at Rowe, Mass., designed originally for 110 mwe output, recently was licensed to move up to 155 mwe, and the Dresden boiling water plant near Chicago, from 180 mwe to 200 mwe.

Currently there is an upswing in utility interest in nuclear power. Today more than 120 investor-owned electric light and power companies are participating in 24 nuclear power study and development projects of many different types. Several consumer-owned systems are building nuclear plants, and others are investigating the possibilities. Both types of systems will participate in distributing power from the 800 megawatt dual purpose reactor being built at the AEC's Richland, Wash., installation.

4. The Long-Range Effort - Fusion Power.

For the long range, several nations have mounted sizeable research efforts that seek a practical way to control an even greater release of energy through controlled fusion of light atoms such as hydrogen. This is the opposite of fission.

Success here may be long in coming but fusion reactors using the heavier kinds of hydrogen atoms would make possible the use of the waters of the seas to generate vast amounts of useful power. To do this, the heavy hydrogen (deuterium) must be heated to temperatures much higher than those found at the very center of the sun. The sun is itself a fusion reactor.

The hot gas must be confined long enough for fusion to take place, releasing energetic neutrons and helium gas that would provide heat for conversion to electricity. One advantage would be that radioactive wastes - a major problem in fission reactors - would not accumulate.

Research began in 1951-52. In the past year, investigators at AEC-supported projects have reported temperatures higher than those of the solar interior. Emphasis has shifted to increasing the confining time of the gas, called plasma. Strong magnetic fields have to be used because no solid walls can withstand the corrosive action of gases heated to millions of degrees Centigrade.

So far, there is no guarantee that fusion reactors can be built. Clear avenues of progress toward the goal are opening up, however, and research is being pressed vigorously because of the importance of the goal. A by-product of this activity has been the accumulation of much new basic data on plasma physics and in related fields.

5. The Atom in Space.

It is not recorded whether Fermi ever envisioned a nuclear reactor making possible man's exploration of the solar system. Today, the Atomic Energy Commission is working on projects designed to propel and furnish auxiliary power for vehicles that will probe the mysteries of outer space and investigate Mars, Venus and possibly other planets.

This work is in the research and engineering development stage. The AEC seeks to develop highly compact and light-weight reactors that will make possible a great decrease in the weight of space ship engines.

The world's first use of nuclear power in space came on June 29, 1961. An "atomic battery" weighing five pounds provided power for two of the four transmitters in the Navy's navigational satellite, TRANSIT IV-A, put into orbit on that date. A second navigational satellite, TRANSIT IV-B, was launched on November 15, 1961. Both transmitted signals back to earth successfully and the nuclear power came from thermo-electric generators fueled with plutonium 238.

There are two major Commission programs in the space field, conducted in cooperation with the National Aeronautics and Space Administration (NASA) and the Department of Defense. One is called SNAP which stands for Systems for Nuclear Auxiliary Power.

The goal of the SNAP program is to develop both isotopic and reactor powered units. The work got underway in 1955 after several years of feasibility studies and the TRANSIT satellite experiments are part of this program. As described earlier, other uses for isotopic power were developed. (See under "Radioisotopes".)

The other part of the AEC's space effort, the ROVER program, seeks to develop nuclear reactors for rocket propulsion. Chairman Seaborg has summed up the possibilities of rocket propulsion as follows:

"Nuclear propulsion provides the potential for large reductions in the weight of the propellant required to perform any space mission. The percentage reductions become larger and larger as we go to more and more distant space missions... We believe that the nuclear rocket will provide ability to perform missions not feasible with chemical combustion rockets."

New basic data must be acquired, especially on materials permitting very high temperature operation, and many technical problems must be solved before nuclear rockets become operational and before we reach the much higher power levels that will be required of SNAP units.

6. The New Nuclear Industry.

Before 1954, the only major segment of the Commission program in private hands was the mining and milling of uranium ore. When the Commission took over in 1947, the United States was relying on imported ore, principally from the Congo, for most of its needs.

An intensive program was launched to stimulate private prospecting for uranium. Many deposits were found and soon a full-fledged "uranium rush," frequently compared to the California gold rush of 1849, got under way. The result was that in 1954, the United States became the world's largest uranium ore producer.

