SPECIAL REPORT

Congressional Hearings Confirm: Fusion Possible in the 1980's

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 this issue), 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 conference 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 research budget 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.

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 towards 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 "magentic 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 forms.

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 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 power reactor, although a team from the University of Wisconsin has developed a conceptual power plant design based on the plasma focus.

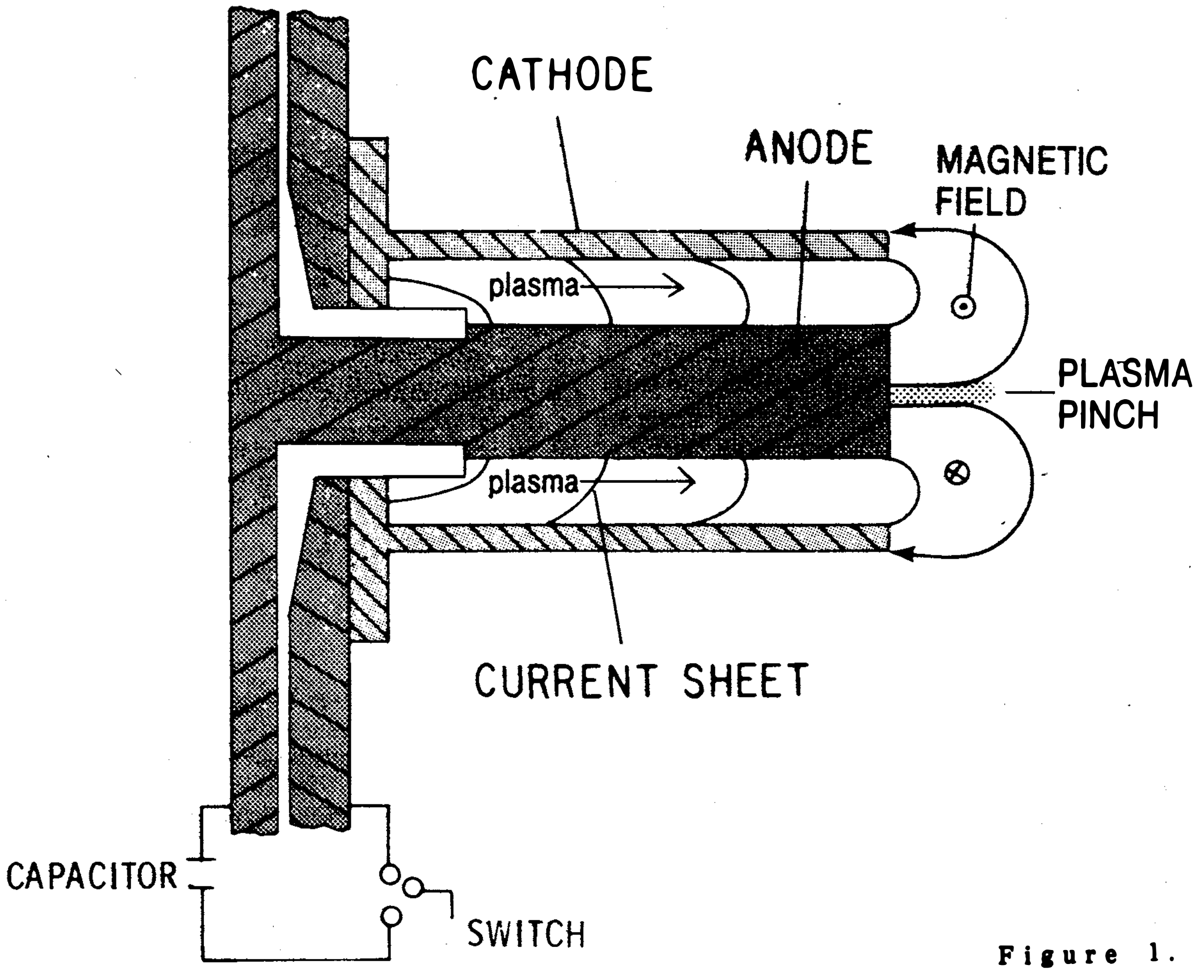

Figure 1.

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 setup. 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.)

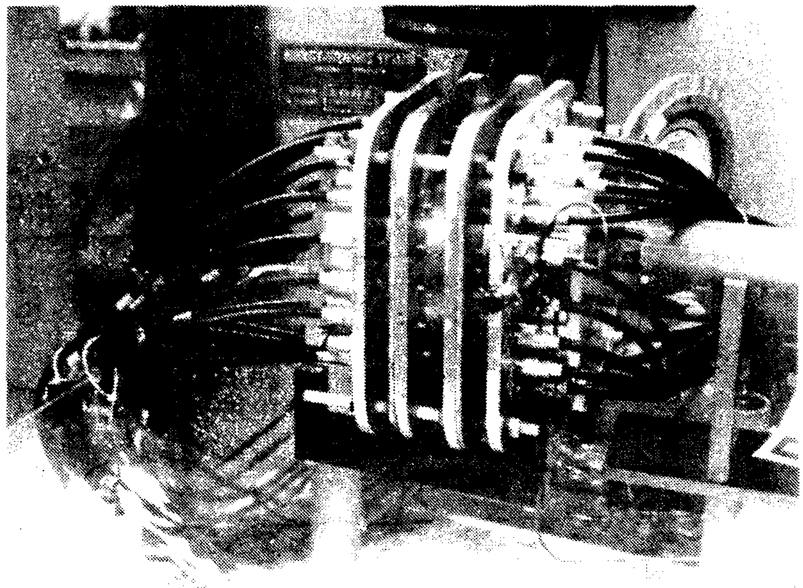

Figure 2.

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.

(In Part II of this article: Plasma Focus meets LINUS, and the Electron Beam.)