U.S. Treasury's issues of currency notes, have abundantly demonstrated, through the miserable performance of their own varieties of economic forecasting, that they have simply not understood the bare fundamentals of our present economic and monetary situation.

This is a matter of foreign policy as much as of domestic policy. If the United States summons its will to restore the power of a gold-reserve-based U.S. Treasury currency note, the world can be quickly induced to submit to our will in this matter. . . .

Unless the shock of this new monetary crisis and economic depression can rouse leading institutions of this nation to clear away the fog of monetarist ideologies we are already as good as finished as a world power.

If we summon our idled agricultural, industrial, and skilled-labor potentials to produce an outflow of capital goods for medium- to long-term high technology development of the productive powers of labor in nations below the Tropic of Cancer, we will find a joyful reception for our policies among those and other nations, as well as a joyful eruption from our farmers, industrialists, and growing masses of unemployed. . . .

Relations with the U.S.S.R.

As to the Soviet Union, in the context of our resurrection of the "American Century" strategic policy, the matter becomes elementary. We say to Moscow: "We are summoning from our idled farms, factories, mines, and labor a power which may stun your powers of imagination. We are creating among our friends in this world a new world economic order, which we call the 'American Century.'
the conceptions of those who designed our Constitution, a world dominated by nations committed to the benefits of technological progress for each and all, arranged through an ordering of our system of credit and commerce to foster this result. Where does the Soviet Union stand with respect to our efforts to lift the hungered nations of the southern portion of our globe out of that heritage of colonialist looting and degradation whose remedy has already been postponed too long?"

These arms negotiations are necessary, but in and of themselves they are almost useless exercises. If the chaos the monetary crises are beginning to unleash is not stopped, we shall go to war whether we presently intend so or not. And, sooner or later, whatever remains of the thermonuclear arsenals of the world will be launched, because no government will know how to stop itself from unloosing them. If we bring the world to order, as the "American Century" implies, then, and only then, does the lessening of the impulse toward war impel nations to spend less on those weapons for which they have no prospective need.

PLASMA PHYSICS

U.S. turning over the lead to Japan

by Steven Bardwell, Military Editor

The most prestigious international plasma physics and fusion science meeting, held in Göteborg, Sweden June 9-15, reflected in a striking way the world economic crisis: the fusion efforts of all countries have dramatically slowed down in the past 18 months, with the single exception of the Japanese, who now boast of the largest, most aggressive, and most engineering-oriented program in the world.

The Soviet program, for a long time the most scientifically sophisticated and creative program, has been totally eclipsed by a military reorientation of Soviet scientific manpower; and the American program, long the leader in engineering and technical development of fusion devices, has slowed its research tremendously, with no new machines having been designed or come on line in the past two years.

Japan and India: the new fusion superpowers?

Contrasting with the downturn in the Soviet and American programs are the world's two newest fusion programs, those of Japan and India.

Four years ago, Japan had essentially no fusion research program. At that point, however, an informal directorate of politicians, scientists, and industrialists proposed a long-range fusion program, which they claimed would play the same role for the 1990s and early 2000s that crucial industries had played in the past (textiles in the 1950s, steel in the 1960s, auto in the 1970s, automation in the 1980s). Fusion, as the lead industry of the 1990s, should become Japan's "energy export" by the year 2000, these leaders proposed.

The result of this group's work was a very rapid acceleration of the Japanese effort; today it is the largest fusion program in the world. The biggest laser in the world devoted to fusion research is in Japan; the Japanese are currently constructing a machine as large as the Princeton tokamak fusion test reactor (TFTR) on the same time scale; they are undertaking experiments in all areas of magnetic confinement (they have both a stellerator and bumpy torus laboratory, unlike the Soviet Union or the United States).

There is no question that the Japanese program lacks the depth in manpower of the present U.S. and Soviet programs; it takes considerably longer than five years to train a significant number of plasma physicists. But, what they lack at the moment in theoretical capabilities they have more than made up for in experimental and engineering finesse.