Since 1957, domestic production and reserves, together with commitments for foreign ore purchases, have provided ample supplies to meet foreseeable requirements. Peak U.S. output came in 1961 when 17,700 tons of uranium oxide was produced. Private estimates put the investment in mines and mills in this country at about $350 million.

The "know-how" of manufacture, processing and use of nuclear materials, reactors, reactor components, etc., was fed into U.S. industrial channels through the system of contract operation of AEC facilities. This system, started by the wartime MED, has been continued and expanded by the Commission.

Normal declassification of technical data adds constantly to useful information on nuclear applications available to manufacturers and processors. A safeguarded program for access to some kinds of still classified data also stimulates development of the new nuclear industry.

Current employment figures show that there are fewer than 7,000 employees on the AEC payroll but operating and construction contractors' employees number 121,000. (Figures as of August 31, 1962.) Industrial and academic contractors operate all major AEC plants and laboratories and in turn subcontract much of the work.

Private enterprise did not have much leeway, however, until enactment of the Atomic Energy Act of 1954. For the first time, under the new law, private ownership of production facilities was permitted, including nuclear power plants and chemical plants to reprocess reactor fuel. Private persons and corporations are being licensed to use special nuclear materials, principally fuel for power and research reactors, and radioisotopes, including the large isotopic sources of radiation coming into increasing use.

Today, private industry has developed the capability to provide all necessary materials and services for civilian uses of nuclear energy with three exceptions.

The exceptions are: (1) enrichment of natural uranium with U-235 which is likely to remain a government monopoly for a long time because of the enormous investment required in gaseous diffusion plants; (2) chemical processing of used reactor fuel to recover usable materials from spent reactor fuel (a private group has applied for authority to construct such a plant, with operation planned by 1965); (3) disposal of high-level radioactive wastes, all of which now are stored on government reservations. It is expected that in the near future there may be private operation of disposal sites under government regulation on state-owned land.

The Department of Commerce compiles annual statistics on the nuclear industry. The latest Census Bureau summary shows that in 1961 shipments of key nuclear energy products manufactured in privately owned establishments, including exports, totaled more than $270 million. This compares with $242 million in 1959.

7. The Safety of the Public.

Moving the 1942 Fermi plant from the racquets court of the University of Chicago to the Argonne Forest Preserve was dictated in part by safety factors. The enormous radiation produced in the fission process in a nuclear reactor is a hazard which must be controlled.

Even in the necessary haste of wartime development, safety had a top priority. Protection of the public, as well as of workers in nuclear energy plants, still has a top priority and, in addition, now is a statutory responsibility of the Atomic Energy Commission.

A National Academy of Sciences Report in 1956 said: "The use of atomic energy is perhaps one of the few major technological developments of the past 50 years in which careful consideration of the relationship of a new technology to the needs and welfare of human beings has kept pace with its development."

The result is a remarkable safety record in a potentially dangerous industry. The AEC and its contractors have won national awards of the National Safety Council several times. In the 43 categories set up by the Council, the average for all industry is 5.99 injuries per million man hours. Currently, the AEC, including its contractors, is fifth, with a 2.03 injury rate. Nearly all AEC and AEC contractor employees get insurance at regular rates.

The major purpose of the regulatory functions assigned to the AEC in the 1954 Act is to protect the public from radiation hazards. Through a system of licensing now well developed, the AEC sets safety requirements for the location, testing and operation of reactors, and for the transport, handling and use of nuclear materials. It specifies standards to be followed by licensees using radioisotopes.

The eye-catching domes and spheres that mark the location of a number of large reactors around the country are only a small but obvious part of the many safety requirements designed to protect the public.

In the score of years that reactors have been in operation in the United States, there has been only one serious accident - one that cost three lives* - and to date, no serious radiation exposure to the public has occurred.

Commercial insurance pools have been formed to provide public liability protection to the public and to reactor operators and others engaged in nuclear work. Recognizing that a serious accident, however unlikely, could bring valid claims beyond the capacity of private insurance, the Congress in 1957 amended the atomic energy law to provide up to $500 million for indemnification when the liability exceeds the amount of financial protection required by the AEC.

