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Senate

By Mr. TSONGAS (for himself, Mr. RIEGLE, and Mr. GORTON):

S. 428. A bill to provide for a study on economically strategic technologies and to identify and provide for the development of such technologies; to the Committee on Commerce, Science, and Transportation.

ECONOMICALLY STRATEGIC INDUSTRIAL RESEARCH AND DEVELOPMENT ACT

Mr. TSONGAS. Mr. President, today I introduce a bill that has application to the high technology industry, which is receiving more and more attention. It is referred to as the Economic Strategy Industrial Research and Development Act. I apologize for the title, but we could not do any better. I introduce it on behalf of myself and Senators RIEGLE and GORTON.

Mr. President, this Nation's technological capability has been the key to our economic progress in recent times. Today our continued progress and long-term economic health are in danger. Those of you who remember the story of the grasshopper and the ants should understand why the United States must act now to keep its high technology industry healthy. As you may recall, the ants worked long and hard preparing for the winter. Meanwhile, the grasshopper loafed along, enjoying the good life. When the winter arrived, the ants were ready for it. But the grasshopper found himself out in the cold, hungry and shivering, and depending on the ants' charity for survival.

Today, the Japanese and Europeans are the ants, and we risk becoming the grasshopper. Our auto and steel industries are hurting badly. These once formidable American industries have lost their competitive edge to Japan. This state of affairs is no mere happenstance. For years, the Japanese have been developing their heavy industry as part of a deliberate national strategy. The same thing is true of consumer goods—televisions, radios, cameras, and so on—all markets that the Japanese have captured so devastatingly.

I would guess that 95 percent of the cameras that are precluded from entering this Chamber were built in Japan.

The next arena is high technology. Technology is important as a source of future markets and as a means to turn around basic industry. The Japanese, the French, and many other industrialized nations are vigorously challenging U.S. dominance in high technology markets. They are pooling vast government and industry resources in targeted technology development programs to build new high-tech industries in computers, robotics, fiberoptics, biotechnology, and others.

Yesterday, I was in New York, at a conference sponsored by the Carnegie Foundation, which was looking at the issue of how you get the United States to begin worrying about its competitiveness in high technology. I must say that even though there is a lack of serious movement in Congress, I think the critical mass of concern in the countryside has finally been achieved.

While the competition from abroad intensifies, we have been reducing an already insufficient level of Federal support for industrial R&D here at home. Japan is planning to increase the percentage of its GNP spent on R&D from 1.94 percent in 1974 to 3 percent by 1990. In France, the figure was 2 percent in 1981, but it plans to reach 2.5 percent in 1985. In the United States, our percentage of GNP spent on R&D has dropped from 3.1 percent in 1965 to 2.45 percent today. But only 1.66 percent of our GNP is spent on civilian R&D. In order to reduce current deficits, the administration cut nondefense R&D almost 20 percent in the last 2 years. It does not take much to conclude that the Japanese are going one way and we are going the other.

An American Associate for the Advancement of Science projects a drop of 25 percent in constant dollars between fiscal years 1983 and 1987. The fiscal year 1983 budget called for $624 million in cuts in domestic research and development funding. And this year, in spite of recognition of the needs of hi-tech in his state of the Union address and calls for expanded NSF spending, the President is requesting additional cuts of $123 million overall.

These developments are a matter of concern for the entire economy. They threaten the vitality of our high technology industries and limit the capacity of our basic industries to innovate and improve productivity.

Today I am introducing legislation that would lead to a course of action for meeting these new challenges. Our proposal calls upon the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine to draw upon the expertise of their members, representing both private industry and academics, to identify economically strategic technologies. These are technologies which offer great potential economic benefit, but whose development is endangered by the targeted R&D efforts of our competitors.

For each economically strategic technology, a technology development program would be recommended. Such a program would identify the industry, university and government resources necessary to maximize the potential for successful development of a particular technology. In effect, the legislation would produce an appropriate partnership for development of each targeted technology.

The bill also would provide budgetary authority so the President could implement recommended technology development programs quickly.

This legislation would achieve several purposes:

First, it would maximize the role of the private and academic research community, the people closest to the problem. This bill is not an effort to substitute a government decision for that of the marketplace. It is an effort to survey the marketplace and take stock of where we stand. With this knowledge in hand, this group will be ideally situated to recommend an implementation program for the designated technologies that will work.

Second, it would pool the best available data on R&D efforts here and abroad and provide the most comprehensive comparative analysis anywhere of those efforts.

Third, it would emphasize the importance of international competitive strategy in assessing the potential of technology development programs. Such an approach looks at the competitive forces surrounding individual industries and develops an approach that best exploits our own comparative advantages. This bill uses a case-by-case approach for each designated strategic technology, thus avoiding the difficulties of trying to fashion a single government program that would respond to such varied industrial circumstances.

Fourth, it would provide a forum for assessing the best mix of public and private investment to maximize the potential for successful technological development. This feature would further the important goal of developing government-business partnerships to face economic challenges. This avoids a new bureaucracy. It utilizes existing institutions to begin a process that will both build a consensus on where our efforts should be concentrated, and develop workable implementation programs.

Fifth, by increasing the authorization for nondefense research and development funding, the bill would enhance our capacity to implement specific technology development programs quickly while still maintaining congressional and administration oversight.

Industry resources will be identified and the areas where additional effort is necessary pinpointed. Educational institutions can be called on to provide essential laboratory facilities or trained personnel. Government may be required to provide additional R&D funding through one of many existing nondefense industrial R&D programs. The technology development programs may also call for new tax treatment, purchasing procedures, or some other form of policy action. Emphasis on the technology development program will be on what works best.

Most important, this legislation would signal that our country has every intention of exercising technological leadership in the rapidly changing global economy of the future. Clearly, this legislation is badly needed. Consider the case of the GTE laboratories in Waltham, Mass. GTE has been a leading developer of new ceramic technologies that could give birth to a new generation of vehicle engines with higher efficiency and great fuel-saving capability. The United States has been a leader in the development of this technology, with the efforts of private industry supplemented by the research of the Department of Energy and the National Aeronautics and Space Administration.

