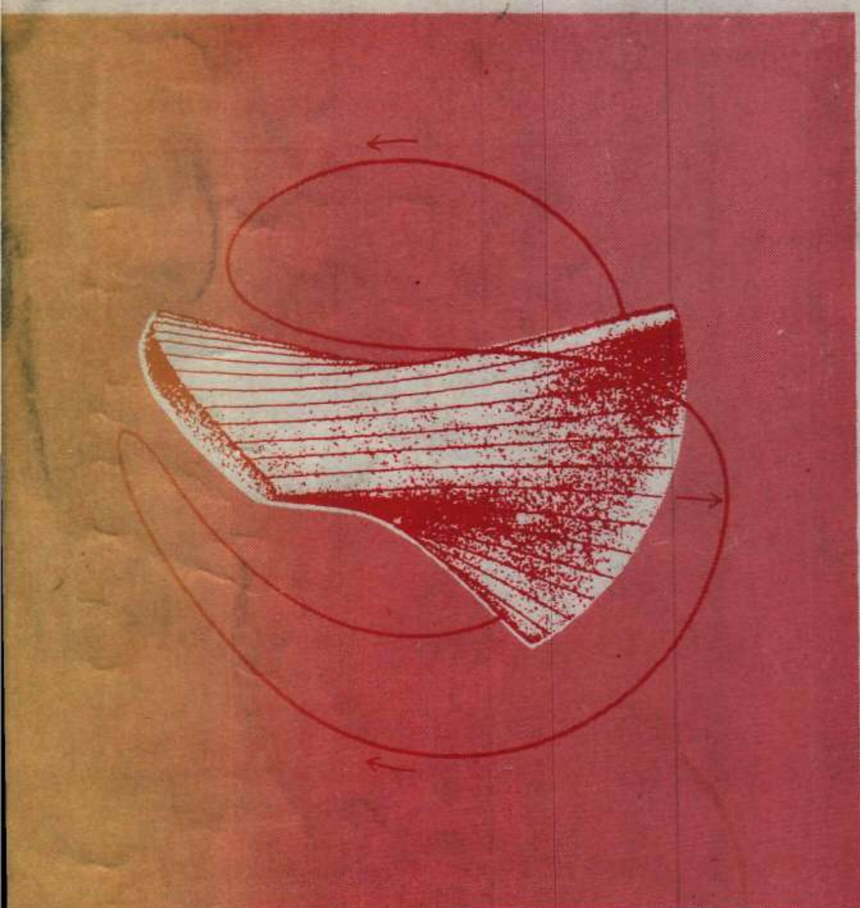
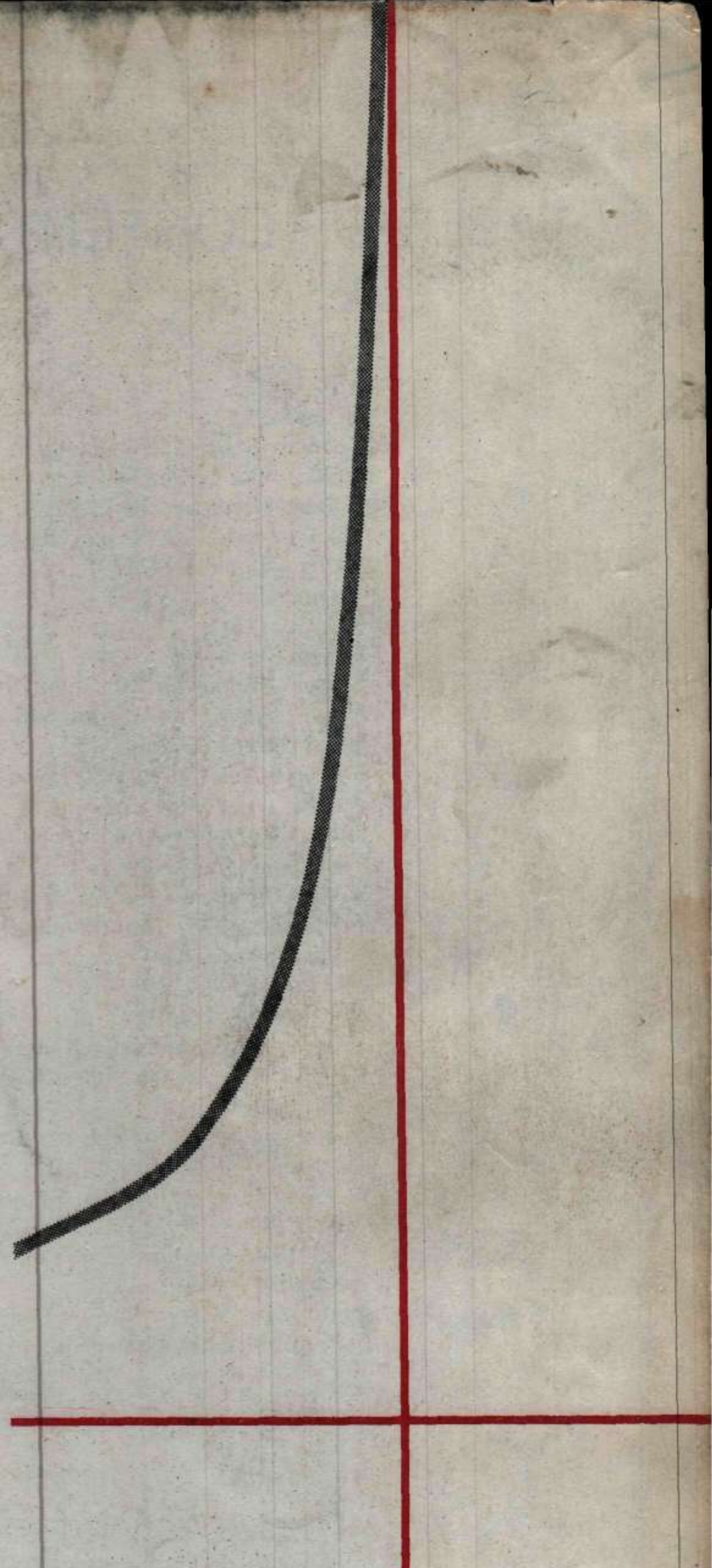
Fusion Energy Foundation





Newsletter

May, 1976
Vol. 1, No. 5
$1.00

TABLE OF CONTENTS

The views of the Fusion Energy Foundation are stated in the editorial. Opinions expressed in signed articles are not necessarily those of the Directors or the Scientific Advisory Board.

Cover: Recent breakthroughs in a half-dozen experiments now pose the question: how to go BEYOND BREAKEVEN.

Editorial

Needed: A New Fusion Program

Despite a burst of ground-breaking results in 1975, we will not get fusion when we need it without a new fusion development policy. The **essentials** of that policy have now been spelled out in the U.S. Labor Party's Fusion Energy Research and Development Act of 1976 which is reproduced in this issue.

The bill, which specifies organizational innovations needed to stimulate basic research, comes at a crucial juncture for fusion. On one hand, there has never been greater **uncertainty** about the future of fusion development: ERDA — The U.S. Energy Research and Development Administration's CTR Director Robert Hirsch, after moving up his timetable for fusion to the 1980s, has been replaced by Ed Kintner, whose previous experience was largely confined to the fast breeder program; and ERDA continues to push the breeder as the medium-term "solution"; the cooperative European program, centered in the Joint European Torus (JET), has been pushed back six months due to the political quagmire over where to site the test device; and budget cuts or limitations threaten back-up and main-line devices such as Scyllac and Alcator in the U.S. and the Garching Stellarator in West Germany. Exploratory and basic research limps along with minimal support.

On the other hand, there continues to be significant progress in the most well known fusion device, the Tokamak — especially with the spectacular recent results of the Soviet T-10 and Oak Ridge Ormak. Several high density approaches, particularly electron beam, which received little or insufficient funding in the U.S., but major support in the Soviet Union, give evidence of near-term breakthrough.

It is particularly this latter group of device types which brings to the fore the theoretical problems which must be subjected to exhaustive study at the National Fundamental Research Centers proposed in the Labor Party legislation. Pending more detailed discussion of these basic theoretical questions in our next issue, we begin their examination in this issue by reporting on recent progress in a class of related devices: plasma focus, electron beam, and imploding liner.

In brief, what theoretical and experimental results for each of these devices indicates is that the most important characteristic of the plasma state of matter is its tendency to form itself into micro-and macro-structures that involve well defined relationship between current and field geometries. Unless that is recognized, and its implications explored as we begin here, it is pure verbiage to call plasma the fourth state of matter — much research will continue to be misdirected, or at least insufficient in conceptual clarity. More generally, plasma, as the characteristic state of matter in the universe, provides the medium not only for investigations leading to controlled fusion, but also for beginning the theoretical unification of the particle-field duality which underlines the disjuncture between general relativity and quantum mechanics.

Our message in this issue can therefore be summarized: while technological and applied scientific advances may lead to energy breakeven, and justify an immediate maximum effort, open-ended fusion development necessitates going to the frontiers of physics — and beyond. With adequate levels of funding for research and training it is possible to stimulate both ingenuity in synthesis and improvement of reactor prototypes and devices as well as necessary fundamental theoretical advances.

This may seem utopian to those who think realism means staying one step ahead of the next budget cut. It is therefore timely to repeat the two basic realities that inform our efforts. First, all energy policies other than the most rapid possible transition to a fusion based economy either **accept** or **ignore** the billions of lives which will be lost — lives necessary to implementing a fusion-based world economy — through an inadequate rate of development. Second, the ecological timetable for bringing a healthy humanity to a new resource base is so stringent, and the scientific and technological problems so demanding, than nothing less than a total effort will do.

If you think clearly about the actual deterioration of the human population over particularly the last four years in contrast to the gains in fusion made with relatively paltry inputs, then you will be realistic enough to know that half measures or capitulation to zero growth nostrums are rationalizations for disaster.

Humanity survives by inventing new resources when it has to. If you are a practical person, you will support the required effort in fusion research.

White Paper On World Energy Policy
Fusion Economy By 1985

INTRODUCTION

The energy policy of the U.S. Labor Party and International Caucus of Labor Committees is directly determined by the technological program necessary to avert the threat of ecological holocaust. The immediate form of this threat is manifest in the decimated areas of the so-called Fourth World, and in the rapid collapse of the advanced sector. Continued implementation of the policy of triage which has caused this devastation will irreversibly destroy the productive capacities of the human species — and therefore the human species itself.

To prevent ecological collapse in the longer term, humanity faces the challenge of realizing a new energy and resource base well before the finite resources on which present production is based are exhausted.

This conjuncture necessitates the most rapid possible rise in the standard of living in the world's population so humanity can develop and produce the technologies required for survival and progress.

That program can be initiated now with existing energy resources and power generators, but can be continued at a more advanced level after the depletion of fossil fuels only through the development of controlled thermonuclear fusion power.

Our program therefore consists of two development stages. In the first, transitional period, the per capita energy consumption globally will be raised to approximately the level which now characterizes the skilled American workers. A massive effort must simultaneously be launched to expand fusion research and development. The second stage is the onset of a fusion-based economy, the only way to accelerate technological development further and to continually raise the material and cultural level of the world's population.

I. Criterion for Energy Growth

The necessary condition for the survival and advance of humanity, which depends on the advance of industrial civilization, is the maximization of the **future** cognitive capacities of the work force and the energy available for ever more advanced modes of technological transformation. The aim of our policy is therefore to do everything possible to ensure the transition of humanity to the **qualitatively** new modes of production associated with fusion technology.

In order to get to that transition point, we must make optimal use of existing resources. The rate of change of energy input required in the immediate future period is determined by setting on a world scale consumption levels at which human beings can survive and reproduce themselves, and below which consumption cannot be allowed to fall. In order to achieve these levels necessary for human survival, the Labor Party's Research and Development staff has estimated year-to-year maximum outputs of food, housing and other essentials which can be produced by fully utilizing the advanced sector's present capacities for capital goods production and the capacities of the available skilled and semiskilled workers. These categories and associated productivity parameters will themselves be expanded over time by suitable re-investment policies in capital goods and by strong emphasis on education and training to upgrade workers' cognitive powers. Studies on these categories will be published shortly.

The determined growth rates of production and consumption can also be expressed in terms of the energy inputs required at the points of production and in households. When all these factors are quantified, the overall growth rate in energy use to optimize development, starting from present conditions, is about 25 per cent per year.

With the onset of fusion reactors in about 1985, the overall rate of energy consumption will shift sharply upward, both because of expanded available energy resources and because of society's increased ability to absorb and transform **free** energy into new production processes.

II. The Long-Term Solution

A. Fusion Power: The transitional period indicates that fossil fuels will be used at a sufficiently high rate by the mid-1980s that significant replacement of those fuels by another primary source — which can increase growth rates further — must occur at about that time. That replacement, in fact is our objective from that outset.

That source must be primarily fusion for two related reasons. Only fusion, through a wide variety of fuel and reaction configurations, offers essentially open ended quantitative growth and qualitative development. These features are essential, since at the end of the first transitional period huge amounts of environmentally acceptable energy and completely new technologies of resource extraction and processing will both be required for continued progress. Fusion provides unique capacities because of the high concentration and temperature of the fusion reaction region and the varied forms of high efficiency energy output.

Basically what is necessary to obtain controlled fusion is to achieve in an ionized bit of matter the appropriate state so that collisions between its nuclei are energetic enough to make the nuclei fuse together, forming heavier units and releasing energy. This state is called the thermonuclear plasma state and is characterized by extremely high temperatures, of the order of tens of millions of degrees centigrade. The second criterion that must be met is to keep the fusion process going for a sufficiently long time so that the overall energy output is more than the amount of energy expended in starting the process. This is expressed by the so-called Lawson criterion: the product nt, of plasma density and confinement time must exceed a specific magnitude for each reaction10^{14} sec/cm^3 for deuterium-tritium.)

The total amount of energy available from fusion is, as a result of the huge inventory of deuterium (used in fusion) in the oceans, essentially unlimited. The two significant issues to be resolved are therefore the speed of implementation of fusion and the technological modalties of the fusion process. These aspects are related.