The Japanese laser fusion program is exemplary. Under the direction of Professor C. Yamanaka at the Osaka University Institute of Laser Engineering, the Japanese have produced three generations of glass lasers in five years. The current laser, the Gekko 12 (of which two arms are complete), is not only the largest existing glass laser in the world, it is larger than any ever constructed (the United States dismantled its large Shiva laser last December in a cost-cutting move). Rather than having been hand-built in the laboratory (as is the usual procedure), the Gekko 12 was contracted out to Hitachi; this strategy of forcing industry to develop technologies and manpower in the most advanced areas is something the Japanese hope to see pay off in 10 years as fusion becomes commercialized. The Gekko 12 laser overcomes many of the engineering limitations of past laboratory lasers: it is highly automated, requiring, according to Yamanaka, only a single operator to align the lasers, position the target, and prepare the diagnostics. It can be fired once an hour, generating three or four times as much data as any previous large laser.

The results that Yamanaka's group presented at the Göteborg meeting were as interesting as the machine itself. In the six months since the first two arms of the laser were put into operation, the Osaka team has generated precise confirmation of past results on wavelength dependence, compression properties, and thermal transport. More interesting, they have investigated a new target design, the "Osaka Cannonball," which has achieved records for compression and absorption efficiencies. The research plan for this machine in the next six months includes research on these exotic targets as well as the so-called direct targets (in which the laser directly interacts with the fuel mixture) and radiation targets (a classified target design in which the laser energy is first converted to X-rays before it interacts with the fuel).

The only other growing fusion program in the world today is in India. One and a half years, ago a group of Indian plasma physicists, working in both India and the United States, drew up a proposal for an Indian plasma physics research program. This proposal, which was strongly lobbied for in India by the U.S.-based Fusion Energy Foundation, received funding this year. It is now the basis for a rapidly growing experimental and theoretical effort. The Indians' traditional strength in mathematical physics has already given them a firm foundation for this research (in many ways a better theoretical foundation than that of the Japanese); and the collaboration of a group of the best experimental plasma physicists ensures that the Indian program will start with the expertise that only long experience can provide. The Indian delegation at the Göteborg meeting was one of the largest, exceeded only by the U.S. and Japanese representation.

Slowdown in the U.S. program

The American nuclear fusion program labored in the shadow of the larger Soviet program until the middle 1970s, when the American program's funding caught up with the Soviet investment, and superior U.S. engineering and industrial capabilities paid off in the rapid construction of a generation of spectacularly successful machines. This generation includes all the large machines now operating in the United States: the Alcator series, which holds the world's record for density of fuel confinement and stability of plasma; the Princeton Large Torus (PLT), which holds the world's record for temperature of plasma achieved in a magnetic confinement machine; and the Impurities Control Experiment (ISX) at Oak Ridge National Laboratory, which has made major advances in scientific understanding of the atomic and radiative processes in a tokamak plasma.

However, funding for the U.S. fusion program has declined steadily since the late 1970s, and stands today at approximately 75 percent of its 1978 value (in real dollars). The combination of Jimmy Carter's opposition to advanced energy research and David Stockman's austerity policies has deprived the U.S. program of any new machines for experimentation in the last two years; has indefinitely deferred the construction of the major non-tokamak machine (the mirror fusion test facility, originally scheduled to be completed in 1984 and now functioning with a continuing delay in construction funds); and has completely destroyed the major engineering research projects (the most important being the Hanford Fusion Materials Irradiation Test). Even more serious, the U.S. laser fusion program has been cut by 40 percent for 1983 alone, with the official policy being that a "civilian laser fusion program" is unnecessary.

The result of this downturn in American-sponsored fusion research in all areas was obvious at the Göteborg meeting, where the U.S. group presented almost no new experimental results in the fusion field. Researchers are in a holding pattern, waiting for construction to be completed on the current generation of larger machines, especially the tokamak fusion test reactor (TFTR) at Princeton, the Mirror Fusion Test Facility (MFTF), and the Nova laser at Livermore Laboratory.