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* The SL-1 military reactor accident at the National Reactor Testing Station on January 3, 1961.

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8. Atoms-for-Peace - International Cooperation

The Atoms-for-Peace program for international cooperation in the nuclear field, made possible by the 1954 law and expanded under subsequent amendments, has become part of U.S. foreign policy and assistance.

It was launched by President Eisenhower at the United Nations on December 8, 1953, in the hope that diversion of special nuclear materials from weapons stockpiles to civilian uses would be the result. An international organization was proposed that would serve as a "world bank" for fissionable materials which could be drawn upon for peaceful uses.

Less than three years later, the International Atomic Energy Agency came into being but the goal of diversion of uranium from weapon production was thwarted by the sudden change from scarcity to abundance in supplies of uranium and by continued Soviet obstruction to workable test ban and disarmament agreements.

The Atoms-for-Peace program, however, has made and continues to make important contributions to expanding the civilian uses of nuclear energy. Pending the organization of the IAEA, the United States worked out an extensive cooperative program with friendly countries, using bilateral and multilateral agreements. A key feature is the sale by the United States of enriched uranium for fuel in research and power reactors abroad, under prudent safeguards that insure against diversion of the material to military use.

As of June 30, 1962, more than 75,000 pounds of enriched fuel containing 3,333 pounds of U-235 has been supplied to 30 countries. Also, 430 tons of heavy water has been furnished and many shipments made of gram quantities of plutonium, U-233 and rare isotopes for research purposes.

To stimulate nuclear research and training, the United States has made grants to 26 countries totaling $5,950,000 toward the cost of new research reactors.

About 20 of these units are in operation. Also, 88 comprehensive technical libraries which are kept updated have been donated to many countries and international organizations.

Nuclear power was the topic of greatest interest at the historic United Nations Conference on Peaceful Uses of Atomic Energy which brought 1,400 scientists, including delegations from the USSR and the Soviet Bloc countries, to Geneva, Switzerland in August 1955.

In February 1956, the United States announced that 40,000 kilograms of contained U-235 would be allocated, as needed, for civilian uses of atomic energy. One half would be for domestic use and the other would be for fueling power and research reactors in friendly foreign countries.

Additional allocations have brought the total U-235 available today to 100,000 kg for use in the United States and 65,000 for other countries.

In November 1956, government charges on enriched uranium were announced. Improvements in production and processing have made it possible to reduce these prices 30-40% since then. The AEC has assured reactor operators in the United States and abroad that the supply of enriched U-235 is adequate to meet all presently foreseeable demands for this reactor fuel.

When the Atoms-for-Peace program was launched, only 19 countries had government organizations set up to foster the civilian uses of nuclear energy. Today there are atomic energy commissions in one form or another in more than 60 nations.

In 1958, the European Atomic Energy Community (EURATOM) consisting of Belgium, France, West Germany, Italy, Luxembourg and the Netherlands was organized. The United States is cooperating with it through an extensive program of assistance in nuclear power development. Several other multi-nation nuclear organizations are now active in stimulating peaceful uses of nuclear energy. A second UN

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Peaceful Uses Conference in 1958 was attended by more than 6,000 persons.

Capstone of the Atoms-for-Peace program is the International Atomic Energy Agency with headquarters in Vienna, Austria. The IAEA was five years old on July 29, 1962 and today 78 countries are members.

In this five years, the Agency has given fellowship assistance to nearly 1800 students. An additional 1500 trainees have attended radioisotope techniques courses carried out with the Agency's two mobile laboratories (donated by the United States). Approximately 5,000 persons, principally nuclear scientists and engineers, have attended some 50 IAEA-sponsored scientific conferences, symposia and seminars. Assistance missions have been sent to 34 countries, mostly to the lesser developed nations.

9. Trained Manpower for the Nuclear Era.

Fermi was first of all a great teacher and in his early career wrote several textbooks, including one on physics for high schools. Perhaps for him the most important statistics would be those showing development of nuclear education and training.

Today there are teaching and research reactors at 46 U.S. colleges and universities, and more in other countries. More than 500 U.S. educational institutions have participated in one way or another in the Commission research and educational assistance programs. Several thousand high school and college science teachers have taken refresher courses in summer institutes sponsored by the Commission and the National Science Foundation.

