(12-84)

United States Government Drell — Department of Energy — ER-72

memorandum

To: DD's Wood.

DATE: JUL 0 1 1988

REPLY TO ATTN OF: ER-30

SUBJECT: Accomplishments of Long-Term Research and Development

TO: Executive Director, Office of Energy Research, ER-1

Per your request, attached is a summary of the accomplishments in long-term research and development during the current Administration. Materials were provided by all of the Associate Directors of ER and the Offices of the Assistant Secretaries for Conservation and Renewable Energy and Fossil Energy.

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Director for Program Analysis
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Attachment

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DISCLAIMER

LONG-TERM RESEARCH AND DEVELOPMENT

Technological breakthroughs cannot be penciled on the calendar in advance. The rate of new technical discovery, while highly uncertain, depends on a base of knowledge acquired earlier. In the economic environment of 1980, progress in basic research, which builds the technology base that will underpin future energy development by Government and industry, was being slowed as cost increases due to inflation grew faster than funding increases.

POLICY

This Administration's policy from the start was to reinvigorate basic research and to turn around the decline in Federal research funding for universities that began in 1968. The policy has been to concentrate on long-term research in areas where the incentives for and availability of private investment are severely limited or nonexistent (despite opportunities for important gains if programs reach identifiable goals eventually) or where the Government possesses unique facilities or capabilities not available to the private sector.

Thus, the Reagan Administration's policy has included strong support for long-term fundamental research in the natural and physical sciences, including high energy and nuclear physics; magnetic fusion energy; biological and environmental science; and basic energy sciences research in materials, chemical, and applied mathematical sciences, engineering and geosciences, and energy biosciences. It has fostered expanded basic research under the Department's *energy technology* programs as well as under its *basic research* programs.

The policy encouraged supporting thousands of individual projects carried out by scientists from laboratories, universities, industry, and other research facilities throughout the United States. Its emphasis on upgrading and expanding the major forefront research facilities at the Department's nine major multiprogram and sixteen single purpose laboratories, has been to enable scientists to continue to expand our technical knowledge base in the many areas of research pertaining to energy development and use.

INITIATIVES AND ACCOMPLISHMENTS

The Administration's continued support of *high energy physics* made possible the realization of Fermi National Accelerator Laboratory's Tevatron proton-antiproton collider--the only high energy physics accelerator that uses superconducting magnets. In the world of elementary particle accelerators, energy equates with leadership. The Tevatron brought back to the United States the leadership that comes with having the world's highest energy accelerator--a position that had been temporarily lost to the Europeans in the 1970's.

Completed in 1983, and upgraded in 1986, the Illinois facility has made possible new discoveries in physics that have added immeasurably to the body of evidence supporting the most current theories describing subatomic elementary particles and their interactions, including describing the constituents of the proton and the neutron.

The continuing commitment to keeping this country in a position of technology leadership is confirmed in the President's initiative to construct the Superconducting Super Collider (SSC), a proton-proton collider with an energy level 20 times higher than that of the Tevatron. The SSC represents the next generation of advanced accelerators. The technological spin-offs from its construction and operation are expected to make major contributions to the economic and technological competitiveness of the United States.

Construction of the Continuous Electron Beam Accelerator Facility (CEBAF) in Virginia began in 1987. CEBAF's combination of continuous beam, high current, and high energy will be unique in the world and will be an important element for maintaining the United States position of world leadership in basic nuclear physics research into the structure of the components of an atom.

DOE scientists observed the brightest supernova (exploding star) in the last 363 years, Supernova 1987, several hours before its visible light reached the earth. A detector designed to detect submicroscopic proton decay, and located deep in a salt mine under Lake Erie, recorded a burst of neutrinos. This was the first time that neutrinos from outside our solar system had been observed. The observation not only provided information on the stability and mass of neutrinos, but also provided a key to the dynamics of the great explosion which marked the end of this star's life.

Three *magnetic fusion energy* devices which began operating in the period 1982-1985, enabled the United States to be at the cutting edge of research on fusion energy, the energy source of the sun and stars. They established world records in confining the energy producing plasma, in the efficiency of using magnetic fields to confine the plasma, and in inducing a steady state current to flow in the plasma. Consequently, the United States is ready to take the next logical major experimental step, an ignition experiment, for which the Administration began architect-engineering design in 1988.