Once one has grasped the significance of the increased effectiveness of human labor power, through cognitive development, as the most important result of the transitional period; and therefore understands the necessity of what at first might seem like an astounding growth rate, it is only a small step to solving the problem of achieving fusion on schedule. Once one realizes that there are in principle an unlimited number of modes for forming plasmas and dynamically injecting energy in all sorts of forms, and that man-made H-bombs (hydrogen bomb) produce fusion, then it follows that there must also be a large number of configurations that will produce significant net energy output. The amount of time required to invent and develop such a configuration is then a function of how much organized intellectual effort is devoted to that objective. A breakthrough is likely to result only as a byproduct of systematically broadened research throughout basic scientific areas.

B. Fission: These criteria immediately render irrelevant the present debates about fission reactors. This is fortunate, since the central issues in that debate are presently not susceptible to definitive scientific appraisal. For example, the biological hazard posed by the low-dose leakage of radioactive materials from fission reactors cannot at present be specified. The data and conclusions from a number of sources are either based on isolated particular cases or unverified assumptions about statistical correlations between radiation levels and health problems. Also, the computed "probabilities" for particular types of disasters fall within such wide bounds as to be meaningless.

One property that can be effectively assessed is that of total radioactivity and its decay time. The comparison of typical fusion and fission reactors demonstrates the clear superiority of fusion in this respect.

However, these questions are eclipsed by the criteria posed by the necessary development program. From that standpoint, in quantitative and qualitative terms, fission cannot do the job. The total energy available from fission processes is, in the final analysis, limited by the total amount of material which can be used directly as fission fuel, or can be readily transmuted into fission fuel. The amount of energy available from uranium-235 (U-235) — 70 Q (one Q is a million trillion BTU) — is small compared with the total available from fusion. The suggestion to remedy this by producing more high-grade fission fuel in the form of plutonium (from U-238) in the breeder reactor, could provide an additional 0.5 million Q, but not at anywhere near the rate required by an optimal development program because of the long breeding time (presently about 50 years for doubling of fuel) of the present devices. It may never be possible to build breeders which operate more efficiently and also deliver significant power. For these reasons, **present** fission-produced energy, even if biologically acceptable, could not cover or keep pace with more than a small portion of the required exponential growth rate in the post-fossil period.

Moreover, fission power is essentially restricted to traditional production of steam-turbine-generated electricity, in contrast with the numerous technological spinoffs from fusion. Its relatively low temperature core (compared with fusion) is neither accessible nor suitable for a new industrial revolution.

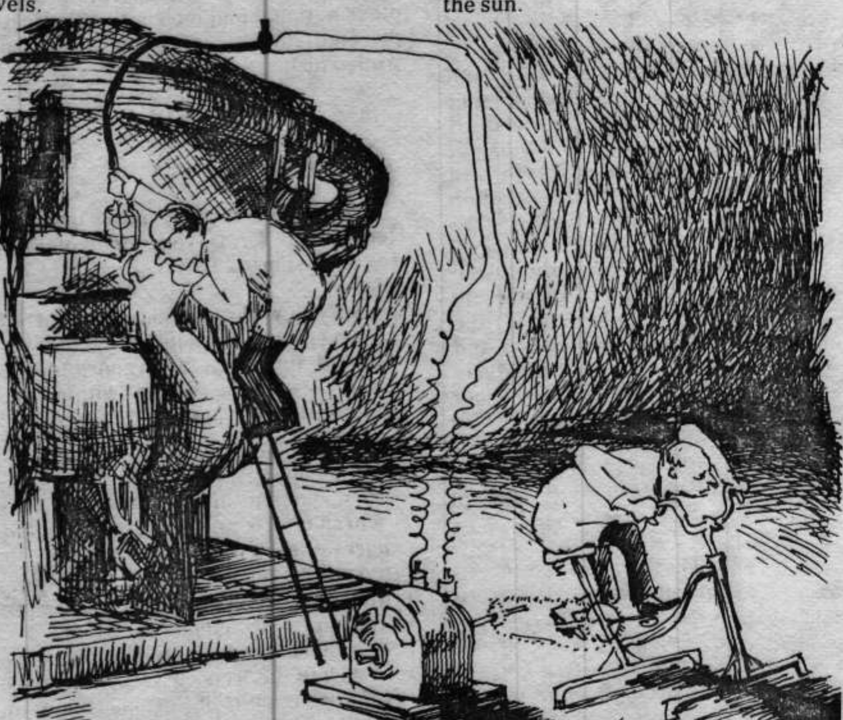
C. Solar: According to the U.S. Atomic Energy Commission's Sub-Panel IX study of solar energy, conducted by the National Science Foundation, large-scale solar power stations of 100 megawatts (MW) electrical (this is small compared even to present fossil and fission plants), based on heat conversion of collected sunlight, would require enormous material inputs of construction materials such as steel, aluminum, and concrete. Without even adding fabrication and transportation costs in terms of energy, it would take approximately 10 years to repay the energy inputs if all the solar output were devoted to replacement. This means that at least 10 years' worth of fossil fuels, at present rates of consumption, would be required to build an all-solar system which simply produced the present total yearly energy output of about 0.20 Q. This would also require covering about one-twentieth of the U.S. with solar hardware: One 1,000-MW solar plant would occupy 10 to 20 square miles.

Sub-Panel IX estimated that solar plants would have about a 25-year lifetime. Thus, a solar-based energy system has a definite upper limit on how much total energy it can produce and it does not add anything to the total stock of energy resources while moving toward that limit. In fact, the energy required to build a 0.20-Q solar system would represent a waste of a full one-fourth of the remaining oil and gas reserves — estimating reserves to be 40 years' worth at present production levels.

If a hypothetical all-solar system were built, ecological conditions would necessarily be worse than they are now. There would be less skilled labor, less transport, less agriculture, less production. Even assuming the materials were still available, a 25-year replacement cycle would dictate that 40 per cent of total output be fed back into primary needs of the system.

This reality properly locates one of the limpest rejoinders offered to proponents of fusion development: that we already have it free of charge from the sun. This argument serves for the billions of years of evolutionary development on earth, including the last several millenia, using indirectly solar-derived fuels such as wood, coal, and oil. But humanity has now reached a stage of real and potential progress for which the sunlight reaching the earth's surface is too diffuse to promote — by itself — further economic and ecological progress. (Progress is defined here as the capacity for increasing freedom from disease and hunger, increasing creative leisure and work, and expanding the biomass and humanity to further develop and use new forms of energy.) What the solar advocates cannot understand is that concentrating on this diffuse energy source (about 1.4 kw/m^2) requires exactly the advanced industrial base which a solar energy economy would destroy.

There will be a significant role for solar energy later when increased global productivity makes possible the capital expenditures necessary to collect solar energy in space, closer to the sun.



Don't Be Fuelish

The Fusion Energy Research and Development Act of 1976

BE IT ENACTED BY THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE UNITED STATES OF AMERICA ASSEMBLED IN CONGRESS; that this Act may be cited as the Federal Fusion Energy Research and Development Act of 1976.

TITLE I

The Congress hereby finds that:

(a) The immediate development of controlled fusion is of priority concern to the Nation and World.

(b) The major reason for the nation's past failure to develop controlled fusion has been the lack of an aggressive research and development strategy designed to bring the necessary resources to bear on the problem.

(c) The neglect of potential controlled fusion resources had led to deficiencies in the nation's array of available material resources.

(d) The nation's energy and resouce requirements can be met if a national commitment is made now to dedicate the necessary financial resources, to enlist our scientific and technological capabilities, and to accord the proper priority to developing controlled fusion to serve national needs, conserve vital resources, and protect the environment.

(e) The urgency of the nation's and world's resource problems requires a commitment similar to those undertaken in the crash developmnet Manhattan and Apollo projects; it requires that the nation undertake a long-range, top-priority research and development program in cooperation with all interested nations of the world.

(f) In order to guarantee the integrity of such a crash development fusion program, Congress will initiate an immediate public inquiry into the possibility that criminal neglect and sabotage are responsible for the failure of the nation to have previously developed controlled fusion. The Congressional investigation will run concurrently with the implementation of the crash development fusion program.

TITLE II:
General Policy

Section 2

The Congress hereby declares as policy:

(a) A National Department for Development of Controlled Fusion will be immediately established to carry out a national crash program of basic and applied research and development, including demonstrations of practical applications, with respect to all applications of controlled fusion.

(b) The Department for Development of Controlled Fusion (DDCF) will be directly responsible to Congress as a whole and will provide monthly public reports on progress of the crash program.

(c) The DDCF shall promptly make all records available for public inspection and copying at reasonable rates.

TITLE III

Section 3

The Congress authorizes and directs that, to the fullest extent possible, the Department for Development of Controlled Fusion Authorized by this Act shall design and execute its activities according to the following principles:

(a) All patent and proprietary rights which bear upon controlled fusion or its development or applications will be held in abeyance.

(b) The DDCF will cooperate with all other national and international efforts directed toward development of controlled fusion.

TITLE IV

Section 4

The Congress further authorizes the Department for Development of Controlled Fusion to:

(a) Review the current status of all U.S. and other efforts into controlled fusion and furnish a full report to the Congress and the nation within two months after the enactment of this bill.

(b) Form a committee to the nation's leading scientists and engineers to review current and projected fusion research efforts and develop a detailed report on implementation of the crash program budgeted herein. The committee will further submit proposals for initiation and governance of the research centers budgeted herein. This report will be reported to Congress within two months of the enactment of this bill.

(c) Obtain under the authority of t.e Congress all classified scientific information and other materials which relate to the development of controlled fusion (particularly laser and electrical beam fusion) and make this information public.

(d) Take possession of all existing governmental facilities (and in particular those of the Energy Research and Development Administration and Department of Defense) which could contribute to fusion research.

(e) Report all of its activities to the Congress and the nation on a monthly basis.

(f) Set up a national communications and translation network to transmit scientific data and reports as rapidly as possible.

TITLE V:
The Department for Development Of Controlled Fusion

Section 5

The Congress hereby declares that:

(a) The Department for Development of Controlled Fusion will replace the Energy Research and Development Administration (ERDA) and function under the same lesislaive authorization as ERDA until Congress completes its investigation of fusion sabotage. The President will temporarily appoint with the consent of Congress an eleven mancommittee to take possession of the ERDA and implement this bill. Their term will end within six months.

(b) All facilities currently engaged in the United States in research on fast breeder nuclear fission reactor research shall be transferred to fusion research under the control of the DDCF.

TITLE VI:
Appropriate Authorization

Section 6

The Congress hereby authorizes the following appropriations for the crash development of nuclear controlled fusion:

(a) In the fiscal year of 1977, $5 billion will be appropriated to the Department for Development of Controlled Fusion. The FY 77 budget of $5 billion (see Table I of Appendix I) would provide for the following major categories of expenditure:

(1) Basic Research: $1.6 billion to set up and maintain ten National Fundamental Research Centers and adjuncts. (see Total, Table II of Appendix I)

(2) Applied Research: $1.714 billion to construct and operate 30 major confinement system projects. (Funding for confinement system development is broken down as follows: construction, $750 million; operating, $500 million; scientific backup, $464 million.) $870 million for upgraded laser and electron beam system development. (see Totals, Tables IIIB and IV of Appendix I)

(3) Engineering: $790 million for technology development for reactors and experimental devices. (see Total, Table V, of Appendix I)

(a) a detailed explanation and breakdown of the FY 77 budget appears in Appendix I.

(b) In the fiscal year of 1978, $20 billion will be appropriated to the Department for Development and Controlled Fusion.

Appendix I

Introduction

The present conjunction of significant experimental progress in several leading lines of fusion research with the continued lack of commensurate progress in appropriate areas of theoretical science plus the persistent underfunding and misdirection of fusion research necessitates a thorough overhaul and redirection of the content and organization of the CTR program in the United States. While it is necessary to vigorously pursue all existing lines of fusion research, an expanded "crash" program is justified only in a context of the primacy of fundamental research.

A new program specified in the Fusion Energy Research and Development Act of 1976, and entailing expenditures of $5 billion for fiscal year 1977, is therefore based on two principal related features:

(1) Ten National Fundamental Research Centers (NFRC) shall be constructed, equipped and staffed in areas of the country already having institutions and individuals with significant competence and experience in the science and technology of fusion. All scientists in an NFRC region will have potential access to its facilities.

Stimulation of and support for a growing spectrum of basic theoretical and experimental investigations is required in order to realize a systematic scientific understanding of the behavior of plasma in general and of particular configurations and ranges of plasma parameters appropriate to controlled fusion. The institution of NFRC's is vital to achieve this basic scientific objective, so that the U.S. can play its proper leading role in an upgraded, internationally coordinated fusion research program of the sort proposed by relevant authorities in Japan, the Soviet Union and Comecon sector, Sweden, Great Britain, Italy and the European Economic Community.

Such an undertaking can move beyond a merely empirical, hit-or-miss approach and toward a condition of purposive plasma control. To achieve this status, however, generalized advances beyond the present norms of theoretical physics must be realized.

(A more in-depth discussion of these issues is contained in the forthcoming publication "The Concept of the Transfinite" and translation of Georg Cantor's "Foundations of a General Theory of Manifolds," available from Campaigner Publications, P.O. Box 1972, GPO, New York, N.Y. 10001.)

This policy component is required both to insure convergence on at least several viable reactor modes in the near term (1980's) as well as to insure that fusion development is properly regarded as an essentially open-ended practical-theoretical enterprise continuously contributing to and deriving support from an ever more productive economy and highly skilled population.

The National Fundamental Research Centers will provide the resources and facilities needed to promote small group innovative investigations, prototype development, and cross-fertilization and synthesis of a multiplicity of approaches. Already existing government laboratories, public and private universities, and regional industry—particularly in the aerospace sector—receiving intellectual and economic inputs from these centers can, in turn, provide the necessary extensive pool of scientific-technical manpower for staffing and backup of the centers.