But the administration has proposed major cutbacks in these Government programs. The timing could not be worse. Japan's Ministry of International Trade and Industry is launching a 10-year, $60 million program in concert with 15 companies that target ceramics R&D as a top national priority.

This story is being repeated in one technological field after another as a result of the estimated 25-percent reduction in civilian R&D advocated by the administration. In the burgeoning industries of robotics, fifth generation computers and biotechnology, among others, we are in danger of forfeiting tremendous technological advantages that could cost our economy greatly. The Japanese have mounted a $500 million alliance between government and industry for developing a fifth-generation computer. Most knowledgeable observers estimate that the Japanese are spending from 3 to 10 times as much as the United States on robotics and related research. The examples go on and on.

I would also like to note that Representative GEORGE BROWN, distinguished member of the House Committee on Science and Technology, today has introduced this bill in the House of Representatives as well. His leadership along with other colleagues in the House, together with our efforts in this Chamber can insure that we take action in this session of Congress to take a big step forward on the path to regaining our technological edge.

Mr. President, to conclude, I ask unanimous consent that several articles adding further documentation on the need for this legislation be printed in the RECORD as well as the bill and a section-by-section analysis of this legislation.

There being no objection, the material was ordered to be printed in the RECORD, as follows:

[From the Los Angeles Times, Oct. 31, 1982]

THE US' BACKSLIDE IN R&D

(By Louis B. Fleming)

Slipping investments in civilian research and development are placing in jeopardy the economic strength and would competitiveness of the United States.

That is the view of many experts in the scientific, engineering and business communities.

"We're laying the groundwork for inferiority," according to Simon Ramo, a founder of TRW Inc. "We are still the strongest in the world, but the margins are slipping."

Paradoxically, the risk is rising at the same time that overall investment in research and development has reached record levels.

"The Reagan Administration is committed to maintaining the world's strongest scientific and technological base," according to the President's science adviser, George A. Keyworth 2d.

That commitment is being backed in the fiscal year that began Oct. 1 with an unprecedented $43 billion in federal funds for research and development, an increase of almost 11 percent over the previous year. That includes $5.8 billion for basic research, an increase of 9 percent. Moreover, since 1980, industry has outspent government for R&D.

Total spending by all sectors in the current fiscal year almost certainly will surpass $80 billion, up from a National Science Foundation estimate of $77.3 billion for the preceding year.

But behind the record figures are facts that have raised concern rather than euphoria:

Federal money, which pays for close to 70 percent of all basic research, is being shifted away from the civilian section with 57 percent of the total R&D money targeted for defense work this year. The American Association for the Advancement of Science has estimated that non defense R&D federal funding will "drop at most 25 percent in constant dollars from fiscal year 1983 to 1987" under the most favorable circumstances.

Industry has focused its R&D funding on short-term, product-oriented work with less than 5 percent going to long-term, basic research, a situation that is improving only slowly, according to Solomon L. Buchsbaum, an executive vice president of Bell Laboratories, the research arm of American Telephone & Telegraph Co.

The United States is lagging in the vitally related area of translating discovery into useful product, a failure that has focused new interest on improving the long-neglected technology of manufacturing engineering.

Most experts agree that the worst is yet to come.

"It is clear to us that nowhere nearly enough is being spent on research and development," commented Norman A. Robins, referring to one of the oldest industries, steelmaking. He is chairman of the research committee of the American Iron & Steel Institute and vice president for research of Inland Steel Co.

American steel companies are buying more and more of their technology overseas, he said.

In robotics, a rapidly growing new industry aimed at improving manufacturing productivity, research also is lagging, according to Roger N. Nagel, chairman of research and development for Robotics International, the professional organization. He is also director of Lehigh University's new robotics institute.

"In mechanical systems, we are not doing as much as we could," he said. "In sensors and complex controls, we are on a par with or ahead of the world, although in some cases we are doing more talking where they do more action," he added, calling particular attention to national R&D programs in France, West Germany and Japan.

If the worst lies ahead, there also are signs of slippage now.

Foreign inventors are accounting for a rising share of patents filed with the U.S. Patent and Trademarks Office, 39 percent in 1981 against 26 percent in 1970. Japan accounts for almost one-third of the foreign patents, according to one study.

Seven of 11 antibiotics developed in 1979 were of Japanese origin. By contrast, pharmaceutical research in the United States has dwindled in recent years from two-thirds of the major world research to one-third, according to the working group on high-technology industries of the Cabinet Council on Commerce and Trade.

Furthermore, impressive as the dollar investment may appear, it represents a declining investment in R&D when measured as a percentage of gross national product, members of Congress were reminded earlier this year by Nobel laureate Torsten Nils Wiesel, chairman of the department of psychiatry at the Harvard Medical School.

Funding fell from 2.94 percent of GNP in 1964 to 2.27 percent in 1981 at the same time that the funding in Germany and Japan was, on the same basis, increasing.

"The obsession with short-term payoff," according to Marvin L. Goldberger, president of the California Institute of Technology, "is what is ruining the country."

"The Japanese have honed production techniques, neglecting their R&D, and making much use of American patents and licenses in some areas," another industrial laboratory expert commented.

Part of the problem is a shortage of engineers.

"The shortage is forcing the industry to focus on short-term issues rather than investing in long-term programs," Robert Henderson, president of Itek Corp. in Lexington, Mass., testified in Congress.

"As a result, we are experiencing a narrowing of the technology gap between the United States and its industrial competitors. This is leading to our inability to maintain export markets, as well as increasing the flow of high-technology products into the United States. At a higher level, it raises questions about our ability to maintain a superior technology position for the defense of this country."

"Business can't take advantage of new developments unless it has people on its staff who understand," Buchsbaum of Bell Laboratories said. "If you don't invest in research you can't take advantage of new developments."

