solar energy are the answer — for the 21st century.

Meanwhile, the nation's major, supposedly independent scientific body, the Federation of American Scientists (FAS), is locked tightly in the grip of spokesmen for either national chauvinism (as in energy "independence") or zero growth corporatism. Rather than respond to the world's crying need for development and scientific progress, the FAS further degrades itself by refusing to discuss these substantive issues with this organization, supposedly because of anonymous slanders that the FEF has "disrupted" U.S. and international scientific meetings.

The issue could not be clearer. Either international cooperation for economic development, scientific progress, and passage to the new mode of production signified by fusion technology, or economic and ecological catastrophe. The litmus test here is the setting of mid-1980s fusion development as a top priority.

This Issue:

Apart from these general considerations, there is a very simple reason for devoting this issue of the FEF Newsletter to Soviet fusion research: it is producing results.

To properly assess recent developments it is crucial not to fixate on whether a particular line of research will pan out or whether the Soviets have had better "intuition" in selecting particular devices for emphasis. Essentially what the Soviets have provided, with an inferior technological base relative to the West, is the **germ form** of the broad-based scientific strategy and program of international collaboration required to **realize** fusion power soon enough to avert economic and ecological catastrophe.

Since this is the basis for the existence of the FEF, it was a welcome circumstance for the FEF to be invited to Moscow in mid-July by the World Federation of Scientific Workers (WFSW). The WFSW Symposium on "The Scientist's Role in Disarmament" — reported in this issue — was also an important example of scientists consciously acting on the principle of international collaboration.

The FEF welcomes future collaboration with that organization (founded by Frederick Joliot-Curie) and its branches in Eastern and Western Europe and the Third World. As indicated in the Symposium report, there must be further discussion of the elimination of the obstacles to global development as the key to eliminating the threat of nuclear war.

The first section of this issue gives an analysis of the historical and sociological bases for the recent Soviet leaps to the threshold of fusion breakthrough. The remainder, in addition to the report of the WFSW Symposium, documents the boldness and breadth of the present Soviet fusion effort. It is now the turn of scientists in that most "pragmatic" society, the U.S., to grasp the potentialities which their own work has put on the agenda for realization.

The Fusion Gap

The "fusion gap" between the Soviet Union and the United States — Soviet superiority in key areas of research and development of controlled thermonuclear fusion — was given a new prominence at the end of May when Edward Teller, U.S. fusion research's top cop, publicly admitted that "the Russians will probably be there first" in achieving the next breakthroughs in laser-induced fusion experimentation. At the same scientific conference which Teller addressed, the Washington, D.C. Laser Applications Conference, Soviet scientists proved Teller right by stating that several large laser facilities in the USSR will begin exploration of laser fusion feasibility within the next year. This came only a month after a Soviet scientist exploded Teller's Rockefeller-dictated claims that fusion power would never be realized in this century with the announcement that the Soviets intend to have a magnetic-confinement fusion test reactor in operation no later than 1982.

The "fusion gap" story, never before made public, reveals that the creators of the "gap" are none other that Teller and Rockefeller's other saboteurs of the U.S. fusion effort, who have consistently prevented U.S. scientists from either cooperating with Soviet scientists or adopting the far more advanced methodology of the Soviets.

Largely due to the efforts of the Soviets and a handful of Western scientists, the development of fusion power as a virtually unlimited source of cheap, clean energy is now not only absolutely necessary but demonstrably possible for the 1980s. The real fusion gap is that between the current, woefully inadequate effort of less than 3,000 physicists and engineers internationally, and the tremendous quantities of scientific, industrial, and human resources which must be mobilized to solve the technological problems involved in achieving a worldwide fusion-based economy within this decade.

However the success of a "brute force" effort does not rest primarily on resources as such, as the achievements of the relatively resource-poor Soviets have shown again and again to the embarrassment of the criminals sitting on the United States' superior technological capabilities. Far more important is an approach, exemplified in germ form by Soviet fusion research, which proceeds from the necessity of human progress rather than bureaucratic demands to get results within the timetable and within the budget.

From the beginnings of research in controlled thermonuclear reactions (CTR), the Soviets have led the way in providing the broadest possible cooperative base for such work and the chief motivation for fusion research outside the USSR. The U.S. scientific community has meanwhile stifled, under "national security wraps," under inane "practical" policies limiting research to ostensibly main-line approaches on a "cost-accounting" basis, when scientific work was not deliberately sabotaged in the higher interests of Rockefeller policy.

Teller Bombs Out

Immediately after World War II, with 20 million dead and its cities and industries in ruins, the Soviet Union was confronted with outright nuclear blackmail and the prospect of renewed war. Starting from scratch in late 1945, the USSR duplicated the technological achievements of the U.S. and Great Britain by producing a nuclear fission bomb (atom bomb) in September, 1949. By 1953, the USSR had developed and detonated a thermonuclear weapon, the first hydrogen bomb, in essence guaranteeing that any future world war would be suicidal. To give a rough measure of the magnitude of this technological achievement, it should be noted that the U.S. used fully 10 per cent of its annual electrical consumption in producing the first atom bomb; the Soviet Union's total energy consumption in 1938, before the devastation of the war, did not total even 10 per cent of that in the U.S.

Soviet fusion pioneer I.V. Kurchatov.

From the start of the Manhattan Project, scientists understood that the fission bomb they were developing would generate enough heat to spark thermonuclear reactions. Throughout the 1940s, however, Rockefeller scientists such as Edward Teller and Hans Bethe were debating the possibilities of "limited" nuclear warfare. It rapidly became clear to these hirelings, the core of what evolved into the CIA's scientific think-tank apparatus, that thermonuclear weapons, thousands of times more powerful than fission bombs, would if developed make any form of nuclear war impossible. Therefore research into any form of fusion was vigorously suppressed in the U.S.

But the USSR's development of the fission bomb upset Rockefeller's estimates of Soviet scientific capabilities. In 1949 Rockefeller Foundation scientists Teller and E.O. Lawrence rushed to slap together a crash program to develop what they called the "Super Bomb." Characteristically, these unleashed pragmatists based their work on combining the simplest, most obvious fusion reaction (deuterium and tritium combining to form helium) and a fission bomb. The inherent problem with this approach was that the hydrogen isotopes of deuterium and tritium are gases under normal conditions and must be refigerated to extremely low temperatures in order to attain the liquid state required for use in a bomb. In 1952 a prototype "Super" was detonated; but its usefulness was hampered by the fact that it weighed more than 50 tons — including the refrigerator. Teller and Lawrence therefore proposed that their monstrous bomb could be hauled over the Soviet Union in an atomic-powered plane roughly the size of a football field. The waste of time and money in attempting to realize this ludicrous project represents only one of the many examples of the "practical" achievements of the Rockefeller think-tanks.

The subsequent history of CTR research shows that while the Soviets pushed for international cooperation to achieve fusion power, the U.S. followed a zig-zag course of outright suppression and feverish attempts to catch up with the USSR's achievements and save face.

The leader of the Soviet Union's wartime nuclear physics research, I.V. Kurchatov, also directed the USSR's nuclear weapons development programs after the war. In 1950, despite the pressing needs of an economy still deeply scarred by the war and the rapid pace of the emerging arms race, Kurchatov decided that significant Soviet resources had to be devoted to the development of controlled fusion — "the second atomic problem of the 20th century." In 1953, Kurchatov assumed direct management of CTR research. The foresight and internationalism of this decision can be judged by the fact that the Soviet Union has more than adequate reserves of fossil fuels to meet its own needs until at least the year 2000.

Using the authority and prestige gained in his work on the weapons program, Kurchatov was able to rapidly mobilize the necessary industrial resources and scientific manpower for the fusion research program. His brute force approach was exemplified by the case of the Ogra magnetic mirror machine, one of the first proposed for confining fusion plasma. When the physicists in charge of the project reported that it would take three years to construct Orgra, Kurchatov intervened and had the experiment functioning within six months.

The Soviet Union's ability to significantly advance fusion research is grounded in the major theoretical contributions which its scientists have made to plasma physics. By definition the plasma-fusion problem does not lend itself to the linear statistical methods that have dominated 20th century science under the hegemony of decaying capitalism. Experimentally, the fruitful lines of research in CTR are those which explore the nodal points of the plasma parameter space, those points which exhibit in concentrated form the most complex aspects of plasma behavior. From the beginning of the 1930s, the USSR has maintained leadership in this crucial field.

The fumbling nature of the U.S. fusion effort, on the other hand, is typified by the fact that plasma physics continues to be regarded by many U.S. physicists as an arcane and overly complex field. The New York Times headlines and government grants go to scientists engaged in the pointless search for the ultimate particle, under the delusion that if the atom can be reduced to its tiniest parts, then and only then can larger atomic processes be actually understood. This fool's errand is of course an endless one, since each attempt to get the last few pieces of the atomic jigsaw puzzle in place only riddles the entire construction with newer, tinier holes to be filled.

That such idiocy is deliberate can be easily shown at every point in the U.S. fusion effort. Funding and other support for CTR research in the U.S. under the aegis of the Atomic Energy Commission (AEC) and its successor, the Energy Resource and Development Administration (ERDA) has been restricted to a limited number of carefully controlled scientific "empires." Within these laboratories, money and support has been concentrated on favored concepts and experiments, while other promising lines of development and parallel research into fusion-related problems has been denied funds and in many cases completely squelched.

The AEC gave its public version of this policy in a 1974 presentation to Congress: "General Approach — Do as much as possible in small, low-cost experiments. Then, when the results justify them, build larger, more expensive experiments for further study and demonstration." In other words, the particle approach. Fusion development in the U.S. has thus been put in the untenable position of having to "deliver" (and publicly promise to deliver) on the basis of only a few developed device types. If one of the small number of favored lines of research pays off, then the development of actual reactor technology will still be severely delayed by the catching up that must be done in the still unexplored related fields; if they all fail, fusion can be written off as impossible.

A favored method of suppressing work in this field has been to isolate individual scientists and their work under the rubric of "national security," making impossible the cooperation and discussion which is essential for any sort of scientific achievement. In the 1950s, all fusion research was classified under "Project Sherwood." Laser fusion research remained classified from 1960 to 1972, and is still under the immediate supervision of ERDA's Military Applications Division.

While this vital research remains tightly covered over, the AEC and later ERDA have made sure that the scientific and general public remain ignorant of both the implications and the problems of work in CTR. Thus in the early 1950s Dr. Louis Ridenour, chief scientist for the U.S. Air Force, could state in the popular journal Scientific American, "We cannot find in the development of the fusion bomb any such peace-time values as are inherent in the development of nuclear fission.... Thus when we discuss the 'hydrogen bomb' we are clearly speaking of a weapon, and a weapon only."

Nowhere was the reason for Rockefeller's suppression of CTR research more obvious than in the April, 1975 document by Edward Teller, titled, "Energy — A Plan for Action," and published by Nelson Rockefeller's own Commission on Critical Choices. Incredibly, the beetle-browed Teller cites the "energy shortage" as a prime reason for cutting back research into fusion! Instead, Teller argues, scientific resources must be applied to developing domestic oil, coal, and uranium reserves and a new "conservation ethic" — the favorite recipe for Rockefeller-ruled austerity. To justify this outrageous proposal, Teller totally distorts the potentialities for fusion development, in what is the most negative statement of record on the prospects for realization of CTR.

What Rockefeller control has done to the U.S. scientific community can be easily imagined. While peabrains like Teller are touted as leading scientists, innovators in the field of fusion research are subjected to harassment and repression. The bureaucratic ossification of every aspect of scientific work in the field has either demoralized or forced out into small university laboratories some of the most talented and creative fusion researchers. Lawrence Livermore Laboratory, a major fusion research facility whose Associate Director-at-Large is Edward Teller himself, is especially notorious in this regard, mutilating numerous important proposals in microwave or radio frequency applications to magnetic confinement stoppering and disregarding new approaches in laser fusion. In such an atmosphere, even many honest researchers have lost all sense of a scientific overview under the pressure of Teller's timetables and cost accounting.