The breakdown of FY 77 funding by primary categories for the NFRC's is as follows:

(a) $600 million for scholarships and grants to be disbursed to 18,000 recipients working at an NFRC or affiliated institutions. The NFRC's will be governed by boards elected from all participants. Stipends are also to be used to maximize international cooperation and exchange.

(b) $400 million for operation and equipment costs.

(c) $600 million for construction, power supplies, and renovation.

(2) There shall be a full allocation of funding to all presently developed and otherwise promising experimental devices, regardless of configuration type or previous level of support, to determine the ultimate potential of the systems as fusion reactors.

There are now approximately ten major confinement system concepts which in their present form or after one or two stages of development, have a significant potential of achieving "break-even" (i.e. net energy-producing) conditions. These approaches must all be accelerated **simultaneously**, through full scientific and technological (industrial) support, in order to draw out the remaining physics and engineering problems, to determine which approaches are feasible as reactors in their present form, and most importantly, to evolve a body of comparative knowledge of plasma physics which can not be obtained from any single device or simple sequence of devices. From this standpoint, even so-called failures will contribute in important ways to the overall program, through the scientific results they provide.

FY 77 construction and equipment costs for these major projects to be continued or undertaken primarily in existing major or secondary laboratories, totals $750 million. The construction, operating, and research costs for all magnetic and inertial confinement projects, respectively, are:

(a) $1.714 billion for magnetic confinement; and

(b) $870 million for laser and electron beam.

Effect on Science and Industry

Several features of the total program are worth noting for their short and long term scientific and economic implications. Immediately, the required number of highly trained scientists, engineers, and technicians will strain the skilled manpower capacities of not only the existing fusion program, but of high technology industry as well—in areas from materials and magnet design to electronics. The solution will be found only in the rapid training of experts in all areas of fusion research and development, developing a pool of such experts hundreds of times larger than that presently existing. This in turn will provide the basis for dramatic advances in future scientific capabilities in the U.S., particularly with regard to the fundamental theoretical issues indicated.

The provision of the NFRC's with stocks of conventional apparatus as well as a specialized power supply and computer capacities linked to research center terminals internationally will greatly increase the scientific effectiveness of research at the centers and throughout contiguous regions,—this compared with the present level of scientific realization of average researchers and teachers presently denied such facilities.

A typical NFRC will be allocated a budget and facilities comparable to a present major government research laboratory, such as the Los Alamos or Livermore National Laboratories, but will function in a wholly different way. Instead of a top-down definition of most of the research activity, as in projects charged with reactor-scale development, the NFRC will exist to service the creative activity of numerous self-defined small research groups or individuals working on fundamental *questions of plasma dynamics.*

When such groups reach the stage of testing hypotheses experimentally or computationally, or building fusion device prototypes based on their prior investigations, an elected committee of peers will allocate space, resources, and technical back-up solely on the basis of the availability of resources. *The guiding philosophy of the NFRC is* "creativity must be trusted." To avoid artificial competition for scarce resources, when expansion of facilities or construction of new facilities is justified by the quality and scope of scientific endeavor, the elected NFRC governing boards shall recommend such expansion to Congress and the *presidentially appointed* administrators of the overall fusion program.

Finally, a construction budget of approximately $1 billion and a development, technology and equipment outlay of approximately $2 billion will provide a much needed stimulus to the construction and aerospace industries. This is not a new pork-barrel or band-aid *for these industries; nor is it in*flationary. The conversion and upgrading of capacities and technologies in these industries is vital for the realization of the 25 per cent per annum rates of industrial growth dictated present world economic needs. (A U.S. Labor Party brief of Dec. 1975 on the conversion of the aerospace *industry establishes a preliminary* estimate of productive needs and associated markets in such areas as machine tools, housing and transportation for the industry.)

Summary

The distinguishing feature of the legislation proposed here is its provision for a unique nexus of research centers primed to utilize the full scientific and productive potentialities of the United States for world development. The process these centers will set in motion will yield working fusion reactors as a byproduct of fundamental scientific advances. In addition, the more specific spinoffs of this program will include the immediate accessibility of industry to fusion reactors for gross power supply as well as for adjustable interfacing with industrial processing.

The expected period of maturation for the indicated program is on the order of five to seven years, which coincides with the interval during whicvh significant depletion of existing resources, under conditions of intensive development is to be expected. The FY 77 proposal for fusion research must therfore be judged in terms of a long term commitment whose first stage will extend over approximately the next decade, and during which a doubling of resources and manpower every two to three years will be required.

There is no question, however, that no *other single program will have the self-*developing positive effects of the program initiated with passage of this act.

References

U.S. Labor Party Presidential Platform 1976

The Campaigner, Dec. 1975 ("The Italy Lectures") and Jan. 1976 ("The Concept of the Transfinite.")

Draft 1975 Division of Controlled Thermonuclear Research (ERDA) Tokamak, High Beta, and Mirror Studies

ERDA Division of Controlled Thermonuclear Research Review of the Research Program 1974

Various Division of Military Ap*plications* (ERDA) Classified and Unclassified Reports and Planning Documents.

USLP 1975 Fusion Research Bill

Report of Subpanel 11 (Nov. 1973)

The Fusion Energy Research and Development Budget

Budget Lines have been computed on the following general basis;

(1) For main line magnetic confinement experiments, allocations for FY 77 are, aside from small increments, equal to the total outlays for respective lines noted in the Nov. 1975 AEC-CTR Subpanel 11 "crash program" for magnetic confinement systems development. In the following tables, such budget lines are broken down by experiment and category.

(2) Allocations to laser and e-beam systems are based on capacities for growth indicated by leading U.S. researchers and the scale of the program in the Soviet Union.

(3) New allocations for national research centers.

Unless otherwise indicated, all figures are in millions of U.S. dollars 1976.

Table I: Proposed Total FY 77 Fusion Research Budget

COMPARISON OF USLP, ERDA FISCAL 1977 AND SUB-PANEL 11 (Maximum Program, FY 79) BUDGETS

A) MAGNETIC CONFINEMENT	USLP	ERDA	SUB-PANEL 11
Operating			
research	874	37.3	173
development and technology	135	43.9	126
confinement systems	500	74.6	450
fusion reactors	325	0.0	325
SUB-TOTAL	$1,834	$155.8	$1,074
Equipment			
research	590		85
development and technology	15		15
confinement systems	200		90
fusion reactors	40		40
SUB-TOTAL	$845	$44	$230
Construction			
research	600	3.7	00
development and technology	45	5.0	21
confinement systems	550	5.0	250
fusion reactors	230	0.5	230
SUB-TOTAL	$1,425	$14.2	$501
TOTAL	$4,104	$214	$1,805
B) LASER AND E-BEAM PELLET FUSION			
Operating			
Laser	160	62.3	
E-beam	60	7	
SUB-TOTAL	$220	$69.3	$124.2
Equipment			
Laser	150		
F-beam	50		
SUB-TOTAL	$200	$7.2	$2.5
Construction			
Laser	350		
E-beam	100		
SUB-TOTAL	$450	$13.97	$26.5
TOTAL	$870	$90.5	$153.2
GRAND TOTAL	$4,974	$304.5	$1,958.2

Table II: USLP Research Sub-Program for Magnetic Confinement and Fundamental Research

A) PERSONNEL FOR MAGNETIC CONFINEMENT PROGRAM

Scientists	1150
Technicians	1625
Support	1150
Other	1150

B) NUMBER OF GRADUATE AND POST-DOCTORATE CANDIDATES RECEIVING GRANTS, FELLOWSHIPS, AND SCHOLARSHIPS

Plasma Physicists and Mathematicians	3,000 at $33,000 each
Physical Sciences, and Engineering in general	15,000 at $33,000 each
	Total $600 million

C) NATIONAL FUNDAMENTAL RESEARCH CENTERS (10 centers)

Operating	10 each at $10 = $100 million
Equipment	10 each at $30 = $300 million
Construction and Capital Equipment	
2 Gigawatt Power Supply	10 each at $40 = $400 million
Building and renovation	10 each at $20 = $200 million
	Total $1 billion

TOTAL for NFRC's and Grants .... **$1.6 billion**

Proposed NFRC sites: Seattle, Wash.; Berkley, Calif.; Chicago, Ill.; Detroit, Mich.; Princeton, N.J.; New York, N.Y.; Boston, Mass.; Washington, D.C. area; Texas; Los Angeles, Calif.

Table IIIB) Major Confinement Systems Project

FY 77 CONSTRUCTION AND EQUIPMENT	COSTS	SITE	ERDA TOTAL COSTS
Ormak (tokamak)	3	OR	30
Princeton Large Torus (tokamak)	8	PPPL	
Technology Test Assembly with Plasma (tokamak)	12	OR	
Technology Test Assembly without Plasma	50	OR	50
Doublet II Tokamak	2	GA	
Doublet III Tokamak	15	GA	26
Alcator I Tokamak	15	MIT	
Alcator II Tokamak	15	MIT	
Poloidal Divertor Experiment Tokamak	10	PPPL	19
Experimental Power Reactor (Tokamak)	10		600
Tokamak Fusion Test Reactor	215	PPPL	215
Stellarator I	20	PPPL	
Stellarator II	30	Chicago	
Scyllac/Staged Scyllac	12	LASL	
Staged Theta Pinch	6	LASL	
Scylla IV-P	10	LASL	
Large Staged Scyllac	60	LASL	55
Scyllac Fusion Test Reactor	10		85
Linear Theta Pinch Feasibility Experiment	80	Chicago	68
Linear Theta Pinch Test Reactor	10		1,000
Diffuse Toroidal Z Pinches (ZT-1, ZT-S, ZT-p, and ZT-2)	5	LASL	
ELMO Bumpy Torrus	20	OR	
Implosion Heating Experiment	5	Univ. of MD.	
High Beta Tokamak	4	LASL	
Mirror Feasibility Experiment	150	LLL	
Mirror Fusion Engineering Research Facility	100	LLL	
Plasma Focus I	5	LLL	
Plasma Focus II	5	LASL	
Plasma Focus III	20		
E-beam Mirror and Laser Solenoid	13		
SUB-TOTAL	$710		
Miscellaneous Equipment and Construction	$40		
Construction and Equip. Total	$750		
Operating (IA)	500		
Research Sub-program (III A)	464		
TOTAL	**$1714**		

***NOTE:** Site names are as follows:

OR - Oak Ridge National Laboratory
PPPL - Princeton Plasma Physics Laboratory
GA - General Atomic
LASL - Los Alamos Scientific Laboratory
LLL - Lawrence Livermore Laboratory

Table IIIA) Magnetic Confinement Research Sub-Program Breakdown

Operating	
Computer	65
Plasma Properties	34
Plasma Production and Heating	22
Plasma Measurements	15
Exploratory Concepts	20
Atomic, Molecular and Nuclear Physics	18
SUB-TOTAL	$174
Equipment*	
General	60
8 Class IV Computers	80
10 Class IV Computers or equivalent	150
SUB-TOTAL	$290

TOTAL = $464 million

*Note As referenced in text the two computer centers would be located at the Berkeley NFRC, and the New York City NFRC. Also it is presumed that existing NASA, or Department of Defense satellite systems would be used for world wide computer link up

Table IV: Laser and E-Beam Pellet Fusion Breakdown

A) PERSONNEL	
Scientists	1000
Technicians	1000
Support	5000
Other	5000
B) MAJOR PROJECTS	
3 10 kilojoule glass laser systems at $50 each	150
3 E-beam 100 terrawatt or better facilities at $33.3 each	100
100 kilojoule glass laser system	100
100 kilojoule gas laser system	100
Total construction costs	$450
C) MAJOR AREAS OF STUDY	
New Lasers	100
Pellet Design	40
Pellet Experiments	40
Diagnostics	20
Reactor Systems	20
Total Operating costs	$220
D) EQUIPMENT, GENERAL	
Laser	150
E-beam	50
	$200
Total	$870

Table V: Development and Technology; and Fusion Reactor Engineering

	Development and Technology	Fusion Reactors
A) PERSONNEL		
Scientists	900	2167
Technicians	900	2167
Support	680	1625
Other	75	1190
B) REACTOR TECHNOLOGY*	$595	
C) DEVELOPMENT TECHNOLOGY*	$195	
Total	$790	

* Note: See Table 1A

Fusion 'Breakeven' Milestone Reached

by Charles B. Stevens

March 22 (IPS) — Scientists in the United States and the Soviet Union have experimentally demonstrated for the first time that the construction of a prototype fusion reactor — the next major milestone in producing cheap, clean, and relatively unlimited thermonuclear fusion energy for worldwide use — is scientifically and technologically possible. The demonstration has been achieved five years ahead of *all previous official time schedules.*

That the milestone of a working reactor is within reach has become apparent to scientists reviewing the results of current fusion research, including three specific projects among a wide range of necessary ongoing research efforts.

The first, reported in a U.S. Energy Research and Development (ERDA) press release dated March 9, is a breakthrough by scientists at the Oak Ridge National Laboratories working on neutral beam heating experiments with the ORMAK Tokamak device. The neutral beam approach has established the parameters for a new and potentially far more efficient kind of fusion system, as well as providing the technology to sharply upgrade present systems.

The second is a revised estimate of the significance of experiments in the Alcator Tokamak project at the Massachusetts Institute of Technology, made in the light of the ORMAK results and reported to Congress March 17 by Dr. Robert G. Hirsch, former director of ERDA's Division of Controlled Thermonuclear Research and currently Acting Assistant Administrator for ERDA's Advanced Energy Systems Division. Hirsch told the Joint Congressional Committee on Atomic Energy, "This past year the Alcator high magnetic field Tokamak...achieved the breakeven density-time product for the first time anywhere in the world."

Breakeven — the point at which the amount of energy output from experimental fusion device equals the amount of energy input — has previously been officially estimated as at least five years away. The achievement of breakeven essentially demonstrates that a *working fusion reactor can be built.*

The third development is the initial highly successful results of the Soviet Union's T-10 Tokamak experiment, currently running at half-power and only 70 per cent of its potential full magnetic field strength. (These have been reported in earlier issues of New Solidarity.)