There also is a growing appreciation that the United States has been neglecting a critical element of productivity, namely, manufacturing engineering, according to Branscomb at IBM.

IBM recently announced $50 million in equipment and cash grants to universities to try to correct this neglect. Westinghouse gives $1 million a year to the Robotics Institute at Carnegie-Mellon University in Pittsburgh. Lehigh University in Bethlehem, Pa., opened its own robotics laboratory in September.

"If you have really high technology in the factory organization, the engineer in the factory will look at what is being invented and be able to say how it can be put to use," Branscomb explained.

"There's enormous pressure to use R&D to improve productivity to take cost out of manufacturing," said W. Dale Compton, vice president for research of Ford Motor Co.

For American companies in high technology, past investments in R&D appear to have played an important role in current profits. Thus, many try to allocate a certain portion of revenue from existing products to research efforts that they hope will yield new products in the future.

Bell Laboratories put 10 percent of its money into basic research. IBM is investing $1.8 billion in R&D this year, 10 percent of it in the research division for fundamental and long-range work.

[From Business Week, Sept. 21, 1981]

New Ceramics That Can Take on Tougher Jobs

The intensifying search for replacements for strategic metals, which are either dwindling in supply or rising in price, or both, is bringing an age-old class of materials into new prominence. Ceramics—made essentially of silica, a ubiquitous sustance that constitutes 90% of the earth's crust—are undergoing a metamorphosis that promises to make them lighter, stronger, and more heat-resistant than many metals.

Until recently ceramics were limited to simple applications—bathroom fixtures, pottery, and cement, among other—because their normally brittle nature makes them susceptible to fracture when subjected to stress. But researchers around the world are now learning how to modify the natural properties of ceramics and made silica combinations that do not occur in nature. These new compounds, in conjunction with new molding techniques, are transforming what once were relatively undistinguished substances into high-performance materials. "Ceramics is becoming much more of a science," says Pellegrino Papa, technical manager of Corning Glass workes' Ceramics Products Div.

Industry is anticipating a windfall of new materials for products ranging from energy-efficient auto and aircraft engines to heat exchanges and ball bearings. "Hardly anyone was interested" in ceramics 10 years ago, recalls Roger R. Willis, manager of Batelle Columbus Laboratores' ceramics and materials processing section. "But there are a heck of a lot of people interested now."

The market for ceramic engine components alone would total $10 billion, says James I. Mueller, professor of ceramic engineering at the University of Washington and president of the American Ceramics Society. Demand for industrial heat exchangers, one of the first commercial applications of the new generation of ceramics, is expected to be equally attractive. "The potential is staffering," says Kent H. Kohnken, ceramic product manager at GTE Products Corp.'s Sylvania Chemical & Metallurgical Div., in Towanda, Pa.

Bad strategy

"If we don't get that business," warns Mueller, "somebody else will"—because a global race to develop alternative materials is clearly brewing. "It is obvious that we are going to deplete [metal deposits] in the earth's crust," says Glenn W. Brown, chief of research and development for Garrett Corp.'s Torrance (Calif.) AiResearch Casting Co. So the fact that ceramics are as common as sand makes them almost inexhaustible. "It is very attractive to be able to dig a hole and make a ceramic," says George W. Weiner, manager of the Energy Systems Div. at Westinghouse Electric Corp.

Much to the chagrin of researchers, the Reagan Administration seems bent on squandering the impressive lead that the U.S. has acquired in industrial ceramics. The Administration is tightening the purse strings on nondefense ceramics R&D precisely when other countries are pouring funds into these areas to establish future positions.

Japan, for example, is targeting ceramics development as a major national goal. "Japan is behind other countries because of a lack of government spending" up to now, says Yasukatsu Miyoshi, a technical official in the Ministry of International Trade & Industry's Ceramics Div. So, in October, MITI will launch a 10-year ceramics R&D program under which it will distribute $60 million in subsidies to a consortium of 15 participating companies.

Already, there are early signs that the U.S. is losing momentum, KBI, formerly Kawecki Berylco Industries, pulled out of ceramics R&D last year after being acquired by Cabot Corp. The company had been developing a new ceramic compound but backed off, explains a KBI executive, because "there was more development work necessary than we were prepared for." And Norton Co., a leading ceramics maker, is diverting funds from gasoline turbine engine research to more "commercially viable," short-term applications, such as pump seals for the chemical industry.

High resistance

However, other major U.S. ceramics producers—Carborundum, Corning, and GTE—remain vitally interested in the long-term potential for so-called engineered ceramics. This is actually a family of materials including silicon carbide, silicon nitride, and amalgams of zirconia and magnesia—compounds that generally do not occur in nature and which exhibit high strength and heat-resistant properties.

The term "ceramics" encompasses an array of substances. The National Academy of Sciences broadly defines them as "inorganic, nonmetallic materials processed or consolidated at high temperatures," usually comprising natural silicons or silicon-oxygen-metal compounds fused together with oxides. The definition takes in everything from cement to dinnerware and plate glass.

Up to the time, much of Japan's work has been centered on alumina compounds. These are the most common of the new ceramics, but they are more brittle than the latest engineered grades. Many have already been commercialized in products ranging from semiconductor packages to electronic filters and sensors. For example, Murata Manufacturing Co., in Kyoto, is developing tiny piexoelectric ceramic speakers; because these speakers do not need an amplifier, Murata expects to sell them for use in telephone receivers and computer-controlled synthetic-voice output devices. And nearby Kyoto Ceramic Co. is perfecting single-crystal "bioceramics" for use as bone implants and artificial teeth.

Fuel saving

But Japan is now beginning to focus on the new engineering ceramics. These materials can be so heat-resistant, compared to the strongest superalloys, but engine parts made from such ceramics can run several hundred degrees hotter—up to 2,500F. Not only does this reduce the need for costly and cumbersome cooling equipment, but it dramatically improves fuel efficiency (page 42J). Japanese government planners think that this could eventually mean a 3% decrease in Japan's annual petroleum consumption, worth $1.6 billion at today's prices.

