spread recognition that ambiguities in the treaty language facilitate such claims. Warnke, for example, says that he is "troubled because the SS25 obviously pushes the treaty pretty hard. The provision is not a masterpiece of clarity, however." Similarly, Spurgeon Keeny, director of the Arms Control Association, believes that "it's not a definitive case." And Turner also says that he is "skeptical—it's simply not that precise."

Thus far, the Reagan Administration has demanded only that the SS25 tests be stopped until the dispute can be resolved through negotiation, a demand that the Soviets have obviously ignored. Beyond this, various parts of the bureaucracy have been unable to come to an agreement. Ironically, at the Pentagon, where the violations have been bitterly denounced, many officials actually favor deployment of the SS25, so long as the United States can test and deploy a prohibited new missile of its own in response, the single-warhead Midgetman.

In addition, there is now a fairly broad consensus in Washington that small missiles of the SS25 type may actually increase global stability, because they threaten fewer military assets and present a somewhat less inviting target. As President Reagan's special Commission on Strategic Forces concluded in April 1983, "over the long run, stability would be fostered by a dual approach toward arms control and ICBM deployments which moves toward encouraging small, single-warhead ICBMs."

Mark Crawford, formerly a correspondent with *Business Week* and other McGraw-Hill publications, has joined the News and Comment staff of *Science*.

At his most recent press conference, Reagan indicated that a final decision on U.S. abrogation of SALT II would be delayed until the U.S.S. *Alaska* is ready to embark. Earlier, he had promised that the United States would continue to respect the treaty, only to be corrected by some of his appointees at the State Department, who said that any decision would hinge in part on a willingness by the Soviets to accede to U.S. demands in the ongoing Geneva arms talks.

Some officials doubt that the prospect of continued compliance with SALT II will offer much bargaining leverage, however. They believe that the Soviet Union has more to gain if the treaty is abandoned, because it could pack additional warheads atop existing missiles, and deploy a fleet of new Soviet submarines, hundreds of new long-range cruise missiles, and several additional types of land-based missiles, all without retiring existing strategic weapons. The officials also argue that such a decision would outrage U.S. allies. This view is also taken by much of the arms control community—even by those who concede that Soviet behavior has exposed significant defects in SALT II.

It is, in short, one of Washington's most unusual arms control debates. On one side are those who fault the treaty overall, yet firmly believe that two of its key provisions are clear enough to sustain a public claim of Soviet cheating. They want the treaty scrapped. On the other side are those who drafted the treaty and continue to support it, yet firmly believe that the provisions at issue are inherently defective. A reasonable middle ground is that both sides should work to repair the defects, and then continue to respect its limitations. But this is highly improbable, given the generally poor climate engendered by the cheating allegations and the small chance that Reagan would eventually submit even an amended version of the treaty to the Senate for ratification. No real progress is likely for some time.

—R. JEFFREY SMITH

This is the third in a series of articles on United States–Soviet treaty compliance. The next will examine additional allegations of Soviet treaty violations.

Japan and the Economics of Invention

A meeting on innovation was dominated by discussion of how the United States can shore up its international competitiveness

Palo Alto, California. Two hundred business and academic leaders got together at Stanford University last month for a conference on the economics of invention.* That was the official topic, but unofficially, the subject became Japan.

The business speakers came from companies that use a lot of basic research and from investment firms that channel money into high-risk ventures. They talked about inventiveness and worried about Japan's success in high-tech fields. The electronics executives were especially edgy, as many seemed to be searching for survival strategies. Not so long ago they would have been worried about keeping up with clients' orders.

A few speakers argued that competitors like Japan are not to be feared or, in any case, not to be prevented from joining the game. According to this view—articulated by Harvey Brooks, professor of technology and public policy at Harvard—America should avoid seeing the competition as a zero-sum game in which one player's gain is another's loss. Rather, America should welcome an expanding market for high-technology goods and should expect to benefit.

Gordon Moore, founder and now chairman of Intel, the silicon chip maker, warned that high-tech industries will find "no salvation" from foreign competition. "In electronics," he said, "the U.S. trade with Japan last year was minus $15 billion. . . . Our electronic trade deficit with Japan is greater than our automotive trade deficit . . . and it is projected to grow to minus $20 billion this year. Even in leading-edge semiconductor technologies, the balance of trade turned negative in 1980 and was $800 million negative last year. It is increasing rapidly in that direction." He added that electronics manufacturing is "going offshore" (especially to Asia) at an "extremely rapid pace," and that technological leadership will probably go with it.

Stanford economist Masahiko Aoki predicted that Japan will become "the largest capital exporter in the rest of the 1980's." Japan exported $50 billion in 1984 alone and invested $6 billion in U.S. common stock and factories. Aoki re-

*"Symposium on Economics and Technology," 17–19 March 1985, sponsored by the National Academy of Engineering, the Center for Economic Policy Research, and the Departments of Chemistry and Chemical Engineering at Stanford.

Government R&D expenditure by fields (1980). [Source: Gary Saxonhouse and Daniel Okimoto]

	United States	Japan	France
Defense and aerospace	47.3 percent	16.3 percent	49.3 percent
Industry	0.3 percent	12.2 percent	7.9 percent
Agriculture	2.7 percent	25.4 percent	4.3 percent
Energy and infrastructure	14.2 percent	34.4 percent	16.0 percent
Health and welfare	15.2 percent	11.2 percent	7.5 percent

ported that there are 1600 subsidiaries of Japanese firms in Los Angeles County, increasing so far this year at the rate of about one a day.