Soviets Force Breakthroughs

It is not surprising, then, that most of the very real achievements of U.S. fusion work can be traced directly to the Soviet Union's consistent efforts to politicize the issue of CTR and force the U.S. to pick up the ball.

In 1955 Kurchatov realized that the difficult scientific and technological problems of CTR could not be resolved with the limited resources of the USSR alone. In a special report to the historic 20th Congress of the Soviet Communist Party in 1956, Kurchatov focused on the problems of controlled thermonuclear fusion. "The solution of this most difficult and imposing problem," he said, "would forever relieve mankind of concern over the energy reserves necessary for human existence." Underscoring the necessity of international cooperation, Kurchatov made it clear that the chief barrier to progress in CTR was political: "Complete frankness among scientists of the various countries occupied with research on controlled thermonuclear reaction is hardly to be expected so long as atomic and hydrogen weapons are not banned."

In April 1956, Kurchatov took personal action to remedy this situation. At the British Harwell Physics conference, Kurchatov presented the full experimental and theoretical details of Soviet CTR research to a startled audience of Western scientists. This was followed within a few months by a similar presentation by Academician L.A. Artsimovich in Stockholm. The furor in the West created by Kurchatov's unilateral disclosure was aggravated by the fact that, as Dr. Winston Bostick describes in his forthcoming Profusion article "The History of the Pinch Effect," U.S. scientists had hardly any data of similar depth to disclose. Therefore, the U.S. program was kept classified for another six months while a crash effort was undertaken. As the graph of U.S. funding for CTR research shows, serious financial support of fusion research began in the U.S. only after Kurchatov forced the breakdown in security classification of such investigations.

The development of two key approaches to magnetic confinement of plasma, the Tokamak and the Stellarator, reveal that here again Soviet science played the catalytic role. In the late 1940s leading Soviet scientist Sakharov proposed that fusion plasma could be contained in a doughnut-shaped magnetic bottle. The geometrical asymmetry of such a closed system would be overcome by inducing an electrical current in the plasma which would transform the circular magnetic field into helical spirals within the doughnut. In this way the plasma regulates *its own confinement.* Despite initially poor experimental results in Tokamak research, due to the atomic radiation created by the presence of impurities (especially oxygen) within the hydrogen plasma, persistent research under the leadership of L. Artsimovich was continued for more than a decade before major experimental breakthroughs were achieved.

Because of the great theoretical complexities involved in the Tokamak, the Soviet results were received with skepticism in the West. But in 1969 a team of British scientists was invited to the USSR and, using advanced laser techniques not available to the Soviets, they diagnosed even higher temperatures than those originally claimed by Soviet physicists.

A similar concept, the Stellarator, was developed in the U.S. by Lyman Spitzer. While the Stellarator is also a doughnut-shaped magnetic bottle, the helical twist in the magnetic field lines is generated externally with a fixed secondary winding around the doughnut. This secondary winding created difficulties which prevented large-scale Stellarators from being constructed before their Tokamak counterparts, but the greater control and conceptual clarity afforded by this approach provided scientists with an essential experimental tool.

When the Soviets publicized the results of their Tokamak research, the U.S. *was forced into further development* of the Tokamak breakthrough. Meanwhile small-scale Stellarator models predictably failed to achieve immediate positive results, and the Stellarator concept was retired to the archives of the Princeton Laboratory. Yet while the U.S. cannibalized other areas of fusion research to leap into the Tokamak breach, the Soviet Union supplemented its Tokamak research with development of the Stellarator idea, and now has the world's largest Stellarator program. In December 1974, a group of U.S. scientists from the major fusion research laboratories went to the USSR to examine the Soviets' latest Stellarator work; they discovered that this Soviet model of the abandoned U.S. concept may be even more promising than the Tokamak!

In addition to prodding the U.S. forward by its own fusion research, the Soviet Union has continously demanded more cooperation between U.S. and Soviet scientists in this vital work. In 1972 the USSR forced the U.S. to sign a full scientific agreement which in particular called for full cooperation on CTR research between the two countries. At the insistence of the U.S., however, laser and electron beam fusion were excluded. More recently, ERDA responded to Soviet proposals for an exchange of scientific teams with laxd-fexcuses about the shortage of U.S. scientific manpower, and in effect refused even to discuss the issue seriously. ERDA's excuses are in fact worse than just lame, for any shortage of scientific manpower stems in large part from the fact that funding for fundamental education of fusion scientists in the U.S. continues to decline from 1969 levels in real dollars.

As this brief survey indicates, Soviet science has provided the basic drive and benchmark for the realization of CTR. But the Soviets' program is limited by their relatively inferior resources, both in terms of skilled labor power and industry. In addition, the demands of an ever increasing arms race have severely depleted the USSR's fusion research arsenal.

Humanity cannot be permitted to die in worldwide famine and plague when the almost inconceivable expansive possibilities of a fusion-based economy are so nearly within our grasp. What is required to make this necessity a reality is to take the best aspects of the Soviet fusion effort as the basis for an international drive to marshal every necessary resource to the speedy solution of the life-or-death question of fusion development.

For example, development of various mainline approaches, together with several new ones, must be explored in parallel research and development efforts, while the full spectrum of scientific questions related to those efforts is investigated on the basis of a vastly enlarged program. In this way, problems which could only arise in the later stages of current bureaucratic timetables can be located and attacked now.

All that stands in the way of such a renaissance in science and in human development are the Rockefellers and their collaborators.

Soviet Science Running Ahead

by Lyndon H. LaRouche, Jr.
U.S. Labor Party Presidential Candidate

One of the important secondary reasons behind Rockefeller's present determination to go ahead with a thermonuclear confrontation is strong *evidence that Soviet science is in the* process of leaping ahead of the U.S. in both basic research and in military and other applications. Given present capitalist depression conditions and Rockefeller's own continued determination to castrate basic plasma physics research, by 1982-1985 the Soviets would have moved a full generation ahead of the U.S. in both aspects.

There are three main facets to the evaluation of the relative positions of U.S. and Soviet scientific progress: **economic, strategic focus of science development policies,** and **relevant differences in applied epistemology.** On the first count, economics, Soviet science has operated at a significant disadvantage to U.S. efforts. On the second count, Soviet strategic focus has given its basic scientific effort a margin of advantage offsetting its economic disadvantages. On the third count, epistemology, the Soviet position has been of mixed quality, marginally superior to U.S. outlooks; however, current developments give the Soviets an emerging decisive advantage on this count.

Köhler's Paradigm

For purposes of analysis it is indispensable to divide the "factors" affecting scientific development rates into two principal interconnected phases, **objective** and **subjective**. The proper approach is defined by comparing the situation of emerging capitalist and socialist societies during the modern period since the late Renaissance to the kinds of problem-situations with which *Gestalt psychologist Wolfgang Köhler* confronted his Tenerife chimpanzees.

Köhler started from the hypothesis that the capacity of the human mental process to create ideas of distinct images and to make creative discoveries was locatable in mental activity distinct from deductive or logical procedures. The special feature of his experimental approach, using chimpanzee subjects, was the recognition passed to Köhler by his teacher, Christian Ehrenfels, that the notion of "characteristics" or "invariants," as developed in the work of the mathematician Riemann, implied a unique means for exploring such phenomena of creative "insight."

Although some interpreters and shallow-minded students of Gestalt psychology have treated the phenomena as a matter of vaguely defined "intuition," that view is incompetent. The notion of an "invariant" as applied to the Köhler experiment defines creative "insight" as a deliberative feature of mental processes which can be prompted to produce whatever valid task-oriented solution exists for a well-defined problem which includes the potential ingredients of such a solution.

Köhler's special problem in setting

up and conducting his experiments was that of eliminating problems which his chimpanzees might have learned to solve through previous experience or imitation. It was essential to eliminate the possibility of learned and deductive or logical procedures, in order to predetermine that solutions to the problems were actually creatively synthesized, and so actually represented the chimpanzee analog of a human scientific discovery.

If the chimpanzees could develop such discoveries repeatedly, then it was uniquely proven experimentally that those creative qualities of mentation were characteristic (i.e., invariant or fundamental) for mental activity as a whole. That is precisely what his experimental work demonstrated conclusively, thus absolutely and finally discrediting all behaviorist "psychology," including that of such present-day charlatans as B.F. Skinner.

Most alternative psychological theories of creativity, including that of the late psychoanalyst Lawrence S. Kubie, make the blunder of regarding human creative discoveries as the result of new reductionist configurations of elements effected by mental "shaking" activities. The significance of Köhler's paradigm to our present subject is that it is the basic crucial experiment which defines the ABCs of studies of creative activity in general. It therefore represents the only existing point of departure for further studies of scientific progress in particular. Köhler set up problems of a type which he, a trained engineer as well as psychologist, could readily solve, but which chimpanzees could not solve in the same way. The discrepancy between the human mind and the ape mind was key to the crucial-experimental feasibility of the kind of study he conducted.

By combining two objective features of a controlled environment, Köhler effected the following paradigmatic arrangement. On the one side, Köhler provided an object which, as a desired object (e.g., a banana) represented a credible task-orientation for the ape. However, the object was placed so that the ape could not solve the defined problem by any direct means. Köhler added elements to the controlled environment, none of which by themselves provided a direct solution to the problem, but which a human being **but not the ape** could quickly know how to use to solve the task. The fact that the apes solved these problems in ways which could not be attributed to "hit or miss" approaches demonstrated that the ape had **synthesized** the solution.

This is broadly analogous to the history of science. Man's successful perpetuation of his society in any specific technology mode inevitably exhausts the relatively finite available resources as resources are defined by such a technology. This apparent resources-limitation barrier defines a problem integral to any fixed mode of social-reproductive behavior. That integral problem represents the analogs of the bananas in Köhler's experiments.

At the same time that production in any specific technological mode creates such problems, it also provides the society with arrays of objects (products, etc.), an integral outcome of the same activity which creates the problem to be solved. These objects correspond to the pileable boxes, connectable bamboo sticks, and so forth of the Köhler experiments.

The process of synthesizing usages of combinations of these produced objects in ways which solve the problem by shifting the society's technology is analogous to the creative insight processes which Köhler observed in successful ape problem-solving.

The additional activity of generalizing a common underlying quality for a succession of specific technological innovations is what we properly define as the basic distinction of **science**. Referring to Georg Cantor's basic accomplishments, **science** is relatively **transfinite** with respect to specific discoveries and thus an invariant form of the knowledge characteristic of a culture.

The principal analytical distinctions in the study of relative rates of development of science are consequently defined in the following broad terms. The objective definition of the problem and the coexisting array of products, etc., available as potential components of a solution are the **objective** features of the analytical effort. The rate of objective progress **relative** to the objective features is a reflected indication of the degree of creative intelligence shown by the society relative to societies of comparable technologies and similar objective conditions, and is the **subjective** feature of the analytical effort. Strategic focus and **epistemological development** are the interconnected distinguishable aspects of this subjective feature.

The objective features are in direct correspondence with the economic development of the culture. We shall outline the interconnection of economic development with the subjective features in the process of presenting the former.

Soviet Versus Capitalist Economy

The most significant primary comparison of economies and sub-economies in approximately comparable modes of basic technology is the division of labor. For industrial economies, the analysis begins with broad categories: agricultural-rural, extractive-construction-manufacturing, science, engineering, medical and educational, administrative and other social services. Within these broad categories, primarily measured as proportions of the total potential labor force, the most important gross distinction is between rural and urban populations, and within the urban population, between industrial labor force and other households. Within the industrial labor force itself, we have the second level of division of labor, among kinds of industries and included specific kinds of occupations.

Societies are initially compared in terms of the ratio of the industrial to agricultural labor force. The society with the lower ratio is the less developed, less productive. The combined effects of higher rate of social surplus and increased rate of growth of per-capita social surplus measure absolute relative development.

Within these terms, societies are to be compared in terms of the extent of diversification in numbers of kinds of industries and numbers of kinds of occupations-skills employed. In general, the more an industrial society develops, the greater the complexity of its included division of industrial labor.