Taken together with related fusion experiments, this recent series of breakthroughs constitutes the most significant potential scientific-technological advance achieved in the twentieth century — one which guarantees that the essential material and energy resources for world industrialization *can rapidly be made available over the* next decade once the rubbish of the Atlanticists' ruined dollar empire is cleared away. The news of the current fusion breakthrough and its implications for rebuilding the world economy will itself speed that process as it spreads to advanced sector politicians, industrialists, scientific and technical personnel, and the international working class.

The political significance of the fusion advance has not been lost on Wall Street, which has so far maintained a near total international blackout on the news. The substance of Dr. Hirsch's Congressional testimony, for example, although carried on the Associated Press wire, has so far been reported only in New Solidarity and the Jerusalem Post. The coverup is typified by Walter Sullivan's March 22 article on fusion in the New York Times, which concluded with the lie that fusion power will not be feasible before the year 2000. Sullivan has admitted that he was fully aware of Hirsch's testimony when he wrote the article.

The conditions for producing net energy-generating fusion reactions as they are usually outlined for conventional types of fusion systems consist of heating fusion fuel to very high temperatures and maintaining the fuel at that temperature and at a specific density for some period of time. To fuse deuterium and tritium, the two isotopes of hydrogen which provide the fuel which requires the least stringent conditions for ignition, requires temperature of 50,000,000 degrees Celsius and a density confinement time of 100 trillion particles per cubic centimenter per second. As it approaches the point of ignition, the fuel becomes a plasma.

Stable magnetic confinement has been demonstrated in Tokamak type of magnetic bottles, and various systems for heating the plasma have also been shown. In the Tokamak, the primary means of heating the plasma has been the electric current induced in the plasma. But the neutral beam method of plasma heating has been recently shown through the calculations of researchers of the Princeton Plasma Physics Lab to open up the possibility of non-conventional fusion systems in which most of the energy producing fusion reactions are produced by the beam itself. The Tokamak plasma in

The T-10 Tokamok at Moscow's Kurchatov Institute, the largest fusion reactor in the world.

this case could operate at already achieved conditions and would act as a "trap" for the high energy neutral beam.

The fact that the Oak Ridge Tokamak also achieved a higher ion temperature than that of the electron temperature with neutral beam heating while still maintaining a stably confined plasma is of great significance in demonstrating the feasibility of non-conventional "beam-driven" fusion reactors. The Oak Ridge researchers simultaneously also achieved a 300 per cent improvement in the crucial plasma beta parameter over that of all previous Tokamak experiments. (The plasma beta is the measure of the efficiency with which the magnetic fields are utilized to confine the plasma. The Oak Ridge plasma beta was 1.5 per cent.)

When the large U.S. Tokamak, the Princeton PLT, becomes fully operational with even larger neutral beam injection systems these results will be further demonstrated.

New Fusion Advance Made With Livermore Lab Mirror Machine

by Charles B. Stevens

April 10 (IPS) — Scientists at the Lawrence Livermore Laboratory in California working on the 2X-IIB mirror machine fusion device have achieved an almost totally unexpected breakthrough which could lead to the immediate development of low-cost, all-electric, all-deuterium fusion power reactors of a type which, it had previously been thought, could only be realized as a "second generation" of fusion reactors **following** development of reactors based on deuterium-tritium fusion reaction.

A just-received March 23 press release from the U.S. Energy Research and Development Administration (ERDA) announced the Livermore achievement, the seventh major advance in fusion research over the last two months in the world effort to harness the virtually inexhaustible, cheap, clean and safe energy of controlled thermonuclear fusion reactions.

Taken as a whole these fusion research advances of the last two months define a totally new world energy situation. In essential terms the major technological and scientific barriers to the realization of the first series of fusion power reactors have been overcome. It is now simply a question of investing the necessary material resources.

Role of Fundamental Fusion

Most significantly the mirror breakthrough, just as in the case of the Soviet acheivement of electron beam pellet fusion, came as a byproduct of research chiefly concerned with fundamental plasma physics.

More than any previous advance in fusion research throughout its entire 40-year history, the milestone in human progress achieved by the dedicated fusion scientists of the Lawrence Livermore Laboratory conclusively demonstrates the potential rates of progress which accrue when research is primarily directed toward resolving fundamental questions.

The Livermore researchers, led by Drs. T.K. Fowler, F. Coensen, and R.F. Post, had effectively demonstrated the "scientific" feasibility of the mirror machine approach to fusion in July 1975, when they demonstrated that the confinement time of a hot fusion plasma in the magnetic mirror trap increases as the temperature of the plasma is raised. Temperatures of over 130 million degrees were achieved — 30 million degrees higher than what is needed to ignite the deuterium-tritium (D-T) fusion reaction on which Tokamak and pellet approaches are based. More recent experiments have reached even higher temperatures.

The most significant and unexpected result of the Livermore group's latest experiments has been the achievement of plasma betas of greater than 100 per cent. Plasma beta is the measure of the efficiency with which a magnetic field confines a fusion plasma. The power density of a fusion plasma's output is proportional to beta to the fourth power. Therfore, the higher the beta achieved, the smaller the fusion reactor needs to be for a given power output, and therefore the lower the capital costs relative to electrical power output.

While the Livermore experiments have reached betas of 100 per cent and in certain circumstances 150 per cent, conventional Tokamaks, for example, operate with plasma betas of much less than 1 per cent. Therefore Tokamak reactors are projected to have huge capital costs based on present understanding of how they would operate.

Hirsch, who is now ERDA's acting administrator for advanced energy systems, is quoted in the March 23 press release as saying, "The new findings also have major implications for the economics and versatility of fusion reactors based on the magnetic mirror principle." More specifically, with the achievement of the surprisingly high plasma beta in which "the maximum theoretical limit was exceeded," Livermore mirror fusion researchers demonstrated the "technical" practicable feasibility of fusion power reactors based on this approach with D-T fusion reactions, a step which even the most optimistic previous theoretical calculations had left in doubt.

The Livermore breakthrough points to the possibility of leapfrogging the D-T reaction altogether and going directly to more advanced, higher-temperature fusion reactions which would in one strike bypass all the major technological problems that have until now been thought to be the main barriers to realizing actual power reactors. The more advanced fusion fuels, such as the all-deuterium or "catalyzed" deuterium reaction, produce more energy in the form of charged electrical particles rather than high-energy neutrons, which in D-T reactions represent more than 75 per cent of energy output. This makes feasible the direct conversion of the fusion plasma energy to electricity and fusion torch applications. Over the past few years scientists at Lawrence Livermore have designed and developed several such "direct conversion" systems with which they have had a great deal of experimental success.

Fusion Is Possible By 1980s, Gov't Officials Tell Congress

March 19 (IPS) — The highest ranking administrators of the U.S. government's fusion research program told congressional hearings of the Joint Committee on Atomic Energy March 11 and 17 that, with a major research effort, fusion reactors can begin to power the economy in the 1980s. Until last week's hearings, the official line was that controlled thermonuclear fusion could not be developed before 1995 at the earliest.

The Congressional testimony and the stunning Soviet advances in the Tokamak and electron beam approaches to fusion reported March 10 in the Soviet Party paper, Pravda (see New Solidarity March 16, 19, and 21), have created conditions where only open Rockefeller agents or the most illiterate scientists can now dare to advocate publicly an energy policy other than an immediate crash program for fusion. Thermonuclear fusion will provide a clean, cheap, and relatively unlimited source of energy.

The March 17 testimony of Dr. Robert Hirsch, Acting Assistant Administrator of the government's Energy Research and Development Administration (ERDA) and until January, head of the Division of Controlled Thermonuclear Reactions, indicates that a pro-crash-program faction is now active within ERDA, an agency largely controlled by Rockefeller oil interests. Hirsch told the Joint Committee that last year's achievement of energy break-even conditions in the Massachusetts Institute of Technology Alcator Tokamak, "plus a number of other (achievements) that did not always make the 'front pages,' have given fusion physicists and engineers worldwide confidence that the problem of fusion power is yielding to their efforts."

Fusion research breakthroughs as well as "recent budgetary decisions" at ERDA to cut vital funding for CTR — controlled thermonuclear reactions — prompted Hirsch in January to withdraw from day-to-day work in order to draft a new plan for fusion development. The major conclusion Hirsch reached (before he was kicked upstairs to administer ERDA's ludicrous programs in geothermal and solar energy) was that with "maximum effective effort" it would be possible to build "an operating demonstration plant in the late 1980s."

Laser Fusion Breakthrough

Hirsch's testimony on the prospects for magnetic confinement breakthrough followed even more pointed testimony March 11 by top leaders in laser fusion research, a program administered by ERDA's Division of Military Applications. A leading physicist at Lawrence Livermore Laboratory, John L. Emmett, reported to the joint committee that significant advances in laser and target design and experiments had greatly reduced the laser efficiency required for economical operation of a laser fusion power plant — precisely the Soviet approach which led to the recently reported breakthrough.

Improvements in laser materials and amplifiers and the development of techniques to correct the instabilities in laser-irradiated targets, Emmett said, will permit very high fusion energy yields when redesigned targets are driven with the now feasible short-wave length, 100-trillion-watt lasers. "If aggressively pursued," Emmett said, these developments "could accelerate the National Laser Fusion Program by four to six years" — as early as 1981. In conclusion, Emmett warned the committee that "this entire area of Research and Development is underfunded, and as a result we are unable to aggressively pursue the laser development necessary for civilian power production." After hearing such indisputable evidence, the committee restored the Ford Administration's fusion budget research cuts March 17.

Fusion Pressure

Pressures are now building in the scientific community to crack the fusion funding situation wide open and provide the actually required funding for a crash fusion program. During Hirsch's testimony, he was asked by Rep. Roncalio (D-Wyo) whether a March 16 New Solidarity article describing Soviet fusion breakthroughs and the U.S. research lag was substantially correct. Hirsch admitted that it was.

This week, Senators Tunney (D-Calif) and Metcalf (D-Mont) mailed a letter of inquiry on fusion, based on background material provided by the U.S. Labor Party, to 38 leading scientists. The letter requests a "frank assessment of the expected progress of fusion technology," since "the development of the fusion process is moving more rapidly and successfully than was previously predicted." Tunney's opponent, Labor Party senatorial candidate Nick Benton, has made fusion a top campaign issue.

A top laser fusion scientist at Livermore who received the Tunney-Metcalf letter commented "this comes at a very opportune time. A group of high-level scientists has just prepared a detailed program for laser fusion development in conjunction with the Electric Power Research Institute. This is just what we need." The Institute, a major, utilities-funded think-tank in California which has close ties to aerospace companies, most likely represents those capitalist interests now eyeing fusion as the issue by which they can coalesce opposition to stop the destruction of the economy.

Soviets Make Fusion Advance, Plan Fusion Economy For 1980

by Dr. Morris Levitt

March 13 (IPS) — Soviet researchers at the Kurchatov Institute in Moscow achieved one of the most significant experimental results to date in the magnetic confinement approach to controlled fusion power, a near doubling of plasma energy confinement time to a record value of one-tenth of a second. This break through was announced in the Soviet Party paper, Pravda, March 10 and on the East German government radio station.

After the successful experiment in the T-10 Tokamak, the Soviet government gave the go-ahead for all-out construction of a T-20 Tokamak demonstration fusion reactor and the development of blueprints for the industrial application of fusion power by the early 1980s.

The announced result shatters the Atlanticists' claims that fusion cannot be developed before the 21st century. The Rockefeller-dominated energy industry here has consistently sabotaged the development of thermonuclear fusion power.

News Stuns U.S. Scientists

News of the breakthrough, circulated in the United States by the International Caucus of Labor Committees, stunned U.S. fusion scientists and their overseers at the federal Energy Research and Development Administration (ERDA). Typical of the responses was that of a leading researcher at the Massachusetts Institute of Technology Alcator Tokamak project, which scored a major breakthrough toward energy break-even conditions (producing more energy than required to maintain and initiate the experiment) last year: "This is very exciting if true. It's quite an achievement."

The Soviet experimental result has since been confirmed by Soviet scientists visiting MIT as well as by direct communique from Kurchatov Director E. Velikhov to the Division of Controlled Thermonuclear Research of ERDA.

According to the report which appeared in Pravda by Soviet Academicians Velikhov and Kadomtsev, the deuterium ion temperature in the recent experiments, which used half the power capacity of the T-10 Tokamak system, "is still not very high — 7 million degrees — but it will be raised in the next stage of experiments." A temperature of about 50 to 100 million degrees is required for a thermonuclear fusion reactor.

While important scientific details on the latest T-10 experiments, such as the plasma density and magnetic field strength, have not yet been released, the results presented so far indicate that the T-10 has confirmed that the plasma confinement time increases with density. The complete information on the most recent experiments will provide definite confirmation of this and will indicate how quickly the Soviets will reach the actual break-even conditions.

ERDA Put On The Line

The Soviet breakthrough makes it

impossible for the U.S. Congressional Joint Committee on Atomic Energy (JCAE) to conduct the upcoming March 22 hearings on ERDA's fusion budget in a business-as-usual atmosphere. ERDA has deliberately withheld funds from fusion research projects such as the U.S. counterpart to the T-10, the PLT at Princeton, New Jersey. Lacking the Soviets' sustained technological and applied scientific backup in its design and construction, the PLT is not yet operational. ERDA is also "negotiating" with the Alcator group at MIT to sit on its hands for a year while the government agency decides whether to allocate enough funds for the essential power supply system to build a break-even Alcator experiment.

In general, U.S. fusion scientists — some of whom will meet next week at Los Alamos to lobby against ERDA cuts — are enraged over ERDA's "holding pattern" funding policy.

The U.S. Labor Party is providing political direction to the growing dissatisfaction with U.S. fusion research efforts in the scientific community. On March 10 Winston Bostick, Professor of Physics at Stevens Institute, and Labor Party representative Eric Lerner met in Washington with John Stewart, a top aide to Senator Kennedy (D-Mass) to press the Labor Party's fusion program. Stewart, Kennedy's man on the staff of the Energy Subcommittee of the Joint Economic Committee and an influential advisor to the Democratic Party Platform Committee, admitted that the development and fusion research programs of the Labor Party were uncontested by anything the policyless Democrats had come up with. He agreed to decide within a week whether to advise Kennedy to hold open hearings on the necessity for a crash fusion development program.