For the longer-term, President Reagan and General Secretary Gorbachev at the Geneva Summit in 1985 spurred creation of the International Thermonuclear Reactor (ITER) Conceptual Design under the auspices of the International Agency. Together, scientists and engineers from the United States, the European Community, Japan, and the Union of Soviet Socialist Republics will formulate a concept for a device to resolve residual scientific questions and to demonstrate the engineering feasibility of magnetic fusion energy.

Pellet injectors which markedly improved the ability to fuel and control fuel consumption in plasmas were completed and tested on United States devices, and then chosen by the European Community and France for use in the most advanced fusion devices. The resulting world leadership status, in special materials and in fuel recycling and handling as well as in pellet injection, is yielding the United States extra dividends in the form of access to technology and fusion science advances attributable to the use overseas of our innovative devices and materials.

In *biological and environmental research* the Administration has embraced perhaps the most significant initiative ever undertaken in the area of human genetics--the mapping of the human genome. The human genome is the set of genetic instructions that governs the growth and function of the cells that make up the human body. Despite a general understanding of how genetic information is recorded and transmitted, the molecular basis for hereditary diseases and cancer remains a mystery that may well be solved by the genome project. The technology being developed to map the human genome would also allow new approaches to study environmental effects on humans and stimulate the Nation's biotechnology industry during the coming decades.

The Administration has undertaken a major scientific initiative to gather the basic scientific information on radon gas -- its origins, movement, behavior, and effects on humans -- that is needed to eliminate indoor radon as a potential public health risk. A new regional marine research program was created to gain an understanding of the impacts of energy related pollutants in the Nation's coastal regions, an area of rapidly expanding energy resource exploration and facilities development. DOE researchers were able to allay concerns around the world following the Chernobyl nuclear reactor accident, by credibly predicting the radiation exposure of people in different countries, and to project the expected health consequences.

Long term DOE research in *nuclear medicine* has paid off with completion of the Donner 600-crystal positron emission tomograph (PET). This latest instrument for medical imaging is twice as precise as any other computerized tomograph and is especially useful in studying such brain disorders as Alzheimer's disease. This new system has significant advantages for studying blood flow and metabolism in the heart and brain, as well as for detecting small tumors that cannot be found by computerized tomography (CT) scans or by magnetic resonance imaging (MRI). New techniques have been developed to use monoclonal antibodies labeled with radioactive isotopes for the treatment of solid tumors.

A major facility for *basic energy sciences* which was completed and upgraded during the Reagan Administration is the National Synchrotron Light Source in New York. Charged elementary particles accelerated near the speed of light produce an incredibly bright light (visible, ultraviolet, or x-ray light) that has special value for both research and potential industrial applications. Researchers from universities and industry travel from across the country to study topics as varied as biology and metallurgy. Work underway at the Light Source on x-ray lithography--a likely method for producing the next generation of computer chips--is an excellent example of the cooperation between government and the private sector. Their common goal is to capitalize on the expanding frontiers of science to strengthen United States economic competitiveness. The

Administration has also endorsed the design and construction of the next generation of facilities--ultra-high-brightness machines in California and Illinois that would become available in 1990's.

ACS APS

Research in the United States in combustion science has been greatly enhanced by the establishment of the Combustion Research Facility (CRF), Sandia National Laboratories/Livermore as a premier research facility. The facility now hosts over 600 visiting scientists each year from United States industries, universities, and National laboratories as well as from foreign countries. It provides unique combustion diagnostic equipment consisting of lasers and computers with supporting combustion modeling software. The staff of the CRF has established a world-wide reputation for scientific excellence in all aspects of combustion science.

In addition to these facilities operated and maintained by the Federal government, a variety of other facilities were constructed at universities. The Administration worked with the Congress to successfully initiate 26 such projects in 15 states since 1984, at a total cost of $350 million.

The 1986 discovery in Europe of high-temperature superconducting materials was among the most startling and promising scientific advances in recent decades. DOE-supported scientists have determined the exact arrangement of the atoms and the electronic structure in such materials. This information has provided the basis for understanding all of the subsequent experiments conducted and theories developed to understand why these compounds are superconducting at such high temperatures.