It is directly relevant to comparison of the Soviet and capitalist sector industrial economies that an increase in the division of industrial labor requires an approximately corresponding increase in the absolute size of the industrial labor force. Each new kind of industry requires a finite minimal number of kinds and ratios of specific operations, so that each such industry requires multiples of least number of employee-operatives. As an industrial society develops, a fixed industrial labor force acts as a barrier to further development at the rate which obtained prior to the absorption of that labor force.

It is also directly relevant to development and its connection to science that as development occurs, the energy consumption per capita for combined production and household consumption tends to increase exponentially in proportion to simple manifest development. Hence, the industrial revolution made thermodynamical functions the central issue of a science appropriate to that development.

The degree of development of the industrial labor force and of the division of labor relative to the total population acts as a limitation upon the relative practical realization of basic new scientific discoveries. Thus, given equal subjective qualifications, the society with the lower rate of development of the division of labor will tend to show a lower rate of realized scientific progress up to the point that the rate of continued development of the division of industrial labor slows significantly relative to the less developed industrial economy.

We shall return to that point below, in connection with the subjective phases of the matter.

In this light, most of the commonplace observations concerning capitalist and Soviet science circulated during the past 40 years or so are ideological nonsense. The Soviet Union began on the basis of a predominantly rural society, ravaged by World War I and Civil War depletion of its relatively modern but narrowly based industrial sector.

Nevertheless, it made major progress toward becoming a world industrial power by 1941. Then, ravaged again by World War II (in both the Soviet Union and Eastern Europe) to an extent for which West Germany, France, Italy, and so forth offer no comparison, it recovered substantially during the 1950s. At the beginning of the 1960s, the continued high rural component represented a barrier to continuing the preceding rates of growth.

The circumstances of those preceding growth rates are also relevant. Always burdened with a relative high ratio of military production, necessary to maintain approximate strategic parity with NATO countries, the Soviet Union's limited capital goods capacity was critically reduced by this requirement. The combined effect of that military tax on production and war-time ravages forced what is now the Comecon to resort to stringent primitive accumulation against the cost of reproduction of labor power and capital stocks of existing industries, especially in the consumer goods department. Although the relatively smaller aggregate industrial labor force available acted as the major, characteristic barrier to diversifying the industrial division of labor, the need to redress the balance somewhat in favor of the material preconditions of development of labor power's quality, keenly felt during the middle 1950s and 1960s, was *highly significant in slowing the rate of* overall economic growth — given the continued circumstances of relatively high military outlays.

Although this placed Soviet scientific development at an objective disadvantage relative to the advanced capitalist sector as a whole, the definition of science in particular countries is given by the dominant technology of the world market and the influence of scientific development as such on a global scale. This point, applicable to the Soviet case, is also notably relevant to developing sector regions. The definition of science is given by the globally most advanced technology rather than the national economy as such. The immediate scope of effective developed diversification of the division of labor upon which an economy depends (including imports) determines the modes and degree of realization of basic scientific progress but, not so significantly, the dominant conceptual problem-definitions of basic science.

Soviet Strategic Focus

Throughout its existence, the Soviet Union has repeatedly won priorities in basic and applied scientific achievements. In addition to notable pioneering in basic physics and mathematics, the influence of Oparin in holistic biology and the broad seminal influence of Vernadsky represent the general picture. Two judgements ensue from that well-known evidence. First that **the index of Soviet basic scientific accomplishments relative to its economic objective basis is significantly higher than in the capitalist sector.** Second, that Soviet scientific achievements reflect a distinctly greater emphasis on **strategic** or **crucial** breakthroughs than is characteristic of the capitalist sector's scientific efforts. The second is the **immediate cause** for the first.

This inevitably carries over into Soviet military equipment, whose relative simplicity and bulkiness contrasts with U.S. engineering complexity and "miniaturization." The latter is expressive of the U.S. sector's advantages in being hegemonic for a capitalist-world-wide division of industrial labor. The former is expressive of a Soviet *propensity for offsetting* inferior development of its division-of-labor base by a marginal advantage in crucial basic technology.

In crude terms, Soviet policy would dictate a higher ratio of scientists to engineers than the U.S. case. However, that is merely a crude approximation; the essential thing, however the numbers of persons may work out as a result, is a higher ratio of basic scientific **research-power** to engineering effort.

Whether this signifies marginal advantages in direct comparisons of Soviet and U.S. scientists as such is of secondary importance here and need not be considered as such. The primary point to be made is that an emphasis on *a strategic or crucial basic-science* approach would give a decided quality advantage per scientist, assuming that the quality of individual scientists is otherwise approximately equal — for reasons already developed in the U.S. Labor Party's 1976 Presidential campaign platform. It immediately signifies a superior progress performance in basic scientific work, and, of longer-term significance, represents a world-outlook more productive of basic scientific breakthroughs among scientists *disciplined in such habits of individual* and cooperative effort.

The Epistemological Issue

Although our limited direct knowledge of Soviet science suggests rather strongly that Soviet science is of significantly superior epistemological quality on the whole, definite superiorities in that direction are only beginning to become clear. It can not be doubted that recent published work by the Labor Committees is in the process of assisting the crystallization of Soviet progress along these lines. It is most fruitful to consider that aspect of the matter from the standpoint of viewing the way in which Labor Committee contributions will probably influence Soviet science.

Despite the Soviet scientist's frequent, almost ritual deferential collateral citations from the writings of Engels or Lenin, the characteristic Soviet epistemological outlook has not been **dialectial** in any meaningful sense *of that term.* However, the Soviet *personality has a qualitatively higher* susceptibility to rapidly assimilate and master the dialectical method. This advantage is initially located in the very fact that **the name** of the dialectical method provokes curiosity and even some receptivity among the Soviet intelligentsia. The Soviet intelligentsia has the further advantage of a rationalist commitment which makes him or her more susceptible to rigorous epistemological thinking than is the case, outside of a few individuals, in empiricism-riddled capitalist intellectual circles generally. Finally the terms of reference in which we have situated the significance of scientific work are in exactly the form best suited to the proof of the relevance of the actual dialectical method to scientific work as such. Once that has been grasped by even a small number of key Soviet scientists, the subjective quality of Soviet science will tend to accelerate — and we are reasonably certain that this process has already begun.

This development coincides broadly with the circumstance that Soviet development creates a condition of overripeness for such additional methodological developments — in a *direction already partially prescribed* by the seminal Vernadsky.

The Moral Decay of U.S. Science

Although U.S. basic science continues to produce important developments, the diminishing proportion of the existing scientists involved in serious research work and the shrinking ratio of scientists as a whole must be emphasized. On this account alone, the scientific future of the capitalist sector would be one of sharp decline relative to the Soviet sector.

More important than the quantity of working scientists is the moral decay of U.S. scientists. The very idea of a "Zero Growth" outlook is axiomatically incompatible with any form of scientific work. Respecting the correlation of realized scientific progress with both industrial capital-intensive expansion and exponential rates of increase in per capita energy throughputs, every policy presently associated with the name of Rockefeller is antagonistic to any scientific effort. An individual who is tolerant of Rockefeller policies is mentally deteriorating in his potential for scientific work. The **idea of progress**, as that idea is associated with "traditional" industrial development **away from labor-intensive modes of production** is a strategic outlook on problem-solving absolutely essential to creative scientific progress. The would-be scientist without an axiomatic commitment to the idea-of-progress outlook is axiomatically incapable of scientific thinking.

"Zero Growth" is, however, far worse than a mere antithesis to the idea of progress. "Zero Growth" is a commitment to a fixedness or retrogression in applied industrial technology which produces environmental circumstances *and outlooks paralleling the charac-*

teristic paranoia of the "oriental village commune" form of society and the victims of a ghetto of permanent lumpenproletarians. The belief in "Zero Growth," like the related pathology of belief in astrology or palm-reading, or as seen in gambling mania, is a symptom of acute paranoid personality deterioration — paranoid in the rigorous clinical-psychiatric sense. A person whose world-outlook is dominated by such paranoid beliefs cannot conduct rigorous logical thought about **the real world as a whole**, let alone creative thought.

Two qualifying points are essential, so that we do not appear to exaggerate in making what is a very conclusive argument.

First, there are numerous people, including some extraordinarily gifted persons, who "flip back and forth" between clear mature thinking and outlooks and paranoid or semi-paranoid outlooks. In the relatively mild case, an individual who is adult and creative in professional work, and so forth, is characteristically paranoid or semi-paranoid in matters relating to sexual relations or to subjects he associates with immediate home and home-life circles of personal associates and activities. The determinant in such cases is that any aspect of personal life which he associates with a situation analogous to childhood (home, eating, family circles, household matters, weekends, and so forth) triggers him into infantile or semi-infantile (e.g., paranoid) outlooks and impulses. Once he is mentally situated away from such associations in his work in the adult "outside world," he becomes a mature, rational person — until acute stress in that world calls forth an infantile response.

Creativity, by its nature, involves situating one's sense of identity in some "outside world" as a whole: the world of universal nature, the planet as a whole, and so forth. It is the viewpoint which takes the universal as coherently lawful in terms of its susceptibility to rational-creative problem-solving, to theory, which distinguishes the sane, mature, and creative individual from the neurotic, "practical," uncreative, semi-paranoid personality.

The paranoid, or semi-paranoid, by contrast, denies the moral or lawful reality of the world in favor of dividing the world into two principal parts. The paranoid, thus echoing the infantile world outlook, sees the world as confined to his immediate family household or simply broadens "my family" by degrees to "my neighborhood," "my ethnic group," "my race," "the people in my set," etc. The neurotic or paranoid individual places "my home" first and makes the issue of moral acts in the world as a whole a far distant matter, if he tolerates such considerations at all. Everything beyond his immediate semi-paranoid world of "family," etc., is a mysterious, rather magical "outside world," to which he responds with propitiatory behavior through which, he desperately wishes to believe, "they" (the mysterious potencies of the "outside world") will be induced to treat him favorably (e.g., astrology, gambling, fad-manias, fetishism generally).

The problem is not that some scientists are part-time paranoids —although that is a problem in its own right. The problem of "Zero Growth" ideology is that it is the imposition of the paranoid outlook in that aspect of the scientists' personality which must be separated from the infantile paranoid tendencies of the other aspect of his personality. Since creativity and the paranoid or "family"-centered outlook are *axiomatic opposites*, the intrusion of "Zero Growth" or astrology into the professional assumptions of the working scientist means a collapse of that aspect of his personality which contains his continued potentialities as a scientist.

The second qualification to be made is that logic per se is by no means a criterion of sanity. Logic is rational (as distinct from paranoid) only when logical activity is premised dialectically on the axiomatic premise of the reality of the *world and universe taken respectively* as a whole. The rule-of-thumb distinction between sanity and mental disorder is the acceptance of the practical consequences of one's acts for a whole, real, lawful world. It is the rejection of an entire lawful world in favor of some extrinsic set of axiomatic considerations which thus represents a dichotomization of the world into the "inner" world for which one acts in opposition to the totality of the "outside world." Indeed, the acutely psychotic individual is sometimes *distinguished* as such by his indelibly schizophrenic mania for deductive constructs. For example, the attempt to reduce musical composition to a mathematical system is a probable symptom of acute schizophrenic tendencies, e.g., to free music of "emotional intuition" and make it as clean as an hysterical anal-fetishist might desire.

To the extent that "Zero Growth" and related paranoid ideologies are introduced into objective circumstances coinciding with labor-intensive technological stagnation, the society so infected must lose the capacity to maintain scientific activity.

The case of Rockefeller's Dr. Edward Teller probably sums up the overall *situation presently emerging*.

Repeatedly, Teller, whose assignment has been (together with Rockefeller's Dr. Hans Bethe) to castrate plasma physics research, has been compelled several times by Soviet breakthroughs to argue for one moment in favor of more open ("security wraps"-free) pushing of some aspect of work in this field. Then, having thus argued almost in favor of a "brute force" thrust, Teller reverses his argument, contradicting himself with obviously *fraudulent "explanations"* of why research must not move an inch past the newly-expanded limits. At this point, he becomes almost dissociated in his efforts to reconcile the coexistence of the adult-scientist and Rockefeller-paranoid impulses fighting for total occupancy of his single skin.