The U.S. Energy Dept. is just as optimistic. Officials there point out that if an engine runs more efficiently, it also produces less exhaust emissions. And because the new ceramics weigh about one-third as much as the superalloy metals used for aircraft and missile engines—primarily cobalt and nickel-based steels—they are especially suited for aerospace applications.

Heat resistance obviously is a major selling point for ceramic heat exchangers. The Energy Dept. is so excited about the potential that it is pumping $1 million into a Technology Acceleration Program to promote ceramic recuperators for high-temperature furnaces, particularly in the metals industries. Users can get the units—developed by GTE Sylvania with Energy funding—for free. In return, they must pay for installation and auxiliary equipment and promise to monitor energy consumption under controlled conditions for six months.

More than 100 of the recuperators will soon be installed on 30 furnaces. Data for the first unit in operation point to a total 60% energy savings, 40% of which is directly attributable to the use of ceramics—in this case cordierite, a blend of magnesia, alumina, and silica. "So far," says an official at an independent agency monitoring the use of the devices, "they look real promising."

The honeycomb-like recuperators recover heat from furnace exhausts and use this energy to preheat the combustion air flowing into the furnace, thus improving combustion efficiency. Cordierite is an ideal material for heat exchangers because it has outstanding thermal-shock properties; the material can be heated red-hot and then cooled suddenly without danger of fracture.

Pioneer

Hague International, of Portland, Me., began selling huge silicon-carbide recuperators four years ago. Its systems can handle up to 1 billion Btu, compared with only 2 million Btu for the GTE Sylvania model that Energy is promoting. Hague President Paul G. LaHaye points out that a key advantage of ceramics is their ability to withstand the corrosive attack of such substances as the alkalis and ash given off by burning coal and wood chips.

Overseas companies are beginning to exploit the high-strength, wear-resistant properties of the new ceramics, too. Germany's Annawerk Karamische Betriebe and Rosenthal Glas & Porzellan are already turning out silicon-carbide and silicon-nitride ball bearings and drill sleeves. At least three companies in Japan—Asahi Glass, Toshiba, and NGK Spark Plug Co.—are selling similar items. While Asahi Glass sold just over $500,000 worth of engineered ceramic products last year, it hopes to triple sales this year.

A host of other products are in the works as well. Examples:

Bell Helicopter Textron is experimenting with ceramic roller bearings for helicopter rotors.

For straining impurities from molten metal, Corning has developed ceramic filters able to withstand temperatures up to 3,000F.

Westinghouse is working on a high-temperature fuel cell that will convert hydrogen—from methane or coal gas—into electricity at 60% efficiency. By comparison, the best conventional generators operate at about 35% efficiency.

For ceramics to live up to their full potential, though, a number of problems must first be overcome. "Ceramics are like a wedding," quips Ludvik F. Koci, general director of engineering at General Motors Corp.'s Detroit Diesel Allison Div., which is working on ceramic truck and car engines. "Everyone has a lot of bated breath because of what it promises, but there is a hell of a long way to go."

Fractures

A traditional weakness of industrial ceramics has been their poor tolerance to thermal shock. In many processes, heat is not uniformly distributed or fluctuates over time. Equipment exposed to such conditions alternatively expands and contracts, creating stress that can cause a component to fracture. Scientists are licking that problem by formulating new ceramics with "low thermal expansion" characteristics. These compounds include silicon carbide, silicon nitride, and cordierite.

Brittleness, however, still remains a problem. "Metal will bend or distort before it fails," notes Brown of Garrett, another company that is experimenting with ceramic engines for autos and aircraft. "But ceramics do not bend very well." At United Technologies Corp.'s Research Center, scientists are working to make ceramics tougher by blending in fibers—of graphite, silicon carbide, and alumina—to form reinforced, or composite, ceramics, much like fiber-reinforced plastics. So much work is being done to perfect the new materials that eventually, says AiResearch's Brown, "We will end up with several alloys in ceramics—very similar to the alloys you have today in supermetals."

One key point of research, therefore is, aimed at determining which ceramics will behave best in a specific environment. At Battelle Memorial Institute in Columbus, researchers are trying to get a fix on ceramics' fracture process in order to develop equations that will allow them to predict with some consistency just how a material will perform in a given situation.

While considerable progress has been made in evolving a science of ceramics materials, the production and fabrication of ceramics remain almost as much art as science. Norton's Alliegro contends that the focus of ceramics research this decade will shift to processing techniques. With various compounds identified, he notes, "now it is a question of how you make them economically."

Complex shapes

Sintering is one method that will play a major role in fabrication. A type of baking technique borrowed from powder metallurgy, sintering can create large and complex shapes. The goal is to come as close as possible to the "near net shape," or final form, during fabrication. This reduces the subsequent machining and grinding required.

All the major U.S. ceramics companies are striving to perfect the sintering process. In Japan, Asahi Glass claims it is among the first to develop a commercial technique in which ceramic powder is shaped and sintered under little more than normal atmospheric pressure. As a result, the company asserts the process is substantially faster than conventional sintering operations, which typically required several hours of processing at pressures up to 1,400 psi.

Another promising technique is injection molding, already being used to produce heat exchanger components, among other items. As with sintering, it offers the advantage of cutting down on expensive machining requirements.

By most people's reckoning, ceramics R&D will continue at a fast clip—especially outside the U.S. And if the future is anything like the recent past, the progress will be remarkable. "In the last two years," says Paul V. Lombardi, director of the Energy Dept.'s Automotive Technology Div., "the state of technology has doubled from what was done in the previous eight years." But some U.S. businessmen worry that cutbacks now in federal support will translate a few years hence into a situation where the U.S. lead in ceramics technology will be slipping into overseas hands.