During 1962, the number of students who had taken the radioisotope and reactor technology training courses at Oak Ridge passed the 5,000 mark. Some 1800 students from abroad have received advanced study in nuclear science and technology in courses supported by the AEC. Adequate textbooks now are available in most phases of nuclear science and engineering.

10. New Particles, New Elements and New Uses for Nuclear Detonations

Advances in several areas of nuclear science and technology that do not stem directly from the achievement in 1942 of controlled nuclear chain reaction deserve to be summarized in any account of progress in these two eventful decades. Among these are the rapid discovery of numerous subatomic particles, of nine new man-made elements. Also noteworthy is the AEC's Plowshare program to develop peaceful uses for nuclear explosives.

In 1942, physicists knew that the neutron and proton did not adequately explain the behavior of the nucleus of the atom. Japan's famed Yukawa had predicted that there was some kind of nuclear "glue" present that overcame the electrical repulsion that otherwise would cause the protons in the same nucleus to fly apart. Production of mesons in 1948 in a particle accelerator confirmed Yukawa's theory.

Soon it was found that there were several kinds of mesons and a host of other elementary particles in what has come to be called the "subatomic world." Other phenomena began to be identified so that today physicists are trying to formulate an orderly or "unified" theory that will explain the function of some 30 elementary particles and 45 other particle-like phenomena called "resonances" that have been identified.

This new branch of science, known as high energy or particle physics, is one of the most exciting areas of investigation today and major U.S. research in this field is financed by the AEC. The principal tools that have made possible these newest insights into the fundamental nature of all matter are the particle accelerator (atom smasher), the bubble chamber and the more recent spark chamber, and computers.

The two types of chambers enable scientists to demonstrate the existence and behavior of particles that live only billionths of a second by observing their interaction on photographic film.

The bigger U.S. accelerators are built by the AEC. The world's most powerful one is at Brookhaven National Laboratory. It produces proton particles of 33 billion electron volts of energy (Bev). Construction has begun on a two-mile-long linear electron accelerator at Stanford University that will cost more than $100 million and is expected to reach an energy level of 10-20 Bev. USSR scientists are building a proton machine designed to go up to 70 Bev.

Physicists say even higher energies -- 300 Bev and beyond -- will be needed in the ceaseless quest for more knowledge about the smallest components of matter that make up the world in which we live.

Particle accelerators, reactors, and a nuclear detonation made possible the discovery of 11 new manmade elements of which neptunium, 93, was the first, discovered by E. M. McMillan and P. H. Abelson in 1940 at the University of California. Plutonium, 94, was the second. It was found in late 1940 by the group headed by G. T. Seaborg (now AEC Chairman), McMillan having been called away to other work.

In 1944, Seaborg conceived the idea that a series of new elements would be similar chemically to actinium and the long-known rare earths. Thus those elements beyond uranium took their place in the Periodic Table as the "actinide series."

Using the actinide concept, the Seaborg group, while still at the wartime Metallurgical Laboratory in Chicago, discovered americium (95) and curium (96) in 1944.

After the group moved back to the University of California, Seaborg and those who carried on when he left proceeded to isolate and identify seven additional elements. They are: berkelium (97), californium (98), einsteinium (99), fermium (100), mendelevium (101), element 102 tentatively called nobelium by investigators who thought

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they had identified a new element, and finally, lawrencium (103), discovered in the spring of 1961. These complete the "actinide" series.

Each of these new elements, usually heavier in atomic weight than its immediate predecessor, has an increasingly shorter half life and the number of atoms available to confirm successive discoveries became fewer and fewer, reaching a low of 15. Ingenious methods had to be devised to carry the investigations to successful conclusions.

Nearly 100 isotopes of the 11 transuranium elements have been identified so far. The AEC has under way a program aimed at production, within five years, of gram quantities of californium and milligram amounts of einsteinium which are needed in the search for even heavier transuranium elements. A powerful High Flux Isotope Reactor is being built at Oak Ridge to produce these isotopes.