Although Teller and other Rockefeller science advisors may not understand the current moving ahead of Soviet science, they see it as a recurring fact and that fact scares the bejabbers out of them!

The Emerging View Of Scientific Activity In The COMECON Bloc

by Susan Welsh

July 15 (IPS) — A full Soviet mobilization for East-West trade and technological development, which bore fruit two weeks ago in the successful firing of the world's largest experimental Tokomak fusion power reactor, is being carried forward by intense intellectual ferment and educational work throughout the East bloc. As a commentator in the Soviet newspaper Pravda expressed it, "intense creative work is raging over the huge expanses of the socialist world."

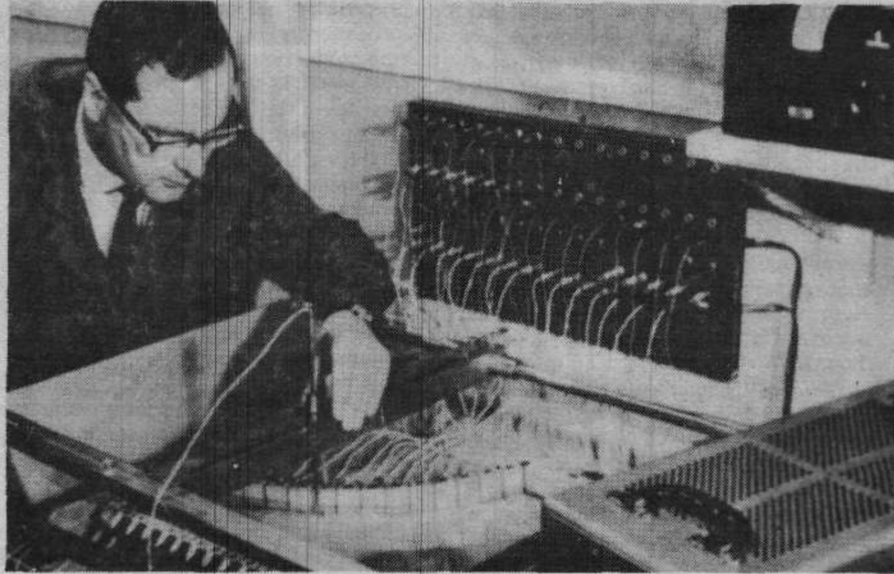
What is the social basis for creative breakthroughs like the Tokamak-10? This question is the theme for the July issue of the East German theoretical journal Einheit. The lead article attacks the view, associated with past mechanistic approaches of the Gosplan-style state planning bureaucracies, that scientific research must be regulated down to the minutest detail by the Plan. Instead, the author advocates a high degree of latitude — *"a calculated risk" — for the scientist* to investigate many different approaches to a problem. Such wide-ranging research, he states, is a crucial feature of social labor power, and no one should label it "useless" if it does not produce immediate tangible results. This is the Marxian notion of universal labor — creative thought in society which makes future development possible.

The impulse for these discussions comes from the top level of the party and government leaderships. East German Prime Minister Horst Sindermann, speaking July 11 at the 275th anniversary of the Academy of Sciences, stressed the importance of universal labor. "At the center of the Academy's activities," he said, "is basic research, the concentrated long-term research on fundamental problems." This investigation of "new, larger dimensions that correspond to *socialist economic integration*" requires cooperation among scientists from the different socialist countries. This in turn "will lead us far into the future in the analysis of social phenomena, in clarifying questions of the acceleration of scientific and technological progress and its effects in improving the working class and living conditions of the working class."

Einheit also develops the notion that it is not scientists alone who are responsible for technological progress, but society as a whole, under the direction of the Communist Party. New teams of scientists, engineers and workers will be set up in the factories to collectively solve the tasks of social reproduction.

But for this work, a highly **competent** labor force is required. A Soviet writer, Ilya Imyanitov, writing in the magazine Literaturnaya Gazeta of June 25, stresses the importance of quality education and free time for workers. "To the usual evaluation of a *person's qualifications*," he says, "is added his ability constantly to transform his activity... Collectives for whom the conflict between the natural conservatism of production and the constant necessity to change it does not become a tragedy, are made up usually *of people capable of self-instruction.*"

It is the process of personal development which produces such workers. "In *the age of mass science*," says Imyanitov, "the individual not only 'doesn't disappear,' but takes on even greater significance." Or, as an Einheit writer puts it, the distinction between manual and mental laborers must be gradually abolished, "by increasing the part *which each person plays in the creative* process, developing each individual."



Soviet science has leaped ahead. The intellectual development of the working class is necessary to solve the tasks of social reproduction.

These conceptions are brought to bear in polemics against the ideology of Zero Growth and its major adherents, the Maoists. The Maoists are put on the firing line in Literaturnaya Gazeta, in an expose by G. Saltykov on the labor-intensive methods of Chinese agriculture. Documenting the literally millions of people who are employed in labor-intensive irrigation projects in three Chinese provinces, Saltykov draws the conclusion, "Of course there are still great unutilized reserves in Chinese agriculture. However, to put them to the service of the people, the path of intensification of agriculture, wide-spread use of machines and mechanization, and artificial fertilizers, etc., must be taken." Since the government has refused to do this, the countryside is left "to fend for itself."

Western philosophers of Zero Growth are attacked in Einheit, which says that "any thought of reducing technology and its progress, or even denying its *contribution to human society, serves* only the capitalists."

ADVANCES IN SOVIET FUSION RESEARCH

New Soviet Experiments Signal Push For Brute Force Fusion Development

by Chuck Stevens

July 4 (IPS)—In an announcement widely publicized throughout the world's communist press, the Soviet *Union reported this week that the* world's largest Tokamak experimental fusion reactor, the T-10 became operational in Moscow on June 29. The announcement was accompanied by a Soviet call for increased international cooperation in fusion development which was broadcast on East German radio. East Germany's daily Neues Deutschland hailed the announcement, stating that fusion power "will provide mankind with a virtually limitless source of energy to meet human needs."

Although the T-10 will not itself generate actual fusion power, Soviet scientists say that if a series of experiments planned with the reactor proves successful when completed approximately a year from now, the USSR will be able to shorten its fusion energy timetable by four years.

Anticipating this successful conclusion, the Soviets have also launched the preliminary design and construction of a fully functional pilot Tokamak fusion generator, the T-20. Sources in the U.S. fusion program, who had not expected the T-10 to become oper*ational before October*, believe that the Soviets have significantly increased the resources they are committing to their fusion program.

At the same time, Soviet scientists who point to recent fusion research breakthroughs achieved with widely varying techniques on opposite sides of the Atlantic, have urgently stressed the need for greater collaborative efforts in face to face meetings with their United States counterparts. In one instance, Dr. M. Rabinovich, a leading physicist at the USSR's Lebedev Institute, told a delegation of American scientists who *recently visited the Soviet Union that* "it is extremely important to have Soviet Stellarator scientists work on U.S. Tokamaks and U.S. scientists work on Soviet Stellarators."

Rabinovich and others cite recent Soviet and West German experiments with new, large scale Stellarators which, in preliminary results, are achieving plasma confinement as good or better than comparable Tokamaks. Like the Tokamak, the Stellarator is a doughnut shaped magnetic bottle used to contain high temperature fusion plasmas. The difference is that the spiral "twist" in the magnetic field which keeps the plasma from diffusing through the "walls" of the field is externally generated in the Stellarator, while in the Tokamak it is generated by the plasma itself. Because of this, large-scale Stellarators are more difficult to build, but they enable scientists to control and study the characteristics of the plasmas more precisely.

Ironically, when the USSR announced successful results with its Tokamak program in the late 1960s, the U.S. rushed to scrap its own Stellarator program in order to construct Tokamaks, while the Soviets continued to develop a joint Tokamak Stellarator approach. Successful results in Stellarator containment of plasmas began to be achieved when their size was increased to the scale of the Tokamaks now being built.

U.S. Successes

In one of the striking creative successes of the U.S. Tokamak program, a team of Italian, Dutch, and American scientists at the MIT-Bitter Magnet Laboratory's Alcator Tokamak has experimentally verified the existence of a plasma "regime" which is the closest yet established to the plasma conditions under which scientists predict that actual fusion will be produced. The scientists accomplished this breakthrough by employing a magnetic field in the Alcator which is twice the strength of those generally used in Tokamaks.

In the fusion reactions now planned, fusion will take place when a mixture of deuterium and tritium, heavy isotopes of hydrogen, is maintained at a temperature of 50 to 100 million degrees Centigrade and a density of 10 to the 14th power nuclei per cubic centimeter for one second. Under these conditions, the heavy hydrogen atoms exist in a form similar to a gas, called a plasma. The plasma assumes varying systems of characteristics, called "regimes," which may be more radically different from each other than the difference between a solid, a liquid, and a gas.

Alcator has experimentally established the existence of a plasma regime called the "trapped-electron mode," which had been theoretically predicted by the Soviet scientist B.B. Kadomtsev. In this regime, which is only one step removed from the regime under which Kadomtsev anticipates actual fusion will occur, the turbulence of the electrons within the electromagnetic field increases as the density of the plasma increases. Thus, the plasma confinement time can increase, without increasing the tendency of the plasma to diffuse through the magnetic walls of the field.

Although the MIT-Bitter team had planned a series of experiments using even more powerful magnetic fields this fall, a decision by the Energy Research and Development Administration (ERDA) to deny the laboratory the funds to pay its electric bill threatens the entire project. According to a source in the project, the Bitter Lab plans to cut back all research by as much as two-thirds to save on its power costs. The money needed for the further experiments is a mere $10 million.

The Soviet's T-10 is designed to create the plasma regime under which scientists predict actual fusion generation of energy will take place, the "trapped ion mode." The T-10 will reach the confinement times and densities, but not the temperatures necessary to achieve actual fusion. However, Soviet scientists officially state that if the experiments with T-10 develop as planned, they will sufficiently establish the practicability of Tokamak fusion generators to enable scientists to completely bypass another series of "burner" experiments which has been thought necessary as the final prerequisite to building a pilot functioning fusion generator.

Soviets Test Fusion Device

by Chuck Stevens

July 10 (IPS)—On July 4 Soviet physicists at the I.V. Kurchatov Institute for Atomic Energy in Moscow fired the first experimental "shot" on the world's largest Tokamak, a magnetic bottle which will provide the basis for producing controlled thermonuclear fusion power. This successful experiment, which comes a full six months ahead of schedule and will be followed by a whole series of tests on the most efficient way of harnessing fusion energy, totally discredits the claims of many scientists that the world must cut back its energy consumption and undergo triage because fusion would not be "economical" until sometime in the 21st century. Controlled thermonuclear fusion will provide humanity with a virtually inexhaustible source of abundant, cheap and clean energy—with one gallon of sea water providing the equivalent amount of energy to that now generated by 300 gallons of gasoline.

The Soviet experimental results, obtained by a major commitment of the USSR's strained economic resources, put teeth behind the East bloc's current negotiation of "three-way" trade deals between the industrialized West, the Comecon sector, and the raw materials producers in the Third World. The development of fusion technology for commercial use over the next ten years is a necessary guarantee for those countries such as Algeria and Iraq, which are now proposing to vastly expand their oil exports to both oil-hungry industrialized nations and poorer Third World countries. Soviet scientists have said that if the current series of tests proves successful, the USSR will be able to shorten its fusion energy timetable by four years. With aid from the U.S. and (or) the European sector which possess more advanced electronic and computer technologies than the Soviets, this timetable could undoubtedly be accelerated significantly.

The Soviets have simultaneously issued a call for increased international scientific cooperation in CTR research. While there is widespread excitement mong U.S. physicists over the Soviet results, the nations energy czars in ERDA, the government energy agency, remained speechless on hearing of the breakthrough. Massive public pressure for a commitment of $20 billion a year on broad scientific research associated with the control of the thermonuclear fusion process is required to make maximum use of this major advance toward world peace and development.