A RACE TO PUT CERAMICS IN CARS

The biggest foreseeable payoff from industrial ceramics will be in engines, where the materials' heat resistance will allow engines to run hotter, boosting efficiency by as much as one-third. This promise of dramatic fuel savings, along with such auxiliary benefits as cleaner emissions and greater durability, is spawning aggressive ceramic-engine research and development programs around the world. Most of the spending is for development of key ceramics parts for turbine engines. Such powerplants eliminate pistons in favor of jet-engine principles. Experts believe that turbine engines will be used in stationary applications—driving pumps and generators—by the end of this decade and in trucks and autos by the early 1990s.

All the major industrialized nations are racing to get in on the action. The U.S., the world's acknowledged leader in ceramics technology, got an early start with turbine-type engines. The first projects got under way during World War II, after intelligence reports from Germany warned that the Nazis were experimenting with ceramic components for a remarkable new type of aircraft engine—the jet. Interest was rekindled in the early 1970s, when the world woke up to the coming petroleum shortage. Since then Washington has committed $85 million for ceramics R&D.

But the Reagan Administration's determination to cut back some programs and eliminate others could jeopardize America's first-place standing. If Reagan has his way, Washington will stop funding joint government-industry programs aimed at developing commercial products—such as auto engines and heat exchangers—and focus instead on basic research and Defense Dept. applications. "We will have to make major changes in our philosophy," says Paul V. Lombardi, director of the Energy Dept.'s Automotive Technology Div.

Government support

Congress prefers more modest trimming, so the probable outcome will be a compromise when House-Senate conferees meet later this month. Whatever the level of the cuts, the prevailing mood in Washington gives many ceramic proponents the jitters, because the pruning comes at a time when other governments, especially the Japanese, are throwing more muscle than ever into helping industry search for new ceramic products.

Japan's Ministry of International Trade & Industry (MITI) is launching a 10-year, $60 million program in concert with 15 companies that targets ceramics R&D as a top national priority. MITI's planners make no bones about their goal. They intend to catch up to and surpass the U.S. "Generally speaking, the U.S. is far ahead of us," laments Shougo Shimuzu, chief engineer at Toshiba Corp.'s Metal Products Div. "There has been much more money for research."

Even before Japan stamped "priority" on ceramics research, the country had recognized the potential of the materials. Under a six-year project started in 1978, MITI's Agency of Natural Resources & Energy is spending about $100 million on development of a new power-generating turbine, some $9 million of which is earmarked especially for ceramics R&D.

In the U.S., the biggest projects are pointed at a radically new type of jetlike engine for cars and trucks. For decades, U.S. auto and truck makers have been interested in the turbine's potential for quiet, vibration-free, low-maintenance performance. As early as 10 years ago, some even thought it was ready for commercial use. But then fuel economy began to emerge as a key issue, and the turbine engines available then—built entirely of metals—could not begin to compete with diesels on this score.

Enter ceramics, which will allow gas turbines to operate at temperatures so high that their efficiency will approach that of diesels. Conventional "hot parts" made of metal superalloys can operate at temperatures up to only 1,900F—and then only with the help of costly, heavy cooling systems that reduce performance. The new industrial ceramics—including silicon carbide, silicon nitride, and compounds of zirconia, alumina, and magnesia—can run at about 2,500F and do not need such cooling gear.

Teaming up

Four major government-aided turbine engine programs are under way in the U.S. under the three-year-old Ceramic Applications in Turbine Engines (CATE) project funded by the Energy Dept. and managed by the National Aeronautics & Space Administration. CATE, which is slanted toward development of 300- to 400-hp. engines for heavy-duty vehicles, has even channeled funds from Washington to such foreign companies as Annawerk and Rosenthal in Germany and Toshiba and Kyoto Ceramics in Japan.

Energy and NASA have also teamed up with the three major U.S. auto companies in separate advanced gas turbine (AGT) projects to develop prototype car engines by 1985. These programs aim to create a 100-hp. engine that will deliver 42.5 mpg with a 3,000-lb. auto similar to the Ford Fairmont or Pontiac Phoenix.

Unfortunately, programs aimed at commercial products are under attack by the Reagan Administration, so progress could be slowed. David W. Richerson, ceramics supervisor for Garrett Corp.'s Phoenix (Ariz.) Garrett Turbine Engine Co., says that the commercial potential of these engines hinges on continued government funding, since there are still many bugs to be worked out. Adds Richerson, "I do not see the necessary level of funding available now."

For example, the White House wants to slash Energy's AGT budget by as much as two-thirds, to $15 million, of which only about $5 million would go for ceramics research. And even that amount would be redirected—to generic R&D rather than commercial products, since the Administration contends that private industry should underwrite development of products with commercial promises and recoup investments through the new tax credits.

However, Energy's Lombardi, among others, thinks the end result will be a dropoff in ceramic auto engine development. If the funding ceases, he warns, "The U.S. leadership role will go down the tubes." Hillard E. Barrett, chief engineer of industrial gas turbines for General Motors Corp.'s Detroit Diesel Allison Div., anticipates that by the end of next year the Energy Dept.'s CATE and AGT programs will be combined into "an obviously reduced effort."

Defense Dept. programs will be spared the ax. Indeed, Defense will spend more than $20 million from 1982 to 1986 on a powerful adiabatic, or heat-stabilized, engine to be built by Cummins Engine Co. around key ceramic components. It will power military vehicles.

The spinoffs

Experts stress that much work remains to be done in ceramic turbines. "These things are still experimental," notes Arthur G. McLean, manager of ceramic materials at Ford Motor Co.'s Scientific Research Laboratory. Although simple working prototypes have been built by several companies, McLean and other specialists list numerous areas where problems remain. Examples: ceramics materials purity, evolving a scientific basis for materials formulations, manufacturing process controls, and general durability and reliability.

Meanwhile, spinoff applications—mainly products that are less critical than a vehicle's main engine parts—seem likely to reach the market much sooner. Auto turbochargers with ceramic parts could be in production within a year. Another near-term application is coating piston rings with ceramics to make them more impervious to the increasing sulfur levels in diesel fuel.