Key to unraveling the complex atomic structure were DOE's unique neutron sources and synchrotron radiation facilities. An addition, the President's superconductivity initiative of July, 1987, established three "Superconductivity Research Centers" at DOE laboratories to overcome the remaining scientific and technical obstacles to practical applications of these materials.

Long term research on *renewable energy* yielded a number of important successes, among them solar photovoltaics improvements demonstrating greater than 10 percent efficiency in converting sunlight into electricity, a significant milestone; and a 3.2 megawatt wind turbine in Oahu, Hawaii, owned and now operated by Hawaiian Electric Industries. The search for understanding the recovery of geothermal energy resulted in a radar instrument that locates metal underground in hard rock formations. This instrument can provide an accurate map of fluid bearing fractures surrounding a deep oil, gas, or geothermal well.

Support for biomass energy demonstrated that concentrated sunlight may be more efficient in destroying toxic chemical waste than conventional incineration. It also developed short-rotation trees grown specifically for energy purposes, with yields five times normal. These high-yielding hybrid poplar trees are now being grown commercially by Crown Zellerbach and Scott Paper.

The Administration's research in the area of *conservation* has also shown a series of successes during the 1980's. They include window coatings that stop the portion of the sun's radiation associated with heat. Almost 10 percent of all residential windows sold now have these coatings. A new solid state ballast for fluorescent lighting that results in a 25 percent improvement in lighting efficiency is already saving energy. Over 2 million of these new ballasts have already been sold. And a new class of ceramic-metal compounds that can be used in the high temperature required for heat engines and heat exchangers has been made available for use by industry.

At the core of the DOE *fossil energy* program is long-range fundamental research that provides new knowledge about the chemical and physical properties of coal, oil and gas and the environments in which they reside. Since 1980, the Administration has provided 266 grants, totaling $44.2 million, to professor-student research teams at more than 100 colleges and universities under the University Coal Research Program. From these fundamental studies a better understanding of coal science, reaction chemistry, engineering fundamentals, environmental science and other related information has emerged. Several concepts now in more mature engineering development can trace their roots to the University Coal Research Program including, for example, the two-stage liquefaction process, microbubble flotation coal cleaning, and basic modeling concepts for underground coal gasification.

Promising new concepts for using microbes to desulfurize coal or convert it into more usable forms and microbial technologies for the enhanced production of crude oil have evolved from fossil energy basic research in the 1980's. New materials such as erosion and corrosion resistant alloys and coatings and ceramic "whiskers" (filament-like structures that can be used in fabricating ceramic composites) for use in advanced coal systems have been created. Our ability to measure flow parameters and combustion characteristics in engines and boilers has been advanced by new diagnostic concepts using fiber optics, infrared spectroscopy, and laser spectroscopy and scattering techniques.

For the future, a major new effort has been initiated to better understand the geologic "anatomy" of an oil reservoir--its structure, geometry, composition and other key factors--to provide information that can be translated into improved oil recovery.

To ensure that an adequate supply of highly skilled new scientists and engineers are available to meet current and future energy research needs, the Administration has supported *university research and scientific education*. Each major DOE R&D program was directed to implement new initiatives such as joint university-laboratory research programs and support of graduate research fellowships in research areas of critical importance to the DOE mission.

The Administration established a competition for financial support to enable university scientists since 1984 to purchase over $25 million of state-of-the-art research instruments essential to continued progress in many scientific fields. It expanded five-fold a program that provides educational institutions with used but still usable laboratory equipment declared excess to DOE needs. This enables small colleges, including minority schools, to equip scientific laboratories.

Since 1984, a high-school honors research program has brought 1,040 of the very best high-school science students from each state, including Puerto Rico and the District of Columbia, to DOE laboratories for hands-on experience at a level of sophistication not made available to high school students before. At the university level, more than 2,000 faculty member and students per year have participated in summer or year-long research and training projects in up to 50 departmental facilities. In 1987, the Administration established Science Education Centers at five major multiprogram laboratories to sponsor several new initiatives, including semester-length research appointments for 400 undergraduate students selected nationally.