A Major Step Forward

The Soviet experiment with the Tokamak, probably carried out by diverting significant industrially used power for a short time, shows how close humanity is to the achievement of a new, vastly expanded source of energy if it is willing to commit sufficient resources. Tokamak T-10, a doughnut shaped magnetic bottle will demonstrate the scientific feasibility of efficiently confining high temperature gases needed for production of controlled fusion power. The fuel, hydrogen, undergoes thermonuclear fusion when temperatures on the order of 100 million degrees are reached. Since a material container could not withstand these conditions, magnetic force fields are formed instead to confine gases at such high temperatures. The T-10 is designed to test the physical conditions which must be achieved in order to produce actual fusion reactors.

Dr. Ronald Parker, group leader of the highly successful MIT-Bitter Magnet Laboratory Alcator Tokamak in the U.S., told FEF that if the same approach were adopted by the U.S. fusion program, that a new type of Tokamak, based on the high-field Alcator design, could be constructed within two years and achieve the conditions needed to produce fusion energy. Recent reports from sources in the lab have indicated that the U.S. government plans to cut back funding to Parker's project. The U.S. equivalent of the Soviet T-10, the Princeton Large Torrus (PLT) is running behind schedule and is not due to start operation until early 1976—due to insufficient funding.

Such major commitment to brute force fusion development would mean the production of energy far and away sufficient to provide the entire world with per capita energy consumption levels beyond those currently experienced only by the most skilled layers of the U.S. working class. In terms of energy alone, CTR will redefine what constitutes "natural resources," allowing the processing of low-grade ores and other abundant materials now too uneconomical to utilize. Exemplary in this regard is the fact that controlled thermonuclear reactions can be fueled by deuterium, an isotope of hydrogen massively and cheaply available in sea water. CTR and the associated science of plasma physics represent the embryonic form of a new revolutionary technology which would eliminate most currently necessary forms of back-breaking and dangerous labor, such as stoking steel blast furnaces and mining, and introduce major new realms of man's control over nature.

Several fruitful approaches to the efficient confinement of fusion plasmas have been developed to the point where experiments to demonstrate scientific feasibility have been mapped out. International collaboration is mandatory for their realization.

In the forefront is the Soviet-designed Tokamak doughnut-shaped magnetic bottle, the Kurchatov T-10.

The equivalent U.S. model, PLT, is scheduled to be brought on line in early 1976. The Alcator, with magnetic fields twice as strong as those used in PLT and T-10, should reach full power this fall. The General Atomic Corporation's Doublet III, a Tokamak with a non-circular cross section, will be constructed within the next year and a half.

A much larger high field Tokamak, based on the Alcator design, is scheduled to commence operation at the Frascati Laboratory in Italy in early 1976. Two major Soviet experiments, the Hurricane II at Kharkov and the L-2 at Lebedev, based on the U.S. designed Stellarator, a Tokamak-like doughnut-shaped magnetic bottle, have just recently begun operation. Soviet physicists believe that these machines will demonstrate that the Stellarator can achieve the equivalent good results of the Tokamak.

Two other alternate magnetic bottle confinement schemes have recently achieved significant experimental success, LINUS and the plasma focus. LINUS is an open-ended magnetic bottle which utilizes pulsed magnetic fields, several 100 times more intense than those used in Tokamaks. Dr. Velikhov, director of Kurchatov, has in particular pushed the development of this approach. Crucial LINUS experiments are planned to come on line later this year at both Kurchatov and the U.S. Naval Research Laboratory in Washington, D.C.

Dr. Winston Bostick, a member of the Fusion Energy Foundation's editorial board for its Journal "Profusion," has informed the FEF of recent new experimental breakthroughs with the plasma focus. A fuller report on this development will be shortly forthcoming in a future issue of FEF Newsletter.

In the case of laser fusion, Soviet scientists will complete the construction of two major facilities within the next year. It is currently expected that these experiments will demonstrate the scientific feasibility of this approach.

Soviets Run Crash Laser-Fusion Program

by Chuck Stevens

July 16—Soviet scientists are rapidly completing several gigantic laser systems as part of an unprecedentedly huge laser fusion research project, Dr. Phillip J. Mallozzi told the Fusion Energy Foundation today in an exclusive interview. Dr. Mallozzi, of Battelle Columbus Laboratories in Ohio, has just returned from a tour of the Soviet Union's laser-fusion research laboratories.

Together with the starting up of the Soviets' Tokamak T-10 experimental fusion device, this tremendous Soviet laser research effort puts the USSR in the forefront of both magnetic and laser fusion approaches to controlled fusion. The solution to the controlled fusion riddle will provide the world with an almost limitless source of cheap, safe energy.

In his interview with the Fusion Energy Foundation today, Dr. Mallozzi said that three massive laser facilities are being constructed by teams of physicists led by the distinguished Soviet scientists Drs. Velikhov, Basov, and Prohkorov, and will be fully operational early next year. The lasers will be the largest in the world and are being completed years ahead of a similar system being built at the Lawrence Livermore Laboratory in California.

This dramatic Soviet push toward a brute-force effort to crack the fusion riddle coincides with a series of economic and political initiatives by the Soviet Union toward the implementation of more immediate aspects of a world reconstruction effort.

Physics of Laser-Fusion

Despite the efforts of several leading U.S. physicists to open laser-fusion research programs in the early 1960s, when the laser was first developed, the U.S. government repressed work in this important field by blanketing it under military weapons research classifications. Major breakthroughs by Basov and Prohkorov in their totally open laser-fusion program during the late 1960s and early 1970s forced the U.S. to begin its own token research effort.

In this approach to controlled fusion, powerful high-energy laser beams are used to compress and heat matter to ignite thermonuclear fusion. The pulsed bursts of laser light, lasting only a few billionths of a second, are simultaneously and symmetrically directed onto a minute pellet of fusion fuel. The interaction of the pellet surface and the laser beam generates a compression shock wave which converges inward to the pellet's core; the resulting heat and compression of matter in the core duplicate the conditions which produce thermonuclear fusion in the core of stars. The ability to focus and amplify coherent laser light makes possible the generation of even greater pressures and thus potential higher efficiencies in creating controlled fusion reactions.

The necessary concentration of energy is made possible by the coherency of laser light. The energy contained in a burst of laser light lasting one billionth of a second (a nanosecond) such as is already produced by existing high-energy lasers is **several times greater** than the total energy consumption of the world's industries during that nanosecond.

Crash Research Effort

In his interview today, Dr. Mallozzi noted that what had most impressed him about the Soviet laser-fusion effort was the speed and scope of its development. "Dr. Basov's 10 beam laser system, which will produce bursts of energy greater than 10,000 joules within a few nanoseconds, is already completed," he said, "two years ahead of the similar system being built at the Livermore Lab. It's big enough to fill an airplane hangar."

He also reported that the Soviet team under Dr. Prohkorov has "a new type of laser" which allows greater amplification and higher concentrations of energy, and "develops 10,000 joule bursts within a few nanoseconds. While Prohkorov didn't say so directly," Dr. Mallozzi added, "it looks like this new system is just a single component of another 10 beam system—a 100,000 joule laser—a system 100 times bigger than anything that exists now."

Dr. Mallozzi is himself a leading laser-fusion researcher, universally recognized as one of the most important innovators in laser technology. His *unique laser system, one of the largest* currently operating, utilizes a new multiple pulsing and pulse recombination technique which is the forerunner of a more general method potentially able to overcome two major problems in existing high-energy laser systems: low efficiency in the conversion of energy into beams of laser light, and low repetition rates for firing these systems. Both must be solved in order to develop functioning laser-fusion power plants.

International Cooperation

Dr. Mallozzi also pointed out a significant difference between the Soviet and U.S. laser-fusion research efforts. "Unlike the Livermore group, who have gone in for optimization of their laser system, pushing state of the art technology, and for sophisticated techniques for shaping the laser pulse," he said, "the Soviets have standardized their laser amplifying modules. They have a **factory** in Leningrad stamping them out!"

He explained that Soviet scientists are going for as large-scale laser energies as possible, rather than restricting themselves to further refinements on already existing laser systems. Instead of trying to control the compression shock wave created when the laser beam hits the fusion-fuel pellet by tailoring the laser pulse, he said, as the Livermore group plans to, Basov and Prohkorov are going to alter the design of the pellet.

Dr. Mallozzi stressed that the USSR's "sputnik"-style crash program to realize laser-fusion is exploring the full range of laser-matter interaction, instead of following up just a few possible lines of research which are supposed to lead to laser-fusion within the terms of a linear bureaucratic model.

In crude terms, the magnitude of the pressure generated in laser compression of matter is proportional to the energy output and intensity of the laser beam. By constructing these "brute-force" lasers, Soviet scientists are creating an essential tool for pushing beyond the boundaries of known physical phenomena. This is an absolutely necessary part of the task of comprehending and controlling thermonuclear processes. Thermonuclear fusion involves the harnessing of microscopic nuclear forces through the utilization of macroscopic inertial (e.g., gravity), electromagnetic, and thermal forces. The evolution of the interdependent totality of these macroscopic and microscopic processes, uniquely produced and self-contained by laser compression of matter, trandcends existing boundaries of physical phenomena as understood by science up until the present and constitutes the subject of the most fundamental sort of scientific inquiry.

Asked whether his Soviet colleagues faced any government-imposed bureaucratic timetables and "milestones," stupidities endemic to the U.S research effort, Dr. Mallozzi replied "They **are** the government. Basov is a member of the Supreme Soviet, and that's like being a member of Congress."

The most significant conclusion that Dr. Mallozzi drew from his tour was that the Soviets sincerely desire totally open, international, cooperative research in this vital field. The Soviet laser-fusion research effort, he observed, in contrast to that of the United States, is completely open. "They answered all of my questions," he said. "There didn't seem to be any security restrictions in the Soviet labs. I guess they (Soviet scientists) plan to get any military applications as a spin-off of this basic program."

Everywhere I went there was full cooperation," he concluded. "Soviet scientists are definitely pushing for full international cooperation."

Soviets Present Plans to Develop Fusion By 1985

Aug. 2 (IPS)—Soviet scientists have presented the Soviet Union's plans to develop fusion power by 19S5 at the June meeting of the Joint Fusion Power Coordinating Committee. As reported in the latest issue of the Fusion Forefront newsletter of the U.S. Energy Research and Development Administration Division of Controlled Thermonuclear Research, the Soviets also presented proposals for a vast increase in the current U.S.-USSR program for exchange of scientists and information.

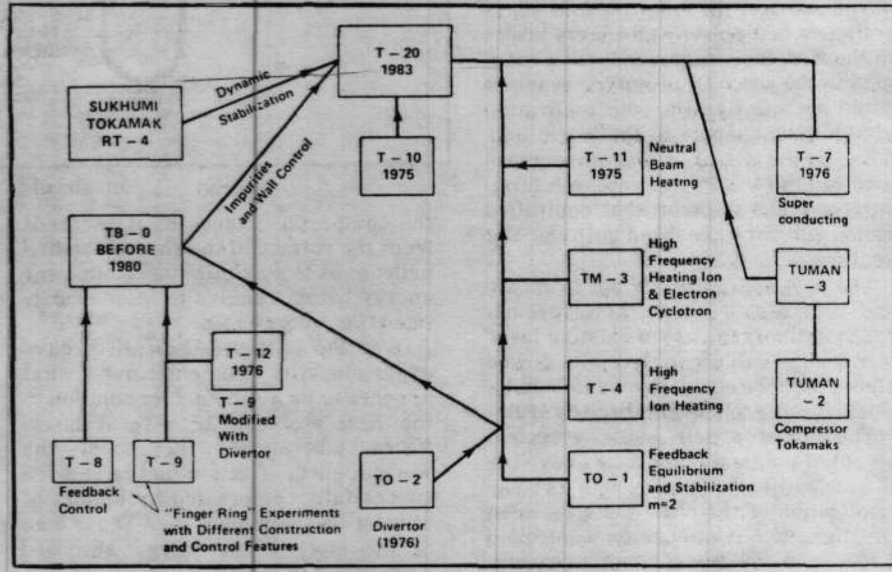
Specifically, Soviet scientists proposed that the Electric Power Research Institute cooperate with the design of the Tokamak power reactor, T-20, so that joint experiments on transmutation of dangerous nuclear fission reactor wastes already produced could also be carried out. Soviet and U.S. scientists fusion researchers were first brought together in the Coordinating Committee by the 1973 USSR-U.S. treaty for Technological Cooperation.