The U.S. is not alone in its ceramic-engine quest. Japan, West Germany, England, Italy, and Sweden all have launched similar projects, most of them subsidized by the government. Kyoto Ceramic Co. and Isuzu Motors Ltd. in Japan, for example, are using MITI funds to develop a ceramic diesel engine. Italy's Fiat already has built bench-scale turbine engines with ceramic pre-combustion chambers and is now developing ceramic piston caps. And in Sweden, Volvo's United Turbine subsidiary plans to have a prototype ceramic gas turbine running by 1983.

So it seems just a matter of time before industrial ceramics help give birth to a new generation of vehicle engines that will save billions of dollars in fuel. The next step will be aircraft engines, where development work has already begun. Britain's Lucas Aerospace Ltd.'s Fabrication Div., for example, is working on a ceramic gas turbine flame tube for the Defense Ministry. Gordon Sedgwick, a Lucas project designer, is confident that ceramics will win out for this and many other engine applications. Says Sedgwick: "The world is spending too much money on this for it not to work out."

[From the New York Times, Jan. 1, 1983]

The Stakes Are High in a Race for Speed

(By William J. Broad)

The fastest computers in the world are today built in the United States, but these symbols of American ingenuity may soon be found only in museums. The Japanese Government last year unveiled a $200 million program aimed at cornering the world market in supercomputers with machines 1,000 times more powerful.

Predictions of an American decline are voiced by academicians and scientists who fear that the race for supercomputers of the future may be somewhat lopsided. The Reagan Administration, ignoring calls for an expensive crash program, has invoked the magic of the market place and the genius of lone inventors.

The stakes in the gamble are high. No computer is now powerful enough, for example, to simulate the airflow around an entire aircraft, so aerodynamic designs are often put together in piecemeal fashion or by the repeated processing of two-dimensional slices. The first country with computers that can design the plane as a whole, according to a recent report of the National Science Foundation, "will undoubtedly produce planes with superior performance." So too, the Government wants bigger supercomputers for building better weapons, breaking codes, and developing new sources of energy.

BEYOND ALL EXISTING COMPUTERS

Pure research, with its unpredictable rewards, also needs the machines. "The problems we are trying to address could not at this point be calculated by all the computers that have ever existed," says Dr. Bruce Knapp, a physicist at the Nevis laboratory of Columbia University. Dr. Knapp and his colleagues, unable to afford the usual $5 million to $15 million for a supercomputer, are attempting to build their own.

What makes a computer super is speed, not size. A supercomputer is any machine that will perform at peak speeds greater than 20 million operations per second. The best models now available will, for short bursts, perform 400 million operations per second. American manufacturers are aiming at a billion, while the Japanese have set their sights on 10 billion.

The complexity of supercomputers is illustrated by the fact that it usually takes a small army of regular computers to feed them problems and digest the results. And their complexity is increasing. The world's first supercomputer, a custom-built machine financed by the Defense Advanced Research Projects Agency and retired in 1981, once computed the dynamics of airflow around the engine of a rocket. The task took 18 hours. The machines the Japanese want to build would do the job in about 10 seconds.

How America is to retain pre-eminence is currently a topic of hot debate. In an attempt to counter the Japanese offensive, American scientists have written ominous articles and lobbied for creation of a crash program. "Military research," wrote a group from the Los Alamos National Laboratory, "may become dependent on access to supercomputers of foreign manufacture." In January the National Science Foundation released a report which found "alarming" the evidence that the Japanese were headed for world leadership and noted that Government support for supercomputers had waned since the 1970's in the United States.

The response of the Government was less than lukewarm. "The Reagan Administration has concerns about too great an involvement by the Federal Government and about interfering with the private market," said Dr. Douglas Pewitt, an assistant director of the White House Office of Science and Technology Policy. "The pool of talent you can put into supercomputers is very thin," he added. "There are fewer than a dozen people who represent the intellectual kernel in this area."

Such remarks, coming amid the search for hefty cuts in the Federal budget, might seem to be mere rationalization. But the case of Dr. Seymour R. Cray lends weight to that kind of generalization.

FASTEST OF THE FAST

Dr. Cray is the founder and continuing force behind Cray Research, a company in Chippewa Falls, Wis., that currently makes the fastest computers in the world. Dr. Cray's first supercomputer, installed in 1976 and known as the Cray-1, packed 350,000 silicon chips into a space a little bigger than a telephone booth.

During the past quarter century the raw speed of computers has approximately doubled each year, mainly because of the shrinking size of micro-electronic chips. With supercomputers, the trick is to keep the chips close together so as to limit to the lowest possible level the time it takes electric pulses to zip among them. It is literally a struggle with the speed of light. Because of the compact arrangement, supercomputers tend to be smaller than their less powerful cousins. What Dr. Cray accomplished was a unprecedented assault on the speed-of-light barrier by packing more chips into a tinier space than ever before. One result of such dense packing was concentration of the computer's waste heat, which had to be removed by large refrigeration units lest the chips burn up.

The Cray company, which has grown from a homespun operation into a corporate complex of 1,300 people, is watching Japanese progress quite closely. "We are not shaking in our shoes," says Peter A. Gregory, vice president for corporate development; "At the same time we'd be fools to ignore the challenge." Last year Cray spent $25 million on research, about 19 percent of its revenues. Mr. Gregory says that if Cray can keep getting the best silicon chips, it will hold fast to the world title.

Despite the company's multimillion-dollar pursuit of faster machines, the heart of its research empire is occupied by one person. Dr. Cray practices the art of creating supercomputers not with the assistance of a computer or teams of specialists but with pads of 8½ by 11-inch paper. His main requirement is solitude, which he often finds by working from 3 P.M. until midnight.

A HIGH-RISK BUSINESS

Only two American companies make supercomputers, and Cray is the only company in the world that markets them exclusively. Together they have sold some 60 machines. It is a high-risk business, according to the Auerbach Corporation, which publishes reviews of computer technology. "For every new supercomputer vendor," it writes, "there is a new ex-vendor."