Imports and investments are pouring into the United States because the U.S. dollar has a high relative value in currency trading. This gives U.S. buyers strong purchasing power and attracts transient capital to the United States. Several speakers bemoaned the federal budget deficit in this connection, saying that debt raises federal borrowing, which raises interest rates, which draws foreign investments. This web of relationships supports the economy, but in a precarious way, making it dependent on debt financing from overseas.

However, those who were adamant about the need to cut the federal deficit neglected to say how or where it should be cut. This may have been a tactful omission, in that many of the companies at the meeting have fed on the recent growth in the military budget.

No one suggested that Japan's success can be explained solely in tariff or financial terms. Japanese businesses have learned to develop novel process technologies, enabling them to make better use of materials. They have become good salesmen in widely different markets. And in the 1980's, they have become innovators in their own right, competing with America on what once seemed exclusively Western turf. Several speakers, including Brooks, said that Europe will probably end up a distant third in the high-tech competition of the next decade.

One of the organizers of the meeting, Stanford economist Nathan Rosenberg, spoke about different patterns of innovation and the ways they are perceived. Japan has excelled at the applied sciences. Rosenberg's coauthor in this paper, Stanford mechanical engineering professor Stephen Kline, called this "rejuggling what already exists." Corporations like IBM, AT&T, and Kodak have learned to compartmentalize this kind of inventiveness.

Another kind of innovation creates "technological discontinuity" and arises with the discovery of new facts about nature. These inventions bring about sharp breaks with the past and involve the type of innovation at which America excels—the "revolutionary" kind, Rosenberg and Kline call it. Recent examples are the development of silicon chip electronics, lasers, and recombinant DNA pharmacology. Discoveries of this type are hard to monopolize.

But Rosenberg and Kline say that the popular view, which sees innovation as something that begins in the realm of science and moves through engineering and marketing, is naive. "Contrary to much common wisdom, the initiating step in most innovations is not research, but is rather a design." The creative process does not flow in one direction but involves both engineering and theory in a repetitive testing of ideas, always centered on a model. There must be a steady flow of information from the basic researchers to the designers and back.

U.S. policy since World War II has rested on what Rosenberg and Kline see as an oversimplified belief that research leads to development, development to products, and products to a fat GNP. The Carter and Reagan administrations invested billions of dollars in basic research, not for the sake of knowledge but in the hope it would improve national productivity. This may do wonders for science, but not so much for the economy.

There is "little doubt about the continuing excellence of the U.S. performance in basic science," said Harvey Brooks, but "our performance in applied science and in the commercialization of new knowledge is much more in question." He mentioned that the share of U.S. R&D-intensive manufactured goods in world trade dropped from 31 to 21 percent from 1962 to 1977, while Japan's share rose from 5 to 14 percent.

Brooks pointed to another sign of the weakening technological infrastructure in America. The U.S. machine tool industry has lost "half of its traditional market" in the last 5 years, he said, and during the same period, "over 50 percent of all machine tools purchased in the United States were manufactured abroad, mainly in Japan and to a lesser extent in West Germany." The message in this and other talks on America's applied sciences was that they deserve more respect and more money.

Ironically, while these experts would like to have more and better engineering, the Japanese are trying to break out of the engineering mold and do more basic science. Daniel Okimoto, a political science professor at Stanford, described the steps the Japanese government has taken since 1980 to boost research and encourage technological creativity.

Until now, Japan has had a very small venture-capital market. The government has begun to deregulate the financial system to promote high-risk private investments. It is "doing all it can to push Japan beyond the frontiers of technology by organizing a variety of ambitious national research projects in such seminal areas as new materials and optoelectronics," Okimoto said. It has increased government support for R&D and may reach a spending level of 3 percent of GNP by the 1990's. Most important, Japan has begun a general curriculum reform to reduce the emphasis on rote learning and encourage "creative synthesis" throughout the educational system.

Okimoto thinks that Japan's system of "targeting" special industries for fast development should not be seen as supercompetitive, but as compensation for the lack of venture capital and absence of a military procurement budget. Okimoto predicted that Japan will have to become more innovative, if only to stay ahead of the "new Japans"—Singapore, Taiwan, and South Korea.

Conferences such as this abound in gloomy forecasts. However, despite the air of foreboding, a few speakers conceded that the news for the United States was not all bad. They seemed to agree that the key to American inventiveness—particularly in California's silicon valley—is inventors' access to money. The relaxation of capital gains taxes under Carter in 1978 and again under Reagan in 1981 opened up a trickle that has now become a flood of speculative investment. William Perry, the former chief of R&D in Carter's Defense Department, now an officer of the investment firm of Hambrecht and Quist, said that high-risk capital invested in 1984 amounted to $4 billion.

Foreign manufacturers of high technology are clearly catching up with the Americans, perhaps at an alarming rate for the companies that will feel the heat. But there is every reason to think that new companies are being born in the United States at an equally impressive rate, and that they will bring with them unanticipated technological revolutions.—**ELIOT MARSHALL**