Alleviating the Bottlenecks

Major experiments with magnetic *confinement, other than Tokamaks,* planned to begin operation this year or in early 1976 are the MK-200, TOR-1, and TOR-2.

A feasibility experiment with imploding liners is planned for 1976. This concept, known as the LINUS in the U.S., utilizes tremendous pulsed magnetic fields, hundreds of times more intense than those used in Tokamaks, for compressing and heating a column of plasma to thermonuclear conditions. The Soviet LINUS TIN-1, which is being constructed at the Kurchatov Institute, will utilize 20 million joules of inductively stored energy to generate the multi-million gauss magnetic fields.

While the Soviet plan calls for developing a Tokamak T-20 by 1983 (see



Each box in the chart above represents different Soviet Tokamak experiments ıeading up to the prototype power reactor Tokamak T-20.

chart), their research program is based *on an in-depth, broad development of all* major approaches to CTR, together with extensive research into the basic science involved.

Experimental Work Begins On Basov Pellet

Most significantly the Soviet team reported on recent experiments on Basov type monster pellets. As Afanas'ev and Basov stated in their Jan. 20 article in the JETP letters, their monster pellet could be compressed and heated by high energy electron beams, instead of lasers. Originally it was thought that experimental work on this new pellet design would have to wait the start-up of Dr. Basov's 10,000 joule laser system which is due to begin operation early next year. However, the Soviet ANGARA-1 electron beam machine has already completed successful experiments with 1-centimeter diameter pellets. The largest pellets imploded via electron beam in the U.S. are less than 0.5 centimeters in diameter. Most importantly, Basov reports, the pellets were uniformly compressed to high densities. This means that the major problem of hydrodynamic stability which has posed the most critical stumbling block to the Basov approach has probably been definitively overcome experimentally.

Electron beam researchers contacted by the Fusion Energy Foundation in the U.S. agreed that these results were quite significant, and bode well for the success of Basov's laser fusion experiments planned for this next spring.

Soviet Scientists Announce New Approach To Laser Fusion

by Chuck Stevens

Two leading Soviet scientists have announced a new approach to laser fusion which will explode all previous timetables for the development of controlled thermonuclear fusion, potentially making this virtually unlimited source of clean, cheap fuel a reality within this decade. In an article in the Soviet physics journal JETP Letters, published Jan. 20, 1975 but only recently made available to U.S. readers, Drs. N.G. Basov and Yu. V. Afanas'ev propose using existing laser-fusion technology with a new fusion-fuel design.

Until this article was published, official Soviet estimates and those of sane U.S. scientists were that—at best—laser fusion or the other major approach to controlled fusion, Tokamak magnetic confinement, would be demonstrated to be scientifically feasible in 1976. Then, after several new technological components had been developed over the following four years (efficient fast-pulse, high-energy lasers in the first case, superconducting magnets in the second), prototype reactors could be built by 1980, with realization of significant inputs to the world economy by the late 1980s. Of course, those who run the U.S. fusion research program continue to claim that controlled fusion will not be realized until the 21st century.

The new approach laid out in Basov and Afanas'ev's article, however, because it allows the use of existing laser technology, will mean that pilot power plants could be completed by 1978 and a world fusion economy realized by 1981!

The Soviet article lights a second potential political bombshell under the U.S. scientific community with its clear implication of the close links between the gigantic Soviet push for controlled fusion and the Soviet arms program. This poses an obvious challenge to the U.S. fusion effort, which is presently crippled by repressive "weapons security classification" restrictions and narrowly focused, "limited project" orientation.

The Physics of Fusion

In the laser approach to fusion, a high-energy laser beam is used to compress and heat a minute pellet of fusion fuel until thermonuclear burn is ignited in the core of the pellet. In the resulting implosion the conditions which produce thermonuclear fusion in the core of stars are duplicated. Figure 1 shows a schematic of a laser-fusion reactor design. The major scientific problems involved are: 1. how to efficiently convert the energy of the laser beam into a compression shock within the fuel pellet, preventing the reflection of the laser light (in effect, preventing the laser light from "bouncing off" its target); and 2. How to control the evolution of

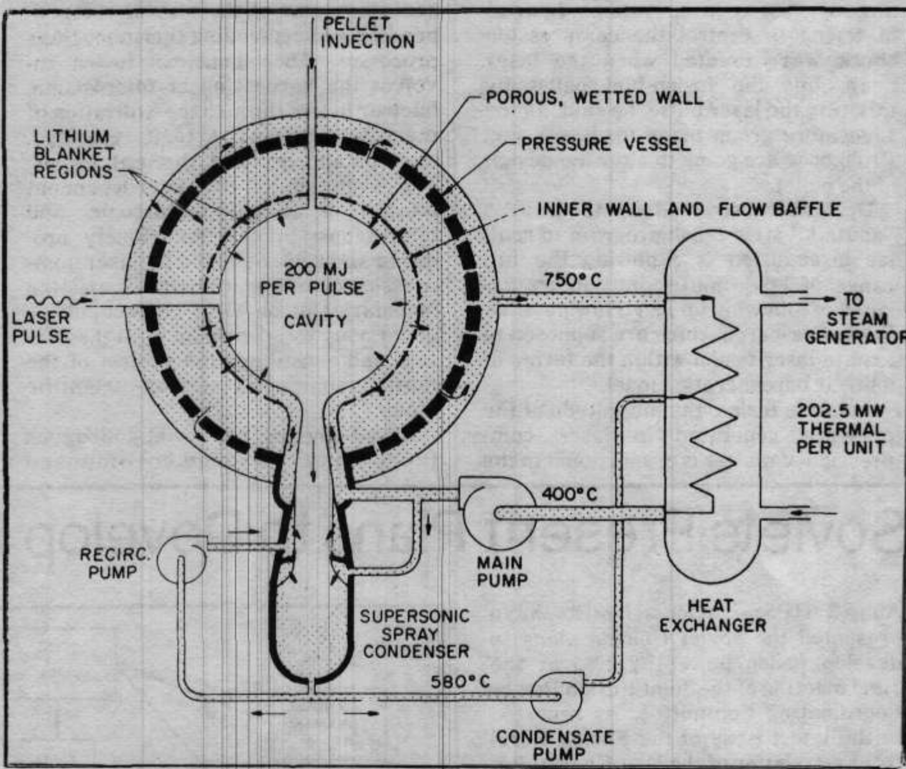


Figure 1 — Schematic of a Laser-Fusion Reactor Design.

the compression shock as it proceeds from the surface of the core of the fuel pellet so as to maximize thermonuclear energy output relative to laser energy input, i.e., energy gain.

Over the past year scientists have experimentally demonstrated what appears to be a satisfactory solution to the first problem. In several laser-fusion laboratories throughout the world, pellets of fusion fuel have been successfully compressed by factors of at least 100, with more than 50 per cent of the laser beam energy absorbed rather than reflected.

The second problem, however, has been the subject of intense debate among scientists in the United States, while essential portions of the scientific research involved remain locked up under "Top Secret" security classifications. Basov and Afanas'ev have now proposed a dramatically simple solution, thus potentially clearing away this major barrier to the quick realization of a fusion-based world economy.

Before elaborating on the scientific questions involved in this problem and the proposed Soviet solution, it is necessary to outline a few of the basic physical parameters involved.

First, the amount of fusion energy produced in any form of fusion process is proportional to what is called the Lawson number, the product of the time during which the fusion fuel is confined and the density at which it is confined. In order to produce more fusion energy than is used to ignite thermonuclear burn, the Lawson number must be greater than 10 to the 14th power (seconds times nuclei per cubic centimeter).

In the case of laser fusion, net energy release is obtained at densities of 10 to the 25th power nuclei per cubic centimeter, with confinement times of less than one billionth of a second. Under this condition the fusion fuel is compressed more than 1,000 times its normal solid density.

A second condition required for net energy production is that of true thermonuclear ignition. As the thermonuclear reaction is sparked, the fusion fuel must be of sufficient density and constitute sufficient mass such that the fusion energy released is trapped within the fuel itself and therefore sustains the thermonuclear burn. For laser fusion this means that the product of the density and the final radius of the compressed pellet must be greater than 0.3 grams per square centimeter.

The Exploding Pusher

As part of the effort to control the evolution of the compression shock set off by the laser-pellet interaction (problem 2. cited above), much work has been done in developing new designs for the fusion pellet, a relatively simpler task than the immensely complicated problem of tailoring the laser pulse itself.

One important design is the "exploding pusher" model. In May of 1974 researchers at KMS Fusion laboratories in Ann Arbor, Mich. achieved significant laser-driven implosion of fusion pellets with production of a small quantity of thermonuclear energy. The pellet used (see Figure 2) was a hollow glass microsphere filled with fusion fuel consisting of deuterium and tritium (D-T, the heavy isotopes of hydrogen) in gas form. The pellet, which would easily fit on the head of a pin, measures 50 millionths of a meter in diameter, and the glass shell is one millionth of a meter thick.

Sixty joules of laser energy in a simply shaped pulse was symmetrically directed onto the sphere in two beams. A significant portion of the glass shell exploded outward, creating an equal inward-directed force which imploded what was left of the glass shell, in the same way that a rocket's backward thrust impels the rocket forward. The implosion of the shell pushed the D-T gas inward, resulting in the compression and heat sufficient to produce thermonuclear energy.

Isentropic Compression

Exploding pusher pellets have also been successfully imploded at the Lawrence Livermore Laboratory (LLL), one of the U.S. government's main weapons research labs. But scientists there have argued that despite the initial successes, true thermonuclear ignition cannot be achieved with this design of pellet, and have proposed an alternative isentropic compression pellet design.

This design is geared to preventing excessive preheating of the fusion fuel before the compression shock set off by the laser light reaches the pellet's core. With exploding pusher pellets, such preheating of the fusion fuel makes compression much harder to achieve by diverting energy away from the inward push into random motion (heat). In the isentropic compression model, the laser pulse is carefully controlled and shaped in the pellet to prevent preheating. Second, the exploding pusher model wastes much of the laser energy due to the significant explosive blowoff of the glass shell. These factors mean that the exploding pusher model uses laser energy less efficiently, and therefore would require much larger lasers than the isentropic pellet to achieve true ignition. Even with the largest lasers now being built in the USSR and U.S., of approximately 10,000 joules of energy, the exploding pusher would not reach the requisite density-radius product of 0.3 grams per square centimeter and so could not achieve true thermonuclear ignition, as the LLL scientists have argued.

In hollow pellet compression the intense energies of laser beams are used to develop gigantic pressures, roughly one trillion times normal atmospheric pressure. A hollow spherical shell, if it can be uniformly compressed, would reach greater compressions than a solid pellet, and would therefore utilize laser energy more efficiently. The reason is fairly obvious. Because the hollow shell does not meet any significant resistance as it implodes until reaching the center of the pellet, it achieves greater momentum and therefore greater compression than would a solid pellet. The larger the ratio of the overall pellet radius to the thickness of the hollow shell (called the pellet aspect ratio), the more efficient the compression.

Even with the more efficient isentropic compression design, the laser requirements are far greater than any existing laser system can produce. The Livermore group believes that compressions on the order of 1,000 to 10,000 would have to be reached in order to produce net energy. In other words, the final density reached by the hydrogen fuel would have to be greater than 1,000 grams per cubic centimeter, 1,000 times normal solid density. The minimum laser requirement for attaining this compression, based on the LLL isentropic pellet compression, would be a laser which puts out 100,000 to 1,000,000 joules in a pulse lasting no more than 10 billionths of a second, with a short wavelength between 0.3 and 0.6 millionths of a meter, and a peak power output between a trillion to 100 trillion watts, with the efficiency of the laser greater than 10 per cent. In almost every category, existing laser systems fail to meet these requirements by a factor of 10, and in some cases by much more.