Simultaneously, the office of JCAE member Senator Tunney (D-Calif) — who has been boxed in by the drive of social fascists Tom Hayden and Ralph Nader to ban nuclear power in sunny California — is preparing to poll leading U.S. scientists on how to accelerate fusion research.

European scientists are also reacting to the Atlanticist sabotage of fusion. In the wake of a contrived Common Market stalemate over where to situate the Joint European Tokamak (JET) and a 7 per cent cut in the most important West German fusion projects such as the Stellarator, the director of the major fusion laboratory at Garching, West Germany recently resigned in protest.

Soviets Describe Their Fusion Breakthrough

March 17 (IPS) — On March 10, Soviet academicians E. Velikhov and B. Kadomtsev announced the results of a successful experiment in the T-10 Tokamak at the I.V. Kurchatov Institute of Atomic Energy. The following are excerpts from the article in the Soviet Party paper Pravda, "Steps Towards Thermonuclear Energy."

Let us explain what is involved here. In order for thermonuclear reaction to take place with sufficient intensity and for the energy produced to compensate for that expended in heating the (deuterium-tritium) plasma, its temperature must be raised to 70 millicn degrees. Furthermore, the so-called characteristic heat-loss time of the plasma must be ... on the order of several seconds for a steady "burn." Thus, heating in the "tokamak" is relatively simple; the way to increase the confinement time of the plasma energy and, consequently, to create a reactor is also known. As theory predicts and experiment shows, it is sufficient to increase the scale of the installation.

In order to test this conclusion, which is basic for further progress, and take the next step towards a reactor, the largest thermonuclear installation, the T-10, was built at the I. V. Kurchatov Institute (IAE). Designed by specialists at the D.V. Efremov Scientific Research Institute of Electrophysical Apparatus (NIIEFA) and built in factories in Leningrad and Kharkov, it was rapidly put to work, and a collective of physicists under the direction of doctor of mathematical physics V. S. Strelkov achieved several interesting results on it.

First of all, the basic conclusion of previous research was confirmed: increasing the scale actually increased the confinement time of the plasma energy five-fold compared to the previous installation, the T-4. Now it is about 0.1 seconds, which was predicted theoretically for research conditions using half the power of the installation. A stable and sufficiently pure plasma was obtained and a stable thermonuclear reaction took place in it, with the number of neutrons per impulse 100 times greater than in the T-4. The temperature was still not very high (about 7 million degrees for ions), but it will be raised with the shift to the next calculated stage.

In this way, the experiments on the T-10 have confirmed the previous established principles and theoretical conceptions for this type of installation and are also useful in projecting the next steps. What are these steps?

Methods must be found to heat the plasma further, and experiments are already being carried out for this on smaller scale installations. In the future, these methods will be transferred to the T-10, with an appropriate modification. But beyond this, the level of understanding now achieved of the processes which go on in the "tokamak's" plasma makes it possible to move to the next step, the creation of a so-called demonstration thermonuclear reactor. In this it will be possible to achieve a full-scale thermonuclear reaction in deuterium-tritium plasma, wherein the quantity of energy released in the course of the reaction will be approximately equal to that put into the plasma. The draft project for such a reactor has already been worked out at NIIEFA.

The demonstration reactor makes it possible not only to study all physical processes in the reacting deuterium-tritium plasma, but also to confront the engineering and technological difficulties, so as to study and then overcome them. It is a question of radiation damages of the materials, their interaction with the high-temperature plasma, the reproduction of tritium, etc. Tests can also be done on systems of output and conversion of the energy of the thermonuclear reactions. More succinctly, this part of the research is close to the goals and tasks of the first atomic electric-power station.

Following the demonstration reactor, an experimental thermonuclear electric-power station could be planned. Of course, it is necessary to choose the optimal variant. In this connection the following should be considered: the energy of thermonuclear reactions is produced as a flux of high-energy neutrons. The question arises: can this quality be utilized in a more sensible way than to simply turn the energy of the neutrons into heat? For example like this: surround the plasma with a layer of uranium, in which neutrons will produce nuclear fission and thus increase the energy output. A so-called hybrid is obtained, i.e. a mixed thermonuclear-atomic reactor, in which the energy is supplied by uranium, while the thermonuclear part serves only as a neutron source.

It turns out that in the hybrid variant, the demands on the parameters of the plasma fall so much that even already-achieved parameters come right up to the necessary level. Working together with ordinary atomic electric-power stations, hybrid stations will find their place in the economic optimization of atomic energy and serve as a good transitional stage to pure thermonuclear energy.

Advances In Three Approaches To Fusion Research

by Charles B. Stevens

Recent advances in three "off-beat" approaches to fusion research show how close the world would be to breakthroughs in applied science leading not only to controlled fusion and a world fusion-based economy, but also toward solutions of theoretical problems which have plagued physics for the last 50 years — would be, if the criminal sabotage of fusion research in the U.S. were ended.

All three approaches — plasma focus, imploding liner, and electron beam — have in common the production of plasma states which exhibit extraordinary concentration of energy into well ordered structures. The Soviet Union has devoted relatively large quantities of money and scientific manpower to work in these three lines of development, as well as a whole range of other approaches, in their broadly based fusion research program.

In contrast, the devices which have commanded the lion's share of fusion research funding in the U.S., primarily the Princeton Tokamak and secondarily other "magnetic bottle" devices, while important first steps, bear roughly the same relationship to the development of functioning fusion reactors as the dirigible does to the jet plane. They lack the type of **internally** determined relationship between the charged matter-in-motion (current) and electromagnetic field configurations (described below) that can be theoretically understood and purposively controlled to increase the operational efficiency of fusion devices.

Plasma, the so-called "fourth state of matter," is appropriate to fusion not simply because it produces fast-moving nuclei for fusion **directly**, i.e., through thermal (heat) energy, but because the high temperature and energy conditions produce (through ionization) semi-stable microscopic structures which act to facilitate the nuclear fusion reaction. Plasma provides not simply "hot" confined ions, but the conditions for the "metabolism" of fusion — the transformation of gross energy inputs into electromagnetic and then nuclear-produced form.

More generally, plasma, as the characteristic state of matter in the universe, provides the medium for beginning the theoretical unification of the particle-field duality which has fragmented physics into air-tight separate compartments for large-scale processes on the one hand and microscopic processes on the other.

No single line of development of fusion, or even a number of them, will lead us to a full-scale fusion-based economy unless they stimulate and in turn are nourished by continually expanding theoretical and experimental work on the frontiers of physics. The speed with which all approaches are fully developed, and theoretical breakthroughs made the basis for even more advanced designs, now depends on closing the U.S.-Soviet "fusion gap" by throwing the full weight of U.S. science and technology into joint work pushing forward the breakthroughs achieved thus far by the Soviets.

Messy Plasmas

The plasma focus and imploding liner, or LINUS, high-density pulsed approaches to harnessing the energy of controlled nuclear fusion reactions are currently not funded at all by the U.S. Energy Research and Development Administration, reflecting the notion held by ERDA and most fusion researchers that plasma physics is not a frontier region of fundamental scientific research in the way that particle physics is. That is, the study of controlled thermonuclear reactions supposedly involves the elaboration and application of existing mathematical physics knowledge, for the most part classical electromagentic theory of the 19th century, while particle physics research is believed to result in the discovery of "new laws" every time a new particle pops out of a bigger accelerator. From this upside-down perspective the plasma focus and imploding liner, or LINUS, approaches are simply too turbulent, too non-linear, **too messy** — they just don't fit smoothly into this tidy theoretical framework.

Despite this bias on the part of the U.S., the Soviet Union has made high-density pulsed fusion the major focus of its exploratory fusion research program, and the LINUS approach is currently being developed as the primary candidate for an "all-fusion" power reactor system, as opposed to the "fusion-fission" hybrid plan for the T-20 Tokamak. In the U.S., a handful of dedicated scientists who have been able to scrape together a few thousand dollars of research grants from various government and corporate agencies other than ERDA have recently achieved major scientific successes in these two lines of attack on the fusion problem. In their cigar-box-sized experiments, these scientists have demonstrated "pragmatically" the efficacy of the Soviet program. But more importantly, these researchers have started to penetrate the "messy" frontiers of theoretical physics.

The Plasma Focus

The plasma focus was among the first laboratory systems to produce copious

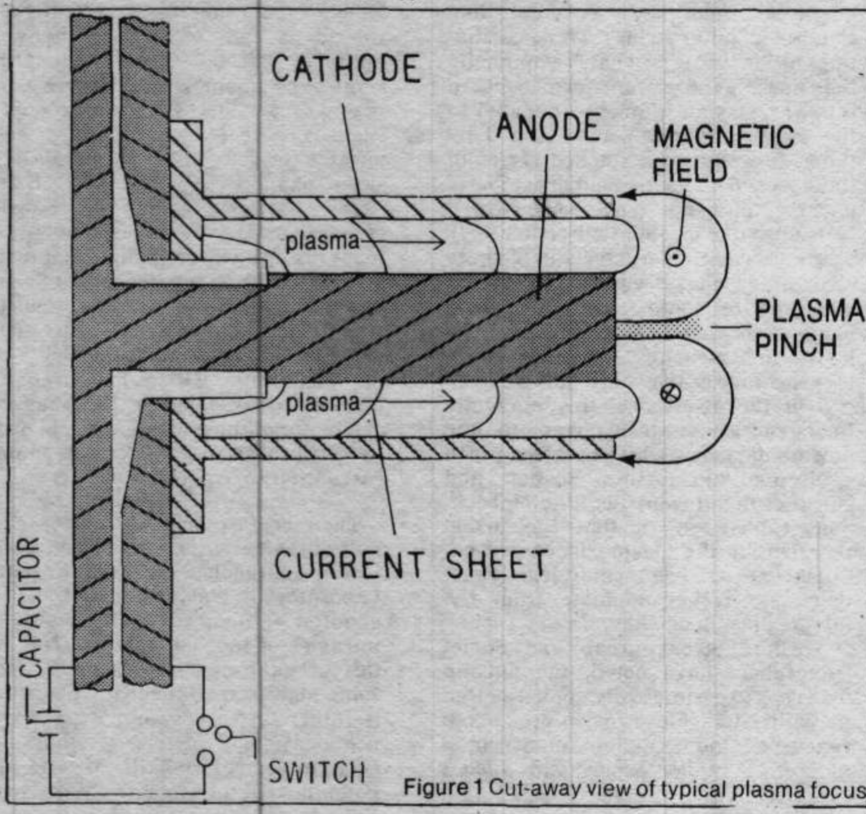


Figure 1 Cut-away view of typical plasma focus

amounts of nuclear fusion. But since the reaction products were emitted not randomly, as would be the case if the system approximated some sort of thermodynamic equilibrium, but directionally, the plasma focus was judged incapable of achieving "thermonuclear" fusion conditions, and therefore, of achieving net energy production — *producing more energy than* it used. The intense electromagnetic fields produced in the plasma focus, were thought to be merely accelerating a beam of nucleii, which reacted with the relatively cold background plasma and so produced a merely "pathological" nuclear fusion.

As is shown is **Figure 1**, the plasma focus in one of its simpler forms consists of two cylindrical electrodes, the cathode and anode. A charged capacitor bank is suddenly switched into the circuit, and within a few millionths of a second or less a gigantic *electrical pulse of energy is* "dumped" into the electrodes. A plasma forms between the electrodes, through which an electrical current passes. As the *current rises, "sheets" of current form* between the electrodes. A magnetic *field is also generated by the current* which flows within the electrode. This *current is directed towards the* "open end" of the device. The current which flows **between** the electrodes, and out of which the current sheets which carry *plasma with them are formed*, interacts with the magnetic field produced by the internal electrode current.

During the passage of the "sheets" of current across the magnetic field, the magnetic field lines oscillate like strummed guitar strings. These oscillations become so large that the magnetic field lines "wrap up" and form loops. In this way plasma filaments, parallel to the current "sheets" and carried by them, form out of a stacked series of these looped magnetic field lines. These plasma filaments form "force-free" *self-subsisting plasma-field structures.*

The essential characteristic of these structures is that "free energy"—energy available to confine and accelerate nuclei — is contained in the magnetic looped field structure. When these filaments collide as they "fall" off the open end of the electrodes, this magnetic field energy is transferred to the plasma particles, while a plasma pinch is formed. Professors Bostick and Nardi of the Stevens Institute of Technology have shown that the fusion reactions in the plasma focus are not "pathological" beam-cold target reactions, but rather emanate from the intense plasma pinch.

As the Stevens group and Soviet researchers have noted, the plasma focus has experimentally demonstrated its ability to achieve fusion breakeven (energy output equal to input) in a modest $10 million experiment. Such a fusion system would be "messy" as a

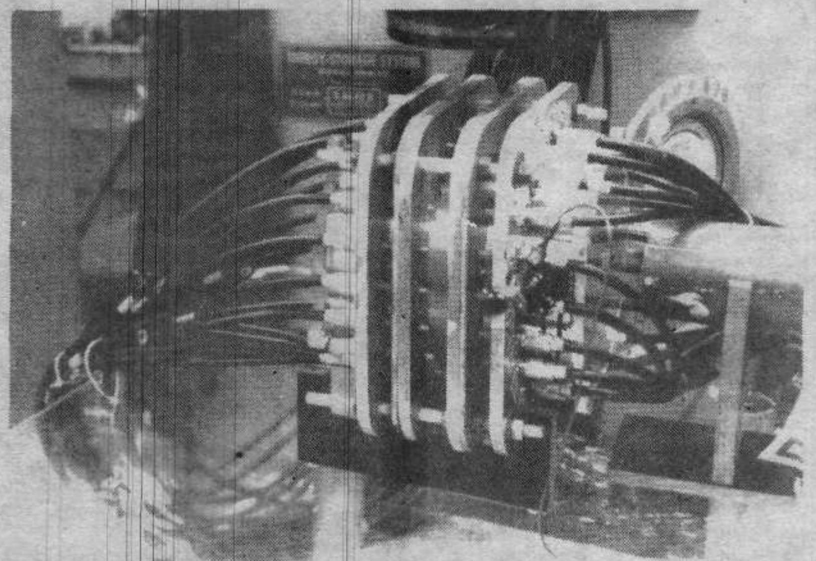


Figure 2 NASA Langly Research Center plasma focus.

power reactor, *although a team from* the University of Wisconsin has developed a conceptual power plant design based on the plasma focus. But *the most important question raised* by the plasma focus is how and why these plasma filaments, or plasmoids, which are in no sense in thermodynamic equilibrium, are formed. These filaments have now been observed in virtually all other types of magnetic confinement systems.