Yet demand for new machines is growing. Until a few years ago, the frontiers of science were adequately equipped with fast computers, according to Dr. Leon M. Lederman, director of the Fermi National Accelerator Laboratory in Batavia, Ill. "Suddenly lots of people realized we needed computers that were not just two or three times but thousands of times more powerful."

Breakthroughs in supercomputing are increasingly based on advances in "architecture," or the way a computer goes about processing its problems. The first computers used sequential processing, in which one part of a problem was finished before the next was started. Today the focus is on parallel processing, in which many computations are performed simultaneously.

An approach even more advanced is being pursued by the Japanese. Known as the Fifth-Generation Computer Project, this $500 million alliance between government and industry aims at innovative developments not just in speed of processing but in computer intelligence. The National Science Foundation report calls it "a revolutionary approach" that would "change the whole domain of the operation of computers in society."

Perhaps the pessimists are correct, and the native genius of America's inventors and the magic of the marketplace will be no match for an organized assault by the Japanese.

QUESTIONS ARE FUNDAMENTAL

Undaunted by such sentiments, Dr. Knapp at Columbia is building his own supercomputer. It will be the size of a refrigerator. The questions he and his physicist colleagues want answered concern the fundamental structure of the universe. Their huge particle accelerators, probing ever more deeply into the heart of the atom, are generating more information than today's computers can digest.

When finished, in about a year, Dr. Knapp's supercomputer will be hooked up to an experiment at Dr. Lederman's Fermi laboratory. With luck, it will perform about 100 billion operations per second. Such blistering speeds are possible only when a supercomputer is "dedicated"—built to solve a specific problem. Dr. Knapp's machine could not handle the diverse tasks of a general-purpose supercomputer.

But with the roving eye of an inventor, Dr. Knapp says the custom-built approach may eventually show up in other areas of supercomputing, such as the prediction of weather or the design and simulation of complex electrical equipment.

"If you tailor the machine yourself," he says, "you can pick up between a thousand and a million times the power for a given investment. That means you can try to answer questions you thought the universe was going to have to do without."

SECTION-BY-SECTION ANALYSIS OF THE ECONOMICALLY STRATEGIC INDUSTRIAL RESEARCH AND DEVELOPMENT ACT

Section 1. Sets forth the title of the Act.

Section 2. Findings—This section finds that:

(1) technology development is vital to the United States economy;

(2) industries engaged in technology development contribute greatly to economic growth, have a growth rate twice the growth rate of total industrial output, and make a positive contribution to an otherwise negative manufacturing trade balance;

(3) technological innovation is the key to the efforts of basic industries to imporve productivity;

(4) United States technology is experiencing strong competitive challenges internationally which have resulted in a world-wide decline in market share for high technology industries in the United States;

(5) intensive targeted research and development plans of other countries are shifting technological advantage overseas in selected fields and may limit development of valuable long-term technology markets by United States industry;

(6) the development of economically strategic technologies, in areas including microelectronics, materials development, biotechnology robotics, manufacturing processes, and artificial intelligence, offers great potential benefits to the economy;

(7) the riskiness of long-term research and development efforts and the growth of foreign research and development programs require a vigorous Federal role in technology development;

(8) assessing the adequacy of current Federal research and development activities and spending priorities requires:

A. identification of economically strategic technologies by the science and engineering community;

B. reliable assessment of research and development activity in other countries on economically strategic technologies;

C. assessment of efforts in the United States, including industrial, academic, nonprofit, State, Federal, defense, and nondefense research and development activity; and

D. consideration of competitive strategy in attaining maximum benefit from development of economically strategic technologies;

(9) a plan for the development of economically strategic technologies can best be developed by industry, the academic community, and government, with each committing appropriate resources to maximize the potential for successful development; and

(10) the National Academy of Sciences, including the Institute of Medicine, and the National Academy of Engineering are representative of the science and engineering community, including members from industry, educational institutions, and government, and are well suited to identify economically strategic technologies and recommend technology development plans.

Section 3. Purpose—This section sets forth five purposes for this act:

(1) develop a widespread consensus within the industrial and academic research community as to what technologies are economically strategic for development;

(2) collect the best available data on research and development efforts on economically strategic technologies in the United States and abroad and provide an authoritative comparative analysis of the efforts;

(3) create a forum for the formulation of technology development programs which will include industry, academic, and governmental efforts and resources;

(4) develop technology development programs that include consideration of the comparative position of the United States and appropriate competitive strategy for development; and

(5) authorize appropriations that are sufficient to implement such programs.

Section 4. Sets forth definitions for this Act.

Section 5. The Study on Economically Strategic Technologies—This section instructs the Director of the Office of Science and Technology Policy to enter into an agreement with the National Academies of Sciences, the National Academy of Engineering, and the Institute of Medicine to conduct a study which will:

(1) designate economically strategic technologies

(2) develop technology development programs for each designated technology

Section 6. Functions of the Research Organizations in Carrying Out the Study. This section sets forth guidelines for the conduct of the study

Section 7. This section sets forth administrative provisions of the act.

Section 8. Authorization of Appropriation: This section calls for authorization of such sums as may be necessary to conduct this study and to implement the technology development programs that may be recommended by the study.

S. 428

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Economically Strategic Industrial Research and Development Act".