Tampered Pellets

Another method of increasing the efficiency of compression is to use outer shells made of heavy materials, such as gold. (See Figure 3) Such a heavy shell shields the fusion fuel from preheat before full compression is reached at the pellet core. By providing better containment of the fusion fuel, the heavy shell aids in realizing true thermonuclear ignition. In addition, the shell also helps stabilize the pellet compression and makes the implosion more uniform, avoiding the "splurt" and other instabilities of the exploding pusher's thin glass shell.

The problem with the heavy shell approach is that the gold tamper, or for that matter a tamper made of any material, displaces the actual fusion fuel. Such a design would relax laser requirements and achieve high energy gains only if the pellet was increased significantly both in terms of aspect ratio and overall size, although this of course would increase the likelihood of the onset of hydrodynamic instabilities, such as the Rayleigh-Taylor instability mentioned above.

Soviet Laser Fusion Approach

Drs. Basov and Afanas'ev propose to do precisely that. The pellet design they put forward in their article is approximately 2 centimeters in diameter, 400 times larger than the KMS and LLL pellets, with a gigantic aspect ratio of 100 to 1—a really **big** pellet. The design also differs from the LLL and KMS models in that only compressions to final fuel densities of 100 grams per cubic centimeter are needed to produce significant fusion energy. In fact, this pellet would achieve a net energy gain of 1,000, i.e., a 1,000 times more fusion energy than laser energy output. This is orders of magnitude greater than the best projections of U.S. models.

The key to this Soviet pellet design is the large density-final radius product which would be obtained. This would be ten times greater than the minimum 0.3 grams per square centimeter requirement—sufficient to create a thermonuclear inferno.

The laser parameters for this giant pellet design are relaxed significantly

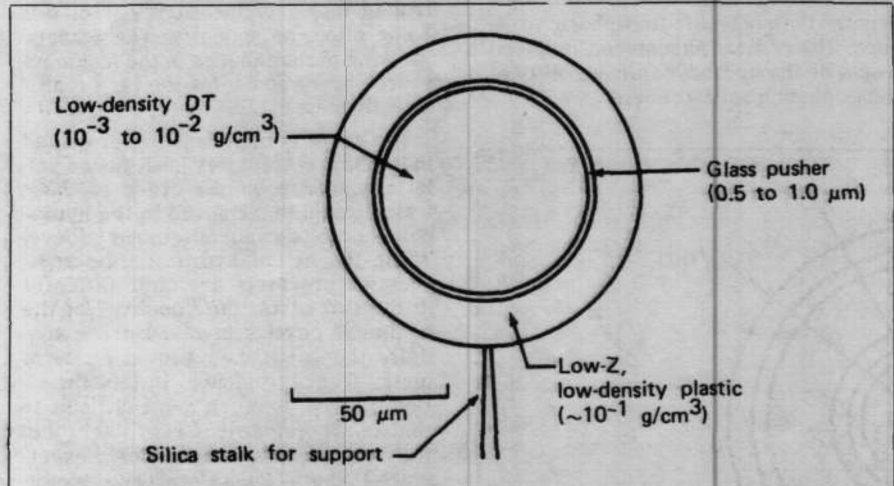


Figure 2. Exploding-pusher type of laser-fusion target. A spherical glass shell filled with low-density DT gas is enclosed by a spherical pusher of low-density plastic. The functions of this plastic are to enhance absorption (via increased cross sections, while minimizing the total target mass so as to maximize temperature) and to improve implosion symmetry via azimuthal electron conduction in the relatively-low-density, low-Z plastic. The DT is compressed and heated by the sudden explosion of the glass when heated by a high power laser pulse.

compared to those for the KMS and LLL models. First, because of the pellet's large size, the laser pulse duration would be as much as a 100 times larger than in the KMS and LLL cases. Second, the necessary peak power would be tremendously decreased due to the large aspect ratio. Further, since the Soviet design uses a gold shell more as a **"barrier"** than as a pusher, the wave-length of laser light could be significantly lengthened. The total laser energies would be of the same magnitude, but the energy gain would be much greater. Most important, the projected relaxation of the necessary laser requirements means that existing laser systems, electron-beam-excited carbon dioxide and chemical lasers such as the hydrogen-flouride and iodine lasers now being successfully developed, would be more than adequate for functioning laser-fusion power plants.

The major questions with this new approach are whether efficient compression can be achieved and whether hydro-dynamic stability can be assured. As to the first, Basov and Afanas'ev "emphasize that in the experiments of (KMS and LLL) the D-T gas is compressed with the aid of a heavy shell with mass much larger than the D-T gas." This, as they point out, leads to much lower energy gains with less efficient compression. They instead propose that the evolution of the compression shock can be tailored through utilizing alternating layers of shells of different densities. In this way the compression can be made quite efficient.

The essential question is the second, hydrodynamic stability. On this score Basov and Afanas'ev write at the end of their short article, "It should be noted in conclusion that the gas dynamic calculations of the targets are based on the experience gained by high-temperature hydrodynamics research in the USSR."

We will now offer some speculation on what exactly is meant by this unprecedented bold statement by these leading Soviet scientists, since the prognosis for realization of the approach they propose hinges on this statement.

The Soviet Union has the largest thermonuclear weapons, hydrogen bombs which have an explosive force of 100 million tons of TNT, many times larger than U.S. bombs. It is very likely that this is what Basov and Afanas'ev mean by "experience gained by high-temperature hydrodynamics research in the USSR."

H-bombs are triggered by nuclear fission bombs. To make thermonuclear weapons more efficiently, and also scale them up in size, it is necessary to increase the ratio of fusion energy versus fission energy released. There are only three ways this can be achieved. First, the thermonuclear fuel mix can be rearranged. Second, the coupling of the fission-fusion reactions can be improved, that is, thermonuclear-produced neutrons can be used to increase the rate of the fission chain reaction. Third and most important—since the first two methods are actually dependent on this parameter—the fission and fusion fuels can be imploded to high densities. This compression of the fission and fusion fuels increases the rates of reaction in both cases.

Replacing the gold outer shell of the proposed laser fusion pellet with a shell of Uranium-235, as is done in actual H-bomb and as has been proposed by the Soviets as a possible laser fusion pellet design, would mean that as the pellet is compressed the uranium reaches critical mass and explodes, which then further compresses the fusion fuel to much higher densities. In H-bombs, the initial compression of the basket-ball size pellet would be obtained with chemical explosives, which can currently reach pressures 10 million times greater than normal atmospheric pressure. The critical phenomena involved would be the **hydrodynamic stability** of the imploding hollow sphere.

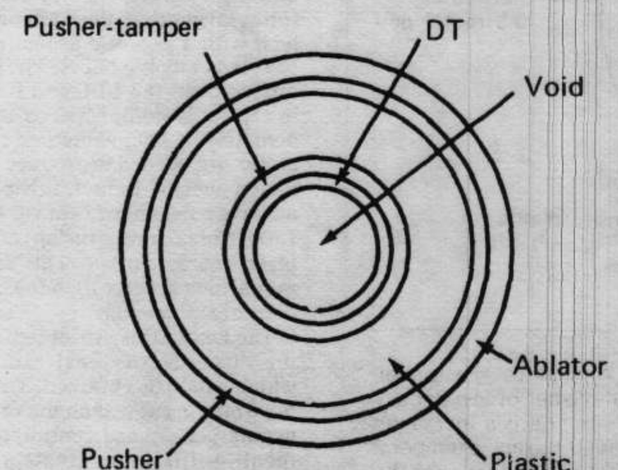


Figure 3 — Spherical laser-fusion target with multiple pushers to reduce required laser power.

Application of implosion physics to atomic weapons was first initiated by Dr. Seth Neddermeyer in the U.S. during the Manhattan Project of World War II. The idea was that imploded spheres would achieve more efficient fission bombs with less fissionable mass. When it developed that Plutonium 239-fueled fission bombs could only be detonated by compression, the whole Los Alamos Laboratory directed its attention to this problem, and John Von Neumann developed the first comprehensive theoretical model of imploding hollow spherical shells.

But in regard to the application of these initial breakthroughs to the current pressing problem of realizing controlled fusion, the effort in the U.S. has been deliberately restricted to narrow, limited lines of approach. Significant areas of this vital work are roped off under the pretext of security, and fusion scientists are left to compete with each other in rival empires of specialized expertise.

As to the methodology implied by this outlook, with respect to the problem under consideration here, Dr. John Nuckolls of the Livermore Lab comments in the LLL 1974 annual report that the non-linear dynamics of large pellets with high aspect ratios can not be studied with the linear Lagrangian computer models that are used at LLL. Furthermore, Keith Boyer of Los Alamos also notes "that these simulations ignore nonlinear effects, which might prove to be stabilizing."

As the history of Soviet fusion research shows, and as the Basov-Afanas'ev article further implies, the USSR is increasingly focusing its resources on the broadest possible research effort into the basic questions of thermonuclear and plasma physics research, drawing both weapons and controlled fusion applications out of this basic effort as spin-offs. The Soviets' growing predominance in the fusion research arena indicates the far greater effectiveness of their methodology.

The range of final densities projected in the Basov-Afanas'ev laser fusion pellet design are on the order of those which would be achieved in the hydrogen bomb design discussed above. While the actual hydrodynamic compression processes are quite different in the two cases, the "quality" of the nonlinear physics involved are essentially the same, i.e., producing symmetry from turbulence. In fact the H-Bomb model is much more difficult to realize. Therefore it is very likely that the hydrodynamics research **"experience"** (both theoretical and experimental) which Basov and Afanas'ev refer to was precisely that which had been developed to solve these problems in thermonuclear weapons design.

Basov and company will begin to fire their giant laser early next year. In combination with the new pellet design, experiments may very well mark the first definitive proof of scientific feasibility.

FEF Board member Dr. Morris Levitt (foreground-left) at recent WFSW Symposium in Moscow on the 'Scientists' Role in the Struggle for Disarmament.'

REPORT ON WORLD FEDERATION OF SCIENTIFIC WORKERS MEETING

Scientists Meet On Peace In Moscow

The following is a special report from Dr. Morris Levitt, a board member of the Fusion Energy Foundation (FEF) and a member of the U.S. Labor Party, on the Symposium on the Scientist's Role in the Struggle for Disarmament concluded in Moscow this week. Dr. Levitt, who represented the FEF at the conference, was asked to join the U.S. delegation by the World Federation of Scientific Workers (WFSW), the convenors of the Symposium.

MOSCOW, July 20 (IPS) — The largest gathering of scientists ever assembled to discuss disarmament — over 400 specialists from 62 countries — concluded a five-day symposium here yesterday by issuing an "Appeal to the Scientists of the World," calling upon scientists to recognize their moral responsibility to support measures for disarmament.

Though the general "Appeal" fell far short of expressing the widespread desire of delegates to link peace to development and scientific growth, the Symposium's final working papers did include an adopted FEF motion that an important future objective of the WFSW would be "economic development and ...increased international scientific and technological cooperation for economic development."

The conference was opened with a valuable statement by Mr. Romesh Chandra, Secretary-General of the World Peace Council, who called upon the assembled scientists to contribute *politically to the defense* of the recent victories of the working class, as in Portugal and Indochina. Chandra warned of the danger of the "imperialist attempt to destroy détente in order to roll back the victories" of workers internationally.

This, however, was the political highpoint of the Symposium, which avoided the necessary discussion of the connection between warmongering in the West and the current collapse of capitalism; the discussion of the role of the scientist in dismantling this warmongering and turning around collapse — by aiding in organizing the necessary economic and scientific breakthroughs *was also not adequately developed.*

The major scientific and programmatic work of the Symposium was centered in five working Commissions which dealt with such topics as measures to be taken by scientists and their organizations in working for disarmament, international cooperation for peaceful uses of science, and policy *on non-nuclear weapons of mass* genocide. The most important scientific work per se was undertaken by the Commission dealing with the latter topic, with detailed documentation of the development and effects of binary nerve gas and other modes of biochemical warfare, and points of entry for climatological and geophysical warfare. This commission recommended a total ban on all research and development for such weapons systems. The full report of the work of the Symposium will be finalized by a committee of the WFSW.