Researchers at the NASA Langley Research Center have recently demonstrated that the pinch formed by two opposing plasma focusses forms a stable structure which confines itself far longer than does a simple plasma focus — more than five millionths of a second as opposed to less than one millionth. It should be noted that this small experiment, seen in **Figure 2**, has reached so-called "Lawson products" (density x confinement time) comparable to $40 million, football-field-sized Tokamak experiments.

The Soviets' leading laser-fusion *researcher, Dr. Basov, is planning to* focus his large laser on a plasma focus, and Polish fusion researchers at Swierk near Warsaw have already reported significant enhancement of the fusion reaction rate resulting from such a set-up. Meanwhile ERDA has fired and blacklisted J.W. Mather, the American originator of the plasma focus, in order to eliminate such "extraneous" research from its program.

LINUS

The recent experimental success of a half dozen researchers working on the LINUS approach at the Naval Research Laboratory in Washington, D.C. will be counted among the technological miracles of the 20th century. Not that this breakthrough represents in itself some significant scientific advance; it is rather just a very important "*technological step*" *of the sort that must* become run-of-the-mill if the full potentials of fusion power are to be *realized. But what makes this advance* so extraordinary was the conditions of minimum funding and maximum administrative pressure under which it was made.

As early as 1963 the linear theta *pinch, a simple open-ended cylinder*, experimentally reached fusion temperatures in what appears to be a "stable" plasma-field configuration. But losses of plasma out the cylinder's open ends meant that, using a conventionally induced magnetic field, the system would have to be made several miles long to reach the confinement times required for net fusion energy production. By increasing the strength of the induced magnetic field, the density of the reacting plasma could be significantly increased, requiring briefer confinement times and therefore shorter systems. Conventionally induced magnetic fields, however, are limited to a measure of 200,000 Gauss by the strength of the structural materials supporting the stationary current-carrying, magnetic-field-*inducing conducters, making the* system necessarily at least two miles long. (To give an indication of the scale involved; the highest fields in magnetic confinement experiments are 100,000 Gauss.)

Much stronger magnetic fields can be produced if the conductor is "dynamic," i.e., designed to collapse in its own field. For example, if an intense electrical current is induced in the surface of a hollow aluminum cylinder, circling the cylinder, the resulting solenoidal magnetic field along the axis of the cylinder will collapse on itself; the magnetic field is in turn trapped and collapsed by the collapsing cylinder (the liner). The resulting magnetic fields reach millions of Gauss. With such a field the linear theta pinch could be shortened to less than *100 yards, and other, more complex*, geometries that "stopper" the cylinder's ends could bring this down to only a few yards.

One major technological problem with this method of producing magnetic fields is that a solid conducting cylinder crimps and wrinkles during its collapse, leading to the breakup of the cylinder during the final stages of compression. Ideally, if the cylinder could be "stabilized" during the compression, it could then be reexpanded by decreasing the induced current. In this way a pulsed, reproducible megaGauss magnetic field could be readily achieved and used to compress and heat dense plasmas to fusion conditions.

The Soviet Union's LINUS research program is as large as the U.S. Tokamak research effort, while in the U.S. only the small group of scientists at the Naval Research Lab are investigating the LINUS system. Continued funding by the Navy, even at its already miniscule level, was made conditional on achieving the technologically difficult task of producing a reversible liner compression. The Soviet researchers appear to be unconcerned about making this important technological step immediately, and are instead currently carrying out "one shot" experiments to demonstrate that breakeven can be reached.

In late December-early January the Navy researchers completed experiments which indicate that they have achieved reversible compression of a liner, by making the cylindrical liner out of liquid metal. Crimping of the cylinder is prevented by rotating the liquid cylinder during compression.

Plasma Focus Meets LINUS

Probably one of the most important recent developments in fusion research generally is the initiation of discussions on possible collaboration between one of Dr. Bostick's former students, Dr. Dan Wells of the University of Miami, and the Naval Research Lab's LINUS group led by Dr. A.E. Robson. In experiments at Miami, Wells and his coworkers have shown that when two doughnut-shaped plasma filaments of the sort produced in plasma focus devices collide, they form a more complex structure which is stable for a limited period of time. This self-subsisting plasmoid would constitute the ideal plasma structure for LINUS compression, if, as Wells' theory predicts, it remains stable during the compression, since this closed field structure would eliminate the problem of end losses that exists for the simple open-ended cylinder (linear theta pinch). Well is currently concluding a series of experiments which will demonstrate that his plasma rings do remain stable during magnetic compression.

Furthermore, only a one-dimensional LINUS compression would be needed for this plasma structure, as opposed to the multidimensional compression required for the more complex geometries that have been devised to avoid the end-loss problem.

Regardless of whether the particular plasma-field structure which Wells has developed experimentally "works," the methodology used in the development of his dynamic theory of plasma stability has already demonstrated the fruitful theoretical context within which self-sustaining plasma field structures can be explored.

Electron Beam Pellet Fusion

On March 10, Soviet Academicians Velikhov and Kadomtsev, in their report on Soviet fusion research in the party newspaper Pravda, announced that scientists led by Dr. L.I. Rudakov succeeded in producing thermonuclear reactions with an electron-beam-driven pellet implosion. While the full significance of this achievement is presently known only to a small number of specialists in the United States, it will shortly become obvious that the Soviet Union has launched a second "technological" Sputnik.

Velikhov and Kadomtsev state in their article that this experimental success "opens the path for development of a pulsed thermonuclear reactor." Last fall at the Lausanne Plasma Physics Conference, Dr. Rudakov outlined the design of an electron beam pellot implosion fusion reactor prototype which is to be built with **existing technology** in the next five years. This plan was confirmed by subsequent statements by Academician Velikhov, and it has been officially included in the next Soviet five-year economic plan. Together with the LINUS and laser beam pellet implosion programs, this effort represents the Soviets' mainline all-fusion backup to their Tokamak fusion reactor development program.

What has amazed informed U.S. observers is the rapid turnaround of the Soviet electron beam effort. Just last spring a Rand Corporation study on electron beam research in the Western region of the USSR concluded that while Soviet scientists were engaged in a much broader theoretical and experimental effort on electron beams than any researchers in the West, the manifest U.S. lead in the technology of generating high-energy electron beams, which depends on electric technology and materials, would keep the West dominant in this field. When Soviet scientists announced their intentions to proceed to an actual fusion reactor prototype based on this system, U.S. specialists commented that "the whole concept seems heroic." Now...

While this new Soviet achievement once again underlines the continued existence of the "fusion gap," its significance for the general technological-scientific standing of the USSR versus the U.S. is much more important.

A review paper by the leading Soviet plasma physicist, V.N. Tsytovich, released in January and first translated and circulated by the U.S. Department of Defense and now published in the science journal Physica, gives an indication of Soviet thinking on the e-beam problem. According to Tsytovich, it is quite likely that qualitatively new states of matter-energy are being produced in e-beam matter interaction systems. (Plasma instabilities generated by the beam, for example, can generate bunching of the plasma together with bunching of the elctric fields trapped in the plasma. These field and plasma "bunches" — otherwise known as cavitons, solitons, etc. —

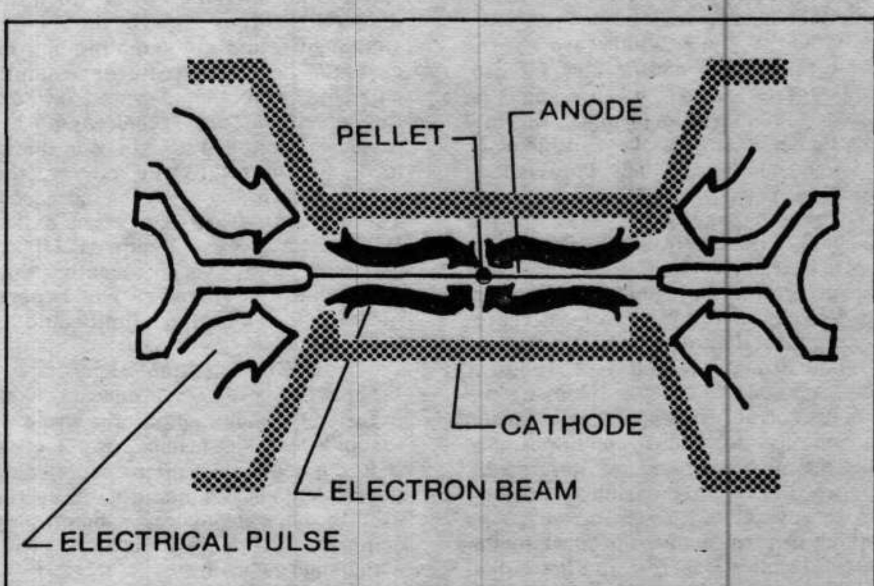


Figure 3 Diagrammatic representation of an e-beam fusion system Massive generators feed an electrical pulse into the system from both sides.

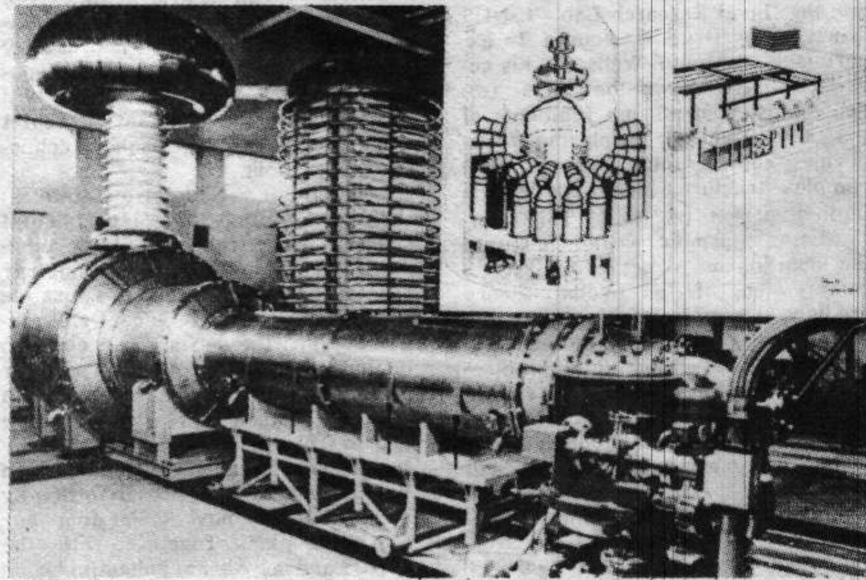


Figure 4 A discussion of the Soviet ANGARA e-beam generator at the Kurchatov Institute in Moscow was included in the Sandia Laboratories' brief to Congress on the e-beam fusion program. Inset shows a Soviet artist's rendering of a planned prototype fusion reactor aiming 20 to 30 ANGARA at a single fusion pellet.

appear to constitute totally new types of discrete structures.)

Compare to Tsytovich's perspective the prevalent attitude of the controllers of the West's scientific community as inadvertantly parodied in a November 1974 Canadian fusion study which noted, "One should emphasize that the generation of the (electron) beams seemed almost in the realm of black magic...The magician was J.C. Martin of AWRE Aldermaston (the British weapons laboratory — Ed.) who mysteriously enough has not published in the open literature...It has been somewhat typical of the field that the experimental achievements in gun operation have outstripped (sic) the theoreticians' understanding; to a lesser extent the same is true for beam propagation."

Because of its close relationship to both the most basic questions in physics and the full range of thermonuclear and electronic weapons systems, the Soviets' ability to take advances in the "purely" scientific aspects of electron-beam plasma physics and develop its technological applications, while simultaneously outrunning the West in an area of long-standing Western technological dominance — all within a year — demonstrates the potentiality for strategic scientific advances which makes U.S. Defense Department strategists shudder.

U.S. and USSR

Electron beams have already found a wide range of technological applications, from color television to garbage disposal. In magnetic confinement fusion systems, e-beams hold great promise, either as a means of plasma heating or as a way of providing confining magnetic fields. Due to various key military applications — such as micro wave generation, nuclear weapons simultation, generation, and weather modification (by using e-beams to change the plasma properties of the earth's ionisphere) — high-energy electron beam research has until recent years been kept under tight security wraps.

Just as in the case of magnetic confinement and laser fusion, it was only when Soviet scientists unilaterally revealed the details of their own work on the e-beam pellet fusion in the early 1970s that the United States was pressured into likewise declassifying much of this research, and further forced to begin a serious research program directed toward controlled fusion applications of e-beams.

In the U.S. Dr. F. Winterberg was the *first to publicly outline how intense,* high-energy electron beams could be used to initiate controlled thermonuclear microexplosions. But his work was and continues to be suppressed; in fact in order to find employment, Winterberg has had to work at the Nevada Desert Research Center on solar energy systems!

The present status of electron beam technology and physics is most representative of the current situation in controlled fusion research as a whole. A few isolated designs for achieving the generation of fusion power exist, based on empirically known conditions, but the means of reproducing these conditions with currently feasible technology raise several key scientific questions which in turn involve the most fundamental questions of mathematical physics. While it may be possible to "pragmatically" solve the problems posed initially, the achievement of a full-scale world fusion economy demands a vigorous and broad-based attack on those fundamental frontiers.