The groups of fusion researchers at Princeton and Brookhaven National Laboratories were responsible for a major new theoretical proposal for fusion development. Although they did not deliver a paper on the subject at the Göteborg meeting, the subject was widely discussed by conference participants informally. This group proposed the use of magnetically polarized fusion fuel (fuel with the magnetic moments, or spins, of the fuel nuclei aligned).

They pointed out that polarized fuel so relaxes the requirements for ignition of fusion that current tokamaks have already reached breakeven conditions for polarized fuel. Estimates by these researchers are that conventional fuels (deuterium and tritium) could be ignited in machines like the PLT, and that larger reactors could be used for the more difficult, but much more benign in engineering terms, cycles using deuterium and helium-three.

This development, still a theoretical insight and requiring experimental tests of its viability in a plasma environment, portends a profound reorientation of plasma engineering. The nuclear properties of the fuel are now opening up the possibilities of a new family of "nuclear-spin technologies."

The only other new results reported by the American researchers were in the exciting new field of astrophysical laboratory plasma physics. This field has come into its own only with the results from the Voyager probes to Saturn and Jupiter:

1) **The reconnection of magnetic field lines.** This process is the dominant physical mechanism responsible for the generation of intense particle beams, intense electric fields, and for shock-wave formation in both solar and stellar and solar system plasmas. For the first time, scientists at the Göteborg meeting reported detailed experimental results on the dynamics of a reconnecting field, both in laboratory simulations, and in measurements from satellite probes. Especially spectacular were the precise measurements of the phenomena made at the University of California by Rainer Stenzel and Robert Gekelman, results which shed much light on the same processes as measured on spatial scales millions of times greater in the magnetosphere of Jupiter.

2) **Generation of plasma radiation.** The richness of wave phenomena in plasmas continues to astound plasma physicists, and the appearance of the same waves in interstellar plasmas, with densities less than one-billionth those of laboratory plasmas, was a striking feature of the experimental results reported at the meeting.

In an introductory lecture on the importance of the new data in astrophysical plasmas, Hannes Alfven, the Nobel Laureate plasma physicist from Sweden, predicted a revolution in astrophysics over the next 10 years, as astrophysicists found out that *most interesting phenomena could only be explained on the basis of plasma physics, rather than gravitational effects or radiation effects.* Alfven said: "The theory of the big bang itself will not withstand the onslaught of plasma physics."

Redirection of the Soviet fusion program

For a long time the Soviet Union has realized the strategic significance of its fusion research program, which has always been conducted in close collaboration with military research and with an eye to its spin-offs in other areas of the economy.

In the early stages of the Soviet program, this symbiotic relationship between the military and civilian fusion programs tremendously benefited the civilian program. Financial and manpower resources that were essentially military in nature were devoted to research in pulsed MHD, beam generation, materials development, and laser technologies in the civilian energy research programs. However, in approximately 1977, a major shift of these resources back into classified military research areas took place. The result for the civilian fusion program has been disastrous.

The priority given to military research by the Soviets for the past five years is felt most intensely in the unavailability of essential advanced technological capabilities. It is *not,* as some observers would like to believe, that the Soviets are unable to manufacture the computers, the automated control systems, or the sophisticated diagnostics required for fusion research.

Rather, their relatively sparse industrial elaboration means that these technologies are available only on a small scale, and this limited capability is devoted to military applications rather than fusion research. As one Soviet physicist pointed out in a private conversation, "With the new generation of big machines now being constructed, the Soviet Union is at a real disadvantage because industry cannot supply technologically advanced components to both the military and the fusion program." At this point, it is the fusion program that takes second place.

The results presented by the Soviet groups at the conference were confined largely to reports from their broad small laboratory program and theoretical results from their prestigious mathematical physics institutes. However, the lack of an aggressive engineering-directed program has had a major affect on the vitality and dynamism of these "scientific" programs. The research reported at the Göteborg meeting by the Soviet groups which had been the world's leaders in theoretical plasma physics was, for this reason, quite disappointing. The results were not new, and to this observer, they lacked the spark of originality which has in the past characterized the Soviet contribution.