FEF Intervention

The Commissions dealing with the benefits of disarmament generally based themselves on the limited conceptions in WFSW founding member J.D. Bernal's book "World Without War" which argues incorrectly that resources are sufficient — in the absence of military spending — to meet the basic needs of the world population. In taking up this question, this writer responded that economic development was not a simple, static by-product of reduced arms spending but was itself a **necessary** and dynamic imperative for preventing ecological holocaust and creating the political conditions to neutralize and destroy the threat of nuclear holocaust. To provide needed agricultural advances in irrigation, fertilizer, housing and other development areas, an order of magnitude increase in energy throughput would be required — which could only be sustained and qualitatively improved through an international crash program for fusion development.

It was then recommended that the WFSW take under consideration an international conference on the transition to a fusion-based economy as the best way to develop a program for economic development and international scientific cooperation.

While the FEF recommendation was not included in the final working papers of the Commission, there was adoption of the more general above mentioned FEF statement on "increased international scientific and technological cooperation for economic development." In addition important parallel statements were made by the Minister of Construction of Sri Lanka: "The most important question for the large masses is development. This must be the standpoint for raising the issue of disarmament."

Discussions were held throughout the conference on FEF and USLP research and development programs with the leaderships of such delegations as Portugal, Cuba, and India and with delegates from throughout the advanced and Third World sectors. After reading the ICLC Third World development programs prepared for last spring's Baath Party meeting in Baghdad, an Indian member of Parliament (Congress Party) commented "for any true development, Indian agriculture must be industrialized."

While the final plenary of the Symposium, voted only on the "Appeal," the more substantive proposals of the working Commissions were left to be finalized by the WFSW Executive. These included: working for the implementation of the UN Resolution to reduce arms spending by nations by 10 per cent, pushing for a total ban on biochemical and climatological research, organizing for the World Peace Council's Disarmament Conference to be held in York, England in 1976, and convening a WFSW Conference on Third World Development.

Resolution Proposed By The F.E.F. To The World Federation Of Scientific Workers

As was stated in the proclamation of the Government of the Soviet Union on the 30th Anniversary of the defeat of Nazism, humanity today has the technical and economic ability to abolish hunger, wipe out all misery and want, and provide to every human being the material prerequisites for the realization of their full creative powers. The real basis for the establishment of peace is the common interest of all people in achieving the international economic cooperation and world wide development which will free mankind from the present horrors of a new depression — a depression deeper than that which spawned Nazism.

As scientific workers, we reject all theories which purport to show that growth and development — the liberation of humanity from want — is impossible. To accept the arguments of "limitations of finite resources" is to endorse policies of reduced consumption and to condemn the bulk of humanity to death by disease and starvation.

In contrast to the theories of Zero Growth, the history of humanity shows that our survival as a species has always depended on the ever expanding utilization of scientific and technological innovations to overcome the apparent limitations of any given mode of production. So today, the achievement on a global scale of the material standards of living required by a developing population must be accompanied by a fundamental revolution in the technology of production.

The foundation of this revolution is the development of controlled thermonuclear fusion power. It is clear that the necessary steps to increase food production, to provide fertilizer, irrigation, and mechanization to the now underdeveloped areas of Asia, Africa, and Latin America, and to vastly increase the industrial capacity of the advanced sector countries for the provision of housing, clothing and other material requisites, will involve energy consumption levels at least an order of magnitude above the present levels. At such energy consumption levels, the existing fossil fuel reserves will be substantially exhausted by 1990. Only controlled thermonuclear fusion power can provide an abundant and economical source of energy on the scale required.

An international program aimed at the crash development of practicable thermonuclear fusion power on a significant scale by 1985 is, therefore, the absolute necessary requirement of any policy of world economic development.

The establishment of such an international program can act as the focus for the revitalization of scientific and technological advances along a broad front. The theoretical and engineering problems involved in the realization of controlled thermonuclear fusion power bear on virtually every fundamental field of the physical sciences. The technological innovations stemming from the development and implementation of fusion power — technologies such as plasma processing, superconductivity and laser development — provide the basis for a complete transformation of the world economy by the late 1980s, and for solving the problems of pollution control and resource availability.

The main task in the next decade is the creation of a world-wide labor force trained in advanced technologies and provided with the necessary material requirements of productive human beings. The existing technologies of agricultural and industrial production, if applied on a sufficient scale, and in the framework of mutually beneficial trade among advanced sector nations, the socialist states and the underdeveloped countries, can supply these requirements in abundance.

It is the task of scientific and technical specialists of various types, collaborating with workers and farmers, to prepare those concrete alternative development plans and economic programs to implement a policy of global development and growth.

It is resolved that the World Federation of Scientific Workers will establish a special Commission on Economic Development to be open to participation by other organizations. This Commission will facilitate the setting up of international working groups of scientists and other specialists to draw up implementable plans of development aimed at increasing agricultural and industrial production, advancing technology and eliminating want.

It is further resolved that the Federation will act together with other interested organizations to promote the establishment of an international crash program for the development of controlled thermonuclear fusion power.

From Lawrence Livermore Laboratory

FOR RELEASE:
Wednesday afternoon, July 30, 1975

PUBLIC INFORMATION OFFICE
Daniel M. Wilkes
Jefferey B. Garberson (source)
(415) 447-1100, Ext. 7407

Major advance in controlled fusion research at Lawrence Livermore Laboratory, the magnetic confinement of superhot fuel at temperatures well within the range where self-sustaining fusion reactions can occur, was announced today (July 30, 1975) by Dr. Robert C. Seamans, Jr., Administrator of the Energy Research and Development Administration (ERDA)

The Laboratory is operated for ERDA by the University of California.

Speaking at the San Francisco Press Club, Dr. Seamans said that Livermore

Press Release

researchers had used the 2XII-B experiment and the world's most powerful fuel injection system to attain the highest temperatures ever observed in a major fusion experiment—about 250 million degrees F.

He said they also demonstrated a scientific effect that is crucial to the "mirror" approach to controlled fusion—the hotter the fusion fuel, or plasma, the longer and more stably it can be confined by "magnetic bottles" of the mirror type.

The mirror approach to fusion is centered at Livermore and is one of several being pursued nationwide.

Length of confinement for the 2XII-B experiment was five thousandths of a second—well short of the length required to simulate reactor conditions, but a factor of 12 higher than that achieved by the previous-generation experiment, 2XII.

In addition, the researchers observed a plasma density only a factor of three or four below that believed needed for eventual reactors.

The results, according to Dr. Frederic Coensgen, leader of the experiment, are "the most significant for the mirror program since 1961," when LLL obtained its first unequivocal evidence of neutrons from controlled thermonuclear fusion reactions.

They indicate that most plasma losses were not due to the internal instabilities that have frequently plagued fusion experimenters but to the much less serious effects of collisions between plasma particles, he said.

Dr. Coensgen's colleagues in the experiment were Dr. Thomas Simonen and William Cummings, Grant Logan, Arthur Molvik, William Nexsen, Barry Stallard and William Turner. Neutral beam fuel injectors developed by Lawrence Berkeley and Lawrence Livermore Laboratories played a major role in the experiment's success.

In equaling or exceeding all major experimental goals for the 2XII-B, the latest results lend strong credence to the possibility that a next-generation experiment may be able to demonstrate the scientific feasibility of the mirror approach to fusion.

"We believe we can extrapolate the 2XII-B results to denser, hotter and larger plasmas in future mirror experiments," said Dr. Coensgen.

In the meantime, he said, LLL researchers are altering the 2XII-B to try to extend current results later this year. The principal modification is a doubling of the injected neutral beam energy to 40 thousand volts (KeV) to investigate plasma stability at temperatures about twice as high as those achieved to date.

The mirror approach is named for the characteristic configuration in which energetic, electrically charged heavy hydrogen nuclei are reflected back and forth between regions of strong magnetic force. It is while they are moving back and forth that they can collide, fuse and release energy.

An important technical feature of this configuration is that in principle, a large amount of energy-producing plasma can be packed into a relatively small "magnetic bottle," thus minimizing the size and capital investment required for an eventual power plant.

2XII-B and Controlled Fusion

The three basic goals controlled fusion researchers are working toward are high plasma temperature, high plasma density and sufficient plasma confinement time.

2XII-B, extending work done with its predecessor experiments, approaches reactor temperatures and densities but, using a powerful but briefly pulsed electromagnet, has a confinement time measured in thousandths of a second. For mirror reactors, a confinement time close to a second (the lifetime of an average heavy-hydrogen nucleus within the "magnetic bottle") is needed.

Baseball II-T, a major companion experiment at Livermore, uses a superconducting magnet to confine a much lower density plasma essentially as long as desired. A next-generation mirror fusion experiment would also use a superconducting magnet and combine technologies developed in both 2XII-B and Baseball II-T research.

Such an experiment could be in operation in the early 1980s. Given success, very substantial engineering challenges would have to be met prior to development of a reactor. These challenges—already being addressed at Livermore and other fusion laboratories around the country and abroad—range from studies of materials damage caused by neutrons emitted from fusion reactions to improvements of superconducting magnets and neutral beam fuel injectors.

Winterberg: New Proposal On Laser Fusion

Aug. 15 (IPS) — A new target design for use in laser, ion, or electron beam, fusion systems which could be less susceptible to hydrodynamic instabilities during the implosion phase was discussed by Dr. F. Winterberg in the July 23 issue of Nature, the leading British science journal.

As in the proposed Soviet laser fusion system, the use of hollow, thin shelled, multi-layered spheres for the laser pellet-target relaxes the stringent requirements for a high energy laser systems to produce net fusion energy. However, the thin shell tends to ripple and tear when it is imploded by an intense beam; i.e., it is hydrodynamically unstable and, thus, fails to achieve the desired compression of the fusion fuel, aborting the ignition of fusion burn.

Dr. Winterberg suggests that the hydrodynamic instabilities can be overcome through a rotation of the target — a hollow cylinder, rather than a hollow, thin sphere — during the implosion phase. The outside shell of this cylinder would have spiral fins of some heavy material such as gold. As the high energy beam strikes, the outer layer of the cylinder, a less dense ablating material between the fins, would explode outwardly. Two forces would then be produced on an inside layer of fusion fuel: an imploding force inwards, and a spiralling radial motion. The result — a collapsing vortex. The turbulent forces produced during the implosion could then be stabilized, in the same way that a tornado vortex funnel stabilizes and directs powerful atmospheric turbulence. A collapsing vortex system could also be used to produce very strong, pulsed magnetic fields to trap and compress fusion fuels to ignition conditions.

Soviet Leader – 'Fusion Power By 1980'

Paris, Sept. 17 (IPS)—Asked today about prospects for fusion power by 1985, Gregori Romanov, candidate member of the Politburo of the Communist Party of the Soviet Union, told European Labor Committee organizers: "1985? You must be kidding. At the rate we are moving, we will get fusion power by 1980!"

The chance meeting between Romanov and the ELC members Occurred at the Festival of L'Humanite, paper of the French Communist party. Romanov is heading the Soviet Delegation to the fete.

Plasma Focus Approach To Fusion

Aug. 1 (IPS) — Professor Vittorio Nardi and Fusion Energy Foundation Editorial Board member Winston Bostick of Stevens Institute of Technology reported in an interview yesterday that the significant advances made by their experimental group and others in research on the plasma focus approach to fusion were being completely cold-shouldered by the Controlled Thermonuclear Research Division of the Energy Research and Development Administration (ERDA).

At the mid-July Conference on Neutron Sources at Argonne National Laboratory, the Stevens group showed that the energy output of plasma focus devices goes up extraordinarily as the fifth power of plasma current. These results indicate that a highly efficient, high-yield neutron producing test facility could be built for only $10 million.

ERDA has so far refused to seriously review the proposal even though it would cost only a fraction of the price of machines proposed by major government-affiliated labs.

Fusion Energy Foundation

The Fusion Energy Foundation was founded in November 1974, at a meeting attended by representatives of the United Nations, the International Atomic Energy Commission, scientists who have made significant contributions to fusion research, and interested laymen.

The purpose of the FEF is to provide a forum of independent, high-level scientific discussion of fusion from the standpoint of comprehensive policy-making. We need your financial support.

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