Fusion Systems

An e-beam generating system consists of two electrodes which are connected to a large capacitor bank through a complex switching system, which allows for the release of millions of joules of electrical energy stored in the bank within a millionth of a second or less. In existing e-beam machines, such as the U.S. Proto-I and the Soviet Angara, this electrical pulse reaches power outputs of a trillion watts during the 100 billionths of a second that the e-beam pulse lasts. This is greater than the **power** consumption of the whole United States during that same time span.

This pulse is transmitted to the electrodes generating the e-beam through a pulse-shaping circuit and an oil- or water-insulated "blumlein" which prevents electrical sparking, i.e., discharging, before the pulse reaches the electrodes. The essential aspect in e-beam-generating technology is that electrical discharging between the electrodes before large electrical potentials are built up on the opposing electrodes must be suppressed by some means. When this suppression is either released or overcome, electrons escape from the negative electrode (the cathode), stream toward the positive electrode (the anode), and explode into it. In e-beam pellet systems the pellet is generally placed on the anode. (See Figure 3)

The electron stream, or current, generates a magnetic field which pinches the current itself. Since the magnetic field strength increases as the density of the current increases, this self-pinching can reach a point (termed the Alfven limit) at which the magnetic field generated by the current significantly limits or actually stops the *current's flow. This is further complicated* by the fact that the speed to which the electrons are accelerated approaches the speed of light, and therefore, due to relativistic effects, the actual mass of the electrons increases. These e-beams are thus often called Relativistic Electron Beams (REB). It was not until very recently that recearchers demonstrated experimentally that the Alfven limit could be beaten.

REB Pellet Implosion

The REB pellet implosion approach to fusion is fundamentally the same as that of laser pellet fusion. The objective is to duplicate on a microscopic scale the high densities and temperatures used to generate hydrogen bombs, by compressing a pellet of fusion fuel with a high-energy beam.

The key to this system is the use of a thin-shelled hollow pellet, as designed by Soviet researcher Basov and his associates. In this way the time during which the beams can be applied to the pellet is significantly increased *without increasing the amount of* matter to be compressed. By allowing greater compressions to be reached, the hollow pellets also allow concomitant increases in the rate of fusion reactions with the same beam power levels, greater than would be the case for simple solid pellets.

In the case of laser beams, high-power density levels are readily produced through optical focusing of the laser beam light. However, at these power densities the total energy output for lasers is quite limited for existing laser designs. Also the efficiency with which the laser beam is generated is very low; less than 1 per cent of the total energy input into the laser system ends up in the laser beam output in existing high-energy laser systems.

On the other hand, e-beam power densities are much less than those obtained with lasers due to the Alfven limit. But e-beam operation is much more efficient, with over 40 per cent of the input energy showing up in the final beam output and the total energy outputs of e-beams are not intrinsically limited.

At the trillion watt power outputs currently achieved in e-beam guns, the lower limit for what Basov details as the power density needed for his relatively huge Super pellet has already been attained. More importantly, the total energy outputs of existing e-beams is already in the tens of thousands of joules, and the next generation currently under construction will have power outputs of 40 trillion watts and total energies on the order of 100,000 joules, sufficient for imploding the Basov Super pellet. The Soviet Union's next five-year plan calls for building a 5 million joule, 1,000 trillion watt e-beam for an experimental prototype reactor.

Progress Cited On Fusion Reactor

The following are excerpts from a March 28 article on page 3 of the Washington Post, under the byline Ed Schumacher:

CAMBRIDGE, Mass. — Massachusetts Institute of Technology nuclear physicists have been doggedly experimenting to develop an inexhaustible and low-risk source of energy, the nuclear fusion reactor ...

... a recent series of breakthroughs at MIT and other centers have brought them so close that many scientists interviewed said they can develop a nuclear fusion power plant by as much as 10 years before the government's end of the century target ...

Stanford University professor Robert Hofstadter, a nobel laureate in physics, predicted that KMS Laboratory in Ann Arbor, Mich., where he doubles as the principal scientist for fusion research, may develop a nuclear fusion reactor to produce synthetic natural gas even earlier — possibly with ten years ...

MIT scientists last fall came the closest to producing a working reactor ... (The article goes on to describe the Alcator Tokamak experiments.)

Three weeks ago at Oak Ridge National Laboratory in Tennessee, nuclear physicists uncovered the same phenomenon with a different method that may be more applicable to an actual power reactor.

Instead of using a stronger magnetic field, they raised the heat with a device that injects heated neutral particles into the gas. The experiment demonstrated that the tremendous heats of over 80 million degrees need for an efficient Tokamak style power reactor are attainable ...

The Tokamaks have been designated by the Energy Research and Development Administration as the priority magnetic method, and received about half of all federal funds for fusion research. Alternatives are being pursued, however.

One is the "magnetic mirror" technique being developed at the University of California's Lawrence Livermore National Laboratory ...

A totally different fusion method given equal priority with the magnetic experiments by ERDA employs lasers ... (article describes laser experiments at KMS fusion.)

The scientists say funding is the hangup in achieving a workable reactor soon ...

The Ford Administration proposed budget for fusion and all energy research and development is up by about 50 per cent over this year. It includes $392 million for fusion research, compared to $612 million for breeder reactors and $2 billion for military nuclear research under ERDA...

ERDA Buries Fusion Under New Energy Pyramids

by Dr. Morris Levitt

March 31 (IPS) — A recently released Energy Research and Development Administration (ERDA) report entitled "A National Plan for Energy Research Development and Demonstration: Creating Energy Choices for the Future" buries the proven feasibility of harnessing the unlimited productive energy of fusion power by the 1980s under a mountain of energy pyramids.

A summary of the plan presented by the ERDA Deputy Administrator Robert F. Fri to Wall Street security analysts appears in the March 19 issue of ERDA's Weekly Announcements. Fri advised the bankers that "According to one of the possible scenarios we have developed for the year 2000, we anticipate the need for 450 nuclear power plants of 1000 Megawatts each, including 80 breeder reactor plants; 400 geothermal power plants of 100 Megawatts each; 200 to 400 solar electric power plants of 100 Megawatts; 220 coal-fired power plants of 1000 Megawatts (by quadrupling coal production), 140 synthetic oil and gas plants each producing the equivalent of 50,000 barrels of oil a day from coal; 80 shale oil plants producing 50,000 barrels of oil a day; 15 million electric automobiles; 10 to 15 million solar heated homes, a supporting infrastructure including mines, transportation and delivery systems ..." All this and "... major changes in end use systems to achieve a 25 per cent reduction in demand growth" too.

ERDA's estimate of the price tag of this laundry list of bankers' boondoggles is .5 trillion dollars, a figure independently confirmed in a recent study by Bankers Trust. Fri told the analysts, "When was the emergence of one or more whole new industries not a golden opportunity for the smart investor?"

Endorsing ERDA's so-called balanced energy program, the New York Times, editorialized March 30, "First priority in any long-range energy policy must go to conservation, to reducing the demand side of the energy equation." Then, "both (solar and nuclear) energy power can play their roles in supplying this country's energy."

Who Will Pay?

Fri neglects to mention, however, who will pay for the mammoth energy pyramids outlined in the ERDA report. The Times, however, was candid enough to admit that the toll will be taken from the working class, stating in their recent editorial, "The policy leadership which this country needs for the years to come will have to make a **sacrifices** in an energy-conscious society."

Austerity Forces Pit Solar Crusade Against Fusion Development

by Dr. Morris Levitt

The counterinsurgent planners who spent billions to hide capitalist economic collapse behind synthetic issues such as busing, abortion, and community control are down to the bottom of the barrel. With working-class politics defined by the Labor Party's program of debt moratorium, and International Development Bank, Wall Street has deployed 37-year-old New Left agent Tom Hayden to lead a children's crusade to replace nuclear energy with solar power.

Hayden's fraudulent energy program, the centerpiece of his campaign for U.S. Senator from California, is beginning to backfire. Last weekend the "dissident" California Democratic Council endorsed Hayden and his Proposition 15 — which would effectively end nuclear power in California. Within the week the office of California Sen. John Tunney — who opposes Prop. 15 — informed the Labor Party that it will circulate a questionnaire to leading fusion scientists to establish the need for a total revamping of fusion research, as outlined in the Labor Party's Fusion Act of 1976, which proposes a brute force development program to achieve a fusion-based economy in the next 10-15 years.

A product of the United Auto Workers-State Department socialist operation which spawned Students for a Democratic Society out of the anti-communist Student League for Industrial Democracy, Hayden preaches a program of labor intensive zero growth. In a world wracked with starvation and disease caused by economic breakdown, there is to be no energy growth. Present fuels will be phased out and replaced by solar energy, with California as the "Solar Energy Capital of the World." Secondary energy sources for a nation reduced to small cities will come from "wind, corn husks, garbage, and sewage." Overall coordination of energy development of this type will be provided by a national and local Energy Corps. Finally, Hayden plans to set loose a pack of "small drillers and wildcatters" on California's beaches to break the "energy empire" of the oil companies and utilities.

Nader's Act

To whip up middle class hysteria behind Proposition 15, Hayden and fellow corporatist agent Ralph Nader have dragged into the limelight three General Electric nuclear engineers who recently quit their jobs, claiming that utilities and nuclear companies were lying about radiation and safety hazards. All three were subjected to brainwashing sessions at an outfit called the Creative Initiatives Foundation. The CIF has heavily penetrated the National Council of Churches in California and acts as a conduit for demoralized scientists into Nader's front group, Project Survival.

According to the Wall Street Journal of March 1, at least 12 other states, including Oregon, Michigan, and Missouri, have been targeted for antinuclear referenda by Nader's Public Interest Research Group. In a December interview with the counter-culture rag Rolling Stone, Nader admitted that the real objective of his campaign *is to break down the economy into* as many small parts as possible.

Nuclear workers respond to environmentalists' at Indian Point, N Y

On the East Coast, the solar-wind campaign has been fanned by Rep. Bella Abzug (D-NY). Abzug and former Attorney General Ramsey Clark led 250 environmentalists on a demonstration Feb. 29 to shut down the Indian Point nuclear plant north of New York City. Following up the resignation under circumstances suspiciously similar to the California "conversions" of Nuclear Regulatory Commission inspector Robert D. Pollard, Bella bellowed about stopping "avaricious powers, like Con Edison." The utility, like most others — *especially in the Northeast* — has long been milked dry by debt payments *to the banks*.

Nobody could hear Bella, however. Not the best figure to represent "small is beautiful" ideology, she was drowned out by 1000 counter-demonstrators from *Utility Workers Union Local 1-2* shouting, "We want jobs."

Scientists' Commitment To Fusion Hurt By Lack Of Funds

by Dr. Morris Levitt

Feb. 25 (IPS) — Writing in the op-ed section of the New York Times on Feb. 24, one day after urging scientists at a Boston meeting of the American Association for the Advancement of Science (AAAS) to express their creativity in armaments design, Vice President Nelson Rockefeller offered the nation "security and energy" if only America had the foresight to invest $800 billion in his Energy Independence Authority (EIA) over the next decade. After all, crowed Nelson, no one has *proposed a workable alternative to the* nation's energy crisis.

Nelson is uninformed. With approximately $100 billion in funding over the next five years, the Department for the Development of Controlled Fusion (DDCF) specified in the U.S. Labor Party's Fusion Energy Development Act of 1976, in conjunction with counterparts in the Comecon, Western Europe and Japan, can bring the world to the threshold of an era of virtually unlimited energy resources and an actively creative existence for the entire world's population.

The controlled environment is rapidly crumbling in which Rockefeller's Energy Independence schemes and *zero-growth alternatives to science* are accepted by a majority of the scientific community. Wall Street opinion shapers would not dare to take an honest poll among scientists on the issue of an all-out fusion program — pro-fusion scientists are now being found even at the highest levels of the Rockefeller-controlled Energy Research and Development Administration. In addition, the media have increasingly focused on the Soviet lead in fusion research and U.S. developments in the field.

In a Jan. 31 interview during a CBS radio national network special on fusion Dr. Robert Hirsch, then the director of ERDA's fusion division, reversed his *usual hedging on the prospects of fusion* development. "I believe there's a good chance we could probably cut off a decade to the advent of fusion power," Hirsch stated.

Shortly following the January broadcast, Dr. Hirsch was replaced as director of ERDA's fusion research by Ed Kintner, a nuclear engineer who had no previous experience with fusion development. Kintner worked professionally on the development of the fast breeder reactor — a research effort diverting crucial resources and manpower from the fusion effort — until late last year when he became Hirsch's assistant.

McCarthyism in Science

An increasingly positive attitude toward fusion among scientists, industrialists, and numbers of U.S. aerospace executives will mean nothing however, without mobilization of the political forces required to stop redoubled Atlanticist sabotage of ongoing fusion research and to force passage of the U.S. Labor Party's $5 billion fusion energy development legislation.

The most brazen example of this dangerous sabotage operation is the case of ERDA's refusal to fund the necessary upgrading of the MIT-Bitter Magnet Lab Alcator Tokamak, a machine which has achieved the closest approach to energy breakeven of any experimental device in its field.

Leading researchers at the Bitter Magnet Lab have informed New Solidarity that ERDA has refused to fund a crucial "breakeven" fusion power Alcator experiment which could be built with a year and possibly could lead directly to a prototype fusion power reactor. Instead of okaying $6 million for the new electrical power supply needed to bring the modified Alcator magnetic field up to 140 kiloGauss and adequately heat the Alcator plasma, ERDA told the MIT team to build any size experiment they want, as long as it can be powered by their present electrical generators. The calculated idiocy of this decision was summed up by one of the designers of the rejected project: "Scientifically this limited type of experiment (proposedby ERDA) would be meaningless. If all we are going to be permitted to do is reproduce our existing results, then we might as well close up shop and go home now."

In a related case, leading fusion researchers have reported that the Los Alamos Scyllac theta pinch project is on the verge of extinction. This "high beta" (high plasma density compared to magnetic field strength) fusion experiment is crucial to fundamental plasma physics investigations necessary to determine if economical tokamak type fusion reactors can be built. ERDA has given Los Alamos an impossible time table to produce experimental results for the project. Predictably, the key group of scientists working on Scyllac have been completely demoralized.