FINDINGS

SEC. 2. The Congress finds that—

(1) technology development is vital to the United States economy;

(2) industries engaged in technology development contribute greatly to economic growth, have a growth rate twice the growth rate of total industrial output, and make a positive contribution to an otherwise negative manufacturing trade balance;

(3) technology innovation is key to the efforts of basic industries to improve productivity;

(4) United States technology is experiencing strong competitive challenges internationally which have resulted in a world-wide decline in market share for high technology industries in the United States;

(5) intensive targeted research and development plans of other countries are shifting technological advantage overseas in selected fields and may limit development of valuable long-term technology markets by United States industry;

(6) the development of economically strategic technologies, in areas including microelectronics, materials development, biotechnology, robotics, manufacturing processes, and artificial intelligence, offers great potential benefits to the economy;

(7) the riskiness of long-term research and development efforts and the growth of foreign research and development programs require a vigorous Federal role in technology development;

(8) assessing the adequacy of current Federal research and development activities and spending priorities requires—

(A) identification of economically strategic technologies by the science and engineering community;

(B) reliable assessment of research and development activity in other countries on economically strategic technologies;

(C) assessment of efforts in the United States, including industrial, academic, nonprofit, State, Federal, defense, and nondefense research and development activity; and

(D) consideration of competitive strategy in attaining maximum benefit from development of economically strategic technologies;

(9) a plan for the development of economically strategic technologies can best be developed by industry, the academic community, and government, with each committing appropriate resources to maximize the potential for successful development; and

(10) the National Academy of Sciences, including the Institute of Medicine, and the National Academy of Engineering are representative of the science and engineering community, including members from industry, educational institutions, and government, and are well suited to identify economically strategic technologies and recommend technology development plans.

PURPOSES

SEC. 3. It is the purpose of this Act to—

(1) develop a widespread consensus within the industrial and academic research community as to what technologies are economically strategic for development;

(2) collect the best available data on research and development efforts on economically strategic technologies in the United States and abroad and provide an authoritative comparative analysis of the efforts;

(3) create a forum for the formulation of technology development programs which will include industry, academic, and governmental efforts and resources;

(4) develop technology development programs that include consideration of the comparative position of the United States and appropriate competitive strategy for development; and

(5) authorize appropriations that are sufficient to implement such programs.

DEFINITIONS

SEC. 4. For purposes of this Act—

(1) the term "Director" means the Director of the Office of Science and Technology Policy;

(2) the term "Academies" means the National Academy of Sciences (including the Institute of Medicine and any other unit of the Academy) and the National Academy of Engineering.

THE STUDY ON ECONOMICALLY STRATEGIC TECHNOLOGIES

SEC. 5. Within six months after the date of enactment of this Act, the Director of the Office of Science and Technology Policy shall enter into an agreement with the National Academy of Science (including the Institute of Medicine and any other appropriate unit of the National Academy of Sciences) and the National Academy of Engineering under which the Academies shall make a full and complete study that identifies economically strategic technologies and plans for the optimal development of such technologies. The agreement shall include provisions for the coordination of the study between the Academies and a committee for making reports required by section 6(c).

FUNCTIONS OF THE ACADEMIES IN CARRYING OUT THE STUDY

SEC. 6. (a) In designating technologies as economically strategic technologies, the Academies shall—

(1) solicit views of private industry and examine evidence of current industrial initiatives;

(2) assess the economic benefit to be gained from each technology including—

(A) a description and estimate of potential market;

(B) job creation potential;

(C) socioeconomic impact;

(D) potential for declining product cost;

(E) potential for follow-up and spinoff product development;

(F) evidence of potential widespread industrial application; and

(G) potential for new business formation;

(3) determine the current effort for technology development by Federal and State government including spending levels for defense and nondefense research and development, the nature of the development program, and the potential for transfer of defense technologies to nondefense use;

(4) prepare a summary of existing and projected levels of research and development activity by private industry for each technology;

(5) determine current levels of research and development effort by foreign nations for each technology and assess the stage of development and the competitive strategy being employed by other nations;

(6) consider the competitive potential of United States industry for future markets, the relative benefits of lead versus follow-up development, and competitive risks involved such as the potential for development of over capacity or external costs;

(7) assess the technological feasibility of development and the risk for each technology;

(8) consider the necessary time for development of each technology, focusing on technologies with a medium-term development horizon of five to eight years; and

(9) consider the potential economic benefit of the technology and evidence that United States industry will fail to realize such benefits in the absence of an enhanced technology development program.

(b) The Academies shall develop a technology development program for each technology designated as economically strategic. The Academies shall establish an advisory committee composed of industry and academic experts to make recommendations for each such program. The terms of compensation for expenses or service, if any, for such members shall be included in the agreement made pursuant to section 5. Each technology development program shall describe the strategy for development and recommend—

(1) participants in the program and program responsibilities;

(2) levels of effort and financial commitment for each participant and program totals;

(3) timetable of milestones and budget outlays;

(4) appropriate licensing and patent arrangements for participants and nonparticipants, giving equal weight to fair financial return to participants and rapid technology transfer and diffusion;

(5) policy action or spending required of the Federal Government, including recommendations for additional Federal funding financing from private sources and a designation of appropriate Federal agencies to participate in the development program and to dispense Federal funds; and

(6) methods for encouraging participation by small business in the technology development program.

(c) The committee, established in accordance with the agreement made pursuant to section 5, shall submit to the President and to the Committee on Commerce, Science and Transportation of the Senate and the Committee on Science and Technology of the House of Representatives interim reports of each technology development program formulated for each designated economically strategic technology, an annual report at the end of each calendar year summarizing the activities of the Academies regarding the study, and not later than three years after the date of enactment of this Act, a final report of the study together with recommendations, including recommendations for legislation.

ADMINISTRATIVE PROVISIONS

SEC. 7. (a) The Academies may, for the purpose of carrying out the provisions of this Act, hold such hearings and consult with such representatives in the business community, educational institutions, Federal, State, and local governments, and other organizations, associations, and individuals as the President of the National Academy of Sciences or the President of the National Academy of Engineering deems advisable.

(b) Each department, agency, and instrumentality of the executive branch of the Federal Government, including independent agencies, is authorized and directed to furnish to the Academies, upon request made by the President of the National Academy of Sciences or the President of the National Academy of Engineering any information such President deems necessary to carry out the study.

AUTHORIZATION OF APPROPRIATIONS

SEC. 8. There are authorized to be appropriated such sums as may be necessary to carry out the study required by this Act and to implement the technology development programs recommended in the study.