The seventh and eighth transuranium elements, einsteinium and fermium, were found in the debris of a large thermonuclear bomb detonation that took place in the Pacific in 1952. This leads to the hope that more new elements may be discovered through the peaceful uses of nuclear explosives now being developed by the AEC.

Theoretical work and two experimental underground detonations to date give promise of opening up important civilian applications of the mighty power contained in nuclear bombs. They would be used underground, thus controlling radiation. The first two detonations, GNOME (1961) and SEDAN (1962) yielded much new scientific and engineering data.

The most immediate prospective application is moving huge amounts of earth and rock such as would be required in building a sea level transisthmian canal. Other potential uses of nuclear explosives appear to be in mining, water resource development, producing isotopes of heavy elements and scientific studies which depend upon availability of large quantities of neutrons, high temperatures and extreme pressures.

C. CONCLUSION

This 20th anniversary of man's control of the power of the atom finds a wide variety of functions and types among the several hundred nuclear reactors now built or building. And there is a fertile stream of new ideas for making them more efficient and more versatile.

Reactors range in power from a few watts of thermal energy in small training reactors to the 800 megawatt electrical power capacity of a new reactor now under construction at the AEC installation at Richland, Wash. In terms of electric power production, this will be the most powerful single unit in the world. Design studies are in progress on single reactors to produce enough heat to generate 1,000 megawatts of electricity.

Nuclear power plants are operating today in at least six countries -- Canada, France, West Germany, the Soviet Union, the United Kingdom and the United States.

The nine civilian nuclear central station plants operating in the United States, as of September 1962, had produced more than 4.3 billion kilowatt hours of electricity for consumers in Illinois, Massachusetts, Pennsylvania and California. Thirteen more plants are under construction, most of them nearing completion. When these are in operation, there will be an installed U.S. nuclear generating capacity of more than 1,000 megawatts (1,000,000 kw) of electric power.

In 1962, the world's first nuclear powered merchant ship, the 22,000 ton NS SAVANNAH, went into operation and has been visiting ports on the Atlantic and Pacific coasts.

Four our own defense and that of the Free World, there are production reactors making materials for nuclear weapons. Nuclear powered submarines set one record after another in speed, time submerged and maneuverability. Surface nuclear powered warships also are setting new records. The AEC is developing for the Army a family of small, transportable nuclear power plants for base and field use. Units of this type are operating at McMurdo Sound, Antarctica and in Alaska and Greenland.

Many reactors are used for testing materials, for research - basic and applied - and for training and education.

It has not been possible to put a nuclear reactor into space by the 20th anniversary of the first pioneer pile. There is confidence, however, that before another score of years passes, nuclear propelled rockets will be taking man on expeditions to explore the far reaches of space. Already "atomic batteries" which convert to electricity the heat generated by the decay of radioisotopes are furnishing power to run instruments aboard earth satellites.

In addition to radioisotopic power, the impact of ever expanding uses of large quantities of many varieties of radioisotopes, made possible by nuclear reactors, is being felt in many fields of basic and applied research. The application of radioisotopes to medicine, industry and agriculture is alleviating pain, making industrial processes more efficient, creating new products and saving millions of dollars for farmers.

The vast arrray of accomplishments and advances in man's use of nuclear energy in the past 20 years represents the work of thousands of nuclear scientists and engineers, and government, educational and industrial managers and administrators.

High on any list of those who made major contributions is the name of Enrico Fermi who, posthumously in 1954, was the first recipient of what is known now as the Fermi Award, presented annually by the President of the United States.

This first award, signed by President Eisenhower, said simply:

> "An Award of Merit to Enrico Fermi for his contributions to basic neutron physics and the achievement of the controlled nuclear chain reaction."

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AEC

UNITED STATES
ATOMIC ENERGY COMMISSION
Washington 25, D. C.

Division of Public Information

20 YEARS OF NUCLEAR PROGRESS

BACKGROUND MATERIAL

RELEASE AT WILL AFTER
NOVEMBER 15, 1962

FACT SHEET: 20TH ANNIVERSARY OF WORLD'S FIRST REACTOR

I. The Event - 1942

At 3:25 p.m. on December 2, 1942, the enormous energy of the atom, calculated from the discovery of fission less than four years earlier, was brought under man's control.