USLP Program For Fusion Polarizes AAAS Meetings

by Dr. Morris Levitt

BOSTON, Feb. 22 (IPS) — At the annual meeting of the American Association for the Advancement of Science (AAAS) here this week, the U.S. Labor Party's programmatic organizing for Congressional allocation of $5 billion to the fiscal year of 1977 fusion research and development budget has polarized this largest organization of scientists in the U.S. Two days of Labor Party interventions into the typical AAAS smorgasbord of single-issue sessions has wholly discredited the mushy-headed idea that the "progressive" promotion of accomodation to, anti-fission and Zero Growth policies will continue to command the respect of the rank-and-file of the U.S. scientific community.

This polarization has penetrated the organizational structure of the AAAS itself. Science Magazine, smarting from the back-fire effects of their slander article on the Labor Committees last October, dispatched their top science news writer, John Walsh, to find out from Labor Party organizers there why they were having such a potent effect.

Walsh's extensive interview of the Labor Party is part of a developing faction fight within the AAAS between the proponents of "anthropologist" Margaret Mead's Third World triage proposals and the U.S. Labor Party's revised bill for a crash program of fusion development as the basis for world development.

Following a briefing on the necessity for a baseline investment of $5 billion into fusion research and development and the effect of such a policy on basic science and technology, AAAS President and Chancellor of the University of California at San Diego, William McElroy agreed to urge Sen. Tunney (D-Cal) and other politicians and industrialists, particularly in aerospace, to support the fusion bill. When next contacted, McElroy had already told a Boston Herald reporter that fusion was a top priority, "and I told him we need a $5 billion program — right?"

A Commitment To Progress

The growing support among conference participants for the Labor Party's program set the basis for their open consideration of the fundamental questions of mathematical-physical theory Feb. 19, on "The Concept of the Transfinite" by NCLC National Executive Committee member Uwe Parpart. At the forum, attended by 30 scientists and 40 Boston USLP members and periphery, Parpart summed up the subject of the Labor Party's intervention: the theoretical advances required for the continued existence of humanity are impossible in the absence of a personal commitment to progress and a simultaneous commitment to its social realization. By the conclusion of the forum, several scientists were beginning to openly struggle with the inadequacy of their scientific ideas that the geometry of the universe, whether considered globally or locally, is a simple linear continuum, precisely because of the moral imperative posed by Parpart.

With this epistemological basis for economic program, U.S. Labor Party interventions at the Conference had the following exemplary impact:

* Dr. Ned Rosinsky delivered a 15 minute mini-educational to the panel on "Frontiers of Neurophysiology" on the necessity of connecting conceptual work in this field to the question of the appropriateness of biological structure to human mentation. The chairman scolded the panel afterwards for not responding adequately to Rosinsky's "valuable dissertation."

*Dr. Richard Pollack addressed the "Advances in Climatology" session on the connection between non-linear, self-modifying interactions within climatological systems which must be understood for climate control as well as for agricultural production, and the similar problems of plasma physics relevant to fusion development. The chairman expressed his appreciation of the need for fundamental theoretical work in these areas and repeated Pollack's announcement of the Labor Party's forum on the "Transfinite."

*At the conference's opening press conference, Margaret Mead, was forced to renounce her advocacy of cutting off technological inputs from the advanced sector to the Third World, and to agree that continuous inputs of fertilizer and technology were needed to prevent millions of deaths.

Democratic Party's Energy Policy: Glass Pyramids, Banker's Socialism

by Eric Lerner

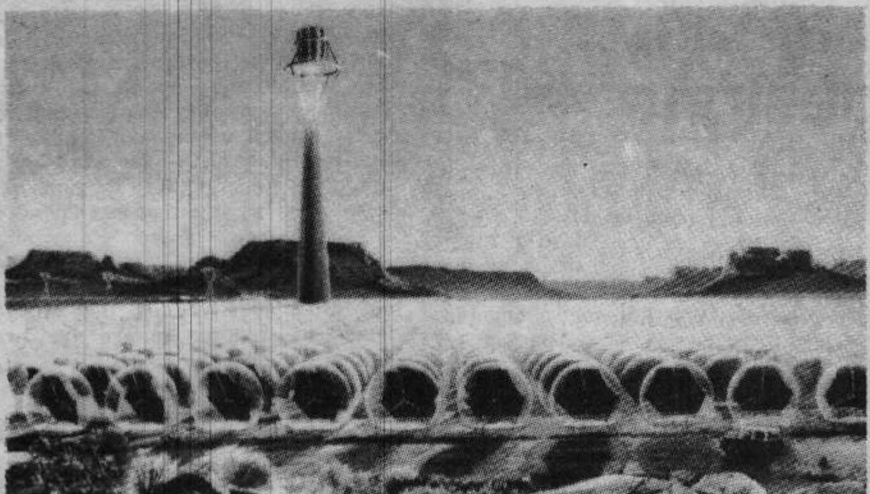
March 23 (IPS) — Strange, isn't it, that all the gladiators in the Democratic primary arena are in complete agreement on the controversial question of energy policy. But this fact is far less surprising than the mind-boggling stupidity of the policy they have agreed on. "Radical populist" Harris, "moderate" Carter, "liberal" Udall, "conservatives" Jackson and Wallace all agree that we must conserve energy by eliminating waste and substituting muscle power for machine power, thus creating jobs into the bargain. They all ignore "impractical" fusion and demand cutbacks in dangerous fission. They all agree that in the short term we must increase coal production, and over the long term shift to full reliance on solar energy.

Thus Udall: "The adoption of a strong energy conservation program is an absolute necessity...coal constitutes one of the nation's most promising energy sources...the federal government must concentrate its efforts on renewable resources such as solar energy." With a down-home twang, Carter: "We must conserve energy drastically, make a major shift to coal, and substantially increase our use of solar energy." And so on down the line.

Where does this remarkable unanimity come from? From the scriptwriters, of course — all the candidates are briefed by the same handful of think-tankers, who in turn take their orders from the New York bankers. In the case of energy, the think-tank involved is Barry Commoner's Scientists Institute for Public Information. Commoner, frequently accompanied by fellow Institute board member and United Autoworkers union executive Irving Bluestone, has been traveling around briefing Democratic candidates, Congressmen, and key Democratic machine leaders on the correct energy line. Commoner's recent series of three articles on energy in the New Yorker magazine are now quoted as the bible of energy policy by practically every top Democrat, and one eager beaver entered the entire series into the Congressional record.

Sci-Fi Horror

Let's examine what the world would look like if the proposals Commoner and his Democratic pitchmen make to replace gas and oil with solar energy were carried through. The fascist regimes and evisceration of living standards required to implement even the early stages of the Commoner plan would ensure that the world would end in either thermonuclear war or a holocaust of disease and ecological collapse in a few short years: the "Year 2000" world described here is only a science-fiction horror story.



One of Commoner's Solar desert fantasies.

The more minor part of Commoner's catastrophe would be the solar heating of individual homes by rooftop solar collectors. For the U.S. alone, the installation of such collectors on each of the 50 million existing one-or two-story homes would involve, very conservatively, a construction labor force of 2 million working for 25 years, to say nothing of those involved in making the materials involved, such as 2 million square feet of plate glass a year, equal to current total U.S. output. Since this labor force is comparable to the total number of skilled construction workers formerly engaged in construction of housing, presumably new housing construction would have to wait 25 years, by which time the solar collectors would be about due for replacement!

This is nothing, however, compared with the core of the energy plans of Commoner and his Democratic friends, the production of electricity and synthetic fuel (hydrogen) from diffuse sunlight. They propose to cover large parts of the American desert, and on a world scale presumably the Sahara as well, with glass pyramids — titanic arrays of mirrors focusing sunlight up to elevated water boilers, which produce steam to generate electricity and to electrolyse water, producing hydrogen fuel.

The scale of waste here is staggering. A solar generator sufficient to produce merely the electric energy consumed by New York City (about 15,000 megawatts) would require a mirror-array covering more than **300 square miles,** using Commoner's own figures. The area of New York City is only 360 square miles! (Now we know why Big MAC banker Felix Rohatyn wants to raze 80 per cent of the city.) If such a generator were to produce all of New York City's energy requirements, the area would have to be four times larger.

Pyramid-Building

For the world as a whole, this means covering a total area of 125,000 square miles (at a minimum) with glass pyramids over the next 25 to 30 years.

A single 300 square mile generator (of which **400** would have to be built) would require at least 10 million tons of glass, plastic, and other materials. Just about as much weight as went into the original pyramids. This is 300 times more mass than the material required by the bulkiest possible fusion reactor for the same energy production. The energy involved in producing that much material would represent two years production for the generator itself. This means that with even a modest rate of energy growth and a 25 year life expectancy for energy collectors, at least 20 per cent of total energy supply will be going into the production of the solar collectors themselves!

In terms of labor, solar generators would require at least 15 to 20 times as much labor as comparable fusion generators, even taking into account the latter's greater complexity. On a global scale, this means the allocation of at least 8 to 10 million workers for the glass pyramid projects, equivalent to 50 to 60 per cent of the total U.S. industrial workforce. These then are the jobs to be provided the U.S. working class under "full employment" slave labor —

building glass pyramids in the desert.

Such an incredible scheme makes sense from only one standpoint, that of the Harriman faction of financiers who pay Commoner and Bluestone in the first place. Far from advocating more productive technologies, like fusion power, which cheapen commodities and permit the rapid expansion of the economy as a whole, they want to turn technology back to preserve the historic value of their paper debt. Labor-intensive boondoggles, requiring little investment of capital relative to the quantities of slave labor, are a dream-come-true feeding-ground for these parasites. For the Nazis, it was armaments and Autobahns; for Rockefeller's faction it was oil shale and coal gassification: the Harriman faction's recipe is glass pyramids.

Bankers Socialism

But it won't do for the Democrats to go around saying, "I'm for labor-intensive schemes and glass pyramids because it's the only way to protect the bankers!" That doesn't win votes.

Here is where Commoner must earn his pay, by devising a "scientific" rationale that will convince, if not workers, at least Democratic Party hacks and their petty-bourgeois peers. Commoner begins by deriving the necessity of raising the return on capital from a more "respectable" theoretical basis — the Second Law of Thermodynamics.

The Second Law asserts that randomness is everywhere increasing, and once energy is used, it is converted into random heat and irretrievably lost. The universe, says Commoner, is running down (a law the Democrats can under-

Barry Commoner

stand upon self-reflection). Therefore, since energy loss is irreversible, we must at all costs conserve energy and everything that takes energy to make, especially capital — plant and machinery. Therefore we must get the maximum "productivity" out of each precious drop of oil and each precious dollar of capital.

Having established this vital point for the bankers, Commoner must then demonstrate that it is in the interest of the working population to preserve the return on capital (in other words, debt service) by turning back technological advance. Quickly donning his overalls, Commoner steps into his role as friend of the working man and proceeds to explain *the present economic crisis* as a result of capitalism's insatiable drive for technology, a view he modestly ascribes to...Karl Marx!

The wicked capitalists, preaches Commoner, have continually replaced primitive methods of production like wood chopping, which uses lots of labor and little capital and energy, with advanced methods like electric generation plants, which use little labor and lots of capital and energy. This creates mass unemployment, by destroying jobs, and leads to energy and capital shortages. This has driven the capitalists to gouge wages to fuel their insane race to invest more and more in high technology, leading to the tremendous technological advances and booming growth in modern plant and equipment since the current depression got underway five years ago.

Since he has identified himself as a Marxist, Commoner's proposed solution to the energy and economic crisis is, of course, socialism, a socialism which will cure the fundamental evil of capitalism — progress. Instead of freeing the development of productive forces from the fetters of capital, as the real Marx proposed, Commoner wants to free capital from the fetters of development. An immediate retreat to the coal-run 19th century is merely Commoner's minimum program; his maximum demand is to return to Ancient Egypt. The socialism of Commoner and his Democratic co-thinkers is the opposite of the socialism of Marx. It is more exactly called bankers' socialism, better known as fascism.

International Journal of Fusion Energy

The International Journal of Fusion Energy is sponsored by the Fusion Energy Foundation for the advancement of theoretical and experimental conceptions necessary for the realization of fusion power. The Journal aims to stimulate investigations of Plasma dynamics from the standpoint of fundamental theoretical problems of physics, as well as to promote development of the revolutionary technologies and production techniques that are intrinsic to fusion processes.

* * * * * *

Why A New Journal?

"A new journal can play a very valuable role. There is need for a more 'relaxed' setting in which to reconstruct the history of various lines of approach to fusion, and what lessons are to be learned from failure and abandonment as well as success.

We should give experimentalists a better sense of various plasma regimes, instead of just a few points on a graph.

Innovative approaches need a journal in which they are treated on an equal footing with established lines of investigation.'"

from Livermore Laboratory

"I am in support of the objectives of the new journal and feel that its publication will help to increase public awareness and support in this most important area of scientific reaearch."

from Bitter National Magnet Lab, MIT

* * * * * *

Sample of Articles in Preparation

"Overview of Fusion Research as of Late 1975"
— Prof Bo Lehnert, Director of Fusion Research, Royal Institute of Technology, Stockholm, Sweden

"History of Physics of the Plasma Focus and Pinch Effect"
— W. Bostick, Stevens Institute

"Re-evaluation of Maxwell's Electrodynamics: Applications to Dense Fusion Media"
— R. Moon, Chicago

Sponsored by

Fusion Energy Foundation

ORDER FORM

Please enter a subscription to : **The International Journal of Fusion Energy**
Baywood Publishing Company, Inc.
43 Central Drive
Farmingdale, New York 11735

Please add $2.00 per volume for shipping if outside the United States and Canada.
Note: All journal subscriptions are sold by the volume only. Each volume consists of four issues.
All subscriptions outside the U.S. and Canada must be prepaid in U.S. dollars drawn on a U.S. bank.

Amount Enclosed$

1 year pre-publication price $35.00 — 2 years pre-publication price $70.00

Check enclosed — Bill me

Name-Title — Organization

Street — City, State, Zip Code