The world's first nuclear reactor "went critical," i.e., the first controlled sustained nuclear chain reaction was achieved. The team of more than 40 pioneer nuclear scientists (including one woman) that accomplished this historic break-through was led by the brilliant Italian physicist, the late Dr. Enrico Fermi.

The scene was the closely guarded racquets court under the West Stands of the Stagg Stadium of the University of Chicago. The United States was at war. This improvised laboratory was part of the $2.2 billion Manhattan Engineering District project to make an atomic bomb.

II. Twenty Years Later - 1962

Twenty years later there are some 500 nuclear reactors of many types, sizes and functions operating or being built in 46 countries. Another 50 are planned, most of which will be built. More than half of the 500 are in the United States.

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Nuclear power plants are operating in six countries: Canada, France, West Germany, the Soviet Union, the United Kingdom and the United States. Nuclear plants are under construction in Italy, Japan, Czechoslovakia and East Germany. Many more countries are planning to build nuclear plants.

Today, nuclear power is being used in stationary land plants, on the sea, under the sea, in the Arctic and Antarctic regions and in space.

Radioisotopes today find hundreds of uses in research, agriculture, medicine and industry and are being used in many countries. Large scale production of hundreds of varieties of radioisotopes was made possible by the successful development of nuclear reactors.

More than 100,000 shipments of radioisotopes have been shipped from the AEC plant in Oak Ridge, Tennessee. Reactors in many parts of the world are supplying isotopes to their countries.

Nearly 2,000 students from other countries have received advanced training in nuclear science and technology in the United States and 46 U.S. colleges and universities have research or training reactors on their campuses.

Some 60 nations now have government agencies devoted to expanding peaceful uses of nuclear energy. The International Atomic Energy Agency in Vienna, capstone of the Atoms-for-Peace program launched by the United States in 1953, has 78 member nations.

Congress has appropriated more than $30 billion to develop and operate the national nuclear energy program in the United States. The Atomic Energy Commission's annual budget has grown to $3 billion. Nearly 130,000 people are employed in the program -- 6700 by the AEC, 121,000 by AEC contractors who operate major plants and laboratories in 22 states, and several thousand more in the mining and milling of uranium ore.

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More than $2 billion has been expended in developing nuclear power and 40 power reactors and prototypes have been built or are under construction in the United States. Hundreds of millions of this sum represents private investment.

III. Milestones

NOTE: All events listed below are depicted on the 30,000 commemorative posters being distributed by the AEC in cooperation with library and educational organizations.

1. The world's first reactor goes critical: December 2, 1942.

2. First weighable amount of a man-made element, plutonium, which reactors were to produce in industrial quantities within two years: September 1942.

3. First reactor to produce radioisotopes for large scale distribution, the "X-10" at Oak Ridge, Tennessee. Began operating in November 1943.

4. For Defense: First atomic detonation, Alamogordo, New Mexico, July 16, 1945.

5. First useful electricity: Four 200-watt bulbs lighted at Experimental Breeder Reactor at AEC Idaho installation, December 1951.

6. First propulsion: Nuclear-powered submarine, USS NAUTILUS, 1954.

7. Atoms-for-Peace: First United Nations Peaceful Uses Conference, Geneva, Switzerland, 1955.

8. First large-scale plant devoted exclusively to producing nuclear power: Shippingport, Pa., December 1957.

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9. First use of nuclear energy in space: two of four transmitters in TRANSIT IV-A navigational satellite powered by atomic batteries, put in orbit June 1961.

10. First nuclear powered merchant ship: N.S. SAVANNAH, 20,000 tons, placed in operation 1962.

IV. Statements on AEC Poster

"The atom is a continuing challenge to man to use its great powers for his benefit and not for his destruction... President John F. Kennedy." (For U.S. Peaceful Uses Exhibits Abroad, 1962).

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"Discovery of nuclear fission and of a way to control its release of energy marked the beginning of our new scientific society. Scientific progress since then has equalled that in all previous history of science. The first nuclear reactor in 1942 led to many of today's uses of this new source of energy.

Glenn T. Seaborg, Chairman
U.S. Atomic Energy Commission"