P+P 900
Atomic energy

EXCERPT FROM
TRUSTEES' CONFIDENTIAL REPORT

November , 1945

To the Trustees:

The article contained in this number of the Confidential Monthly Report was written by George W. Gray of our staff and is of such unusual interest that I am sure all the Trustees will want to read it carefully. Whether the release of atomic energy in the long run will result in good or evil for the race, no one can now say; but whatever the consequences, the Foundation and its related boards cannot escape their share of the responsibility, indirect as it may be. The atomic bomb is the result of influences which, for the most part unintentionally and unwittingly, we helped to set in motion, because we were interested in pushing out the boundaries of knowledge. It is a tragic irony that when men have been most successful in the pursuit of truth, they have most endangered the possibility of human life on this planet.

The towering question which faces the world now is whether the new energies can be controlled. It is, I know, the hope of all of us that the Foundation may be able to make some contribution, however slight, to this end.

Raymond B. Fosdick

C O N T E N T S

THE ATOMIC BOMB AND THE ROCKEFELLER BOARDS

THE ATOMIC BOMB AND THE ROCKEFELLER BOARDS

Many agencies - universities, industrial corporations, and other civilian organizations and individuals - shared in the vast teamwork which produced the atomic bomb. Trustees of The Rockefeller Foundation who glance through the official report, "Atomic Energy for Military Purposes" by H. D. Smyth of Princeton, will find many names familiar to them. Practically all the top research men were either former fellows or scientists whose work in prewar years was assisted by grants from one or more of the Rockefeller boards. Every university that took a leading part in the program had strong departments in the physical sciences which had been aided in the past by Rockefeller grants. And there were at least two appropriations made by the Foundation during the war that were specifically for the atomic bomb development, although at the time the appropriations were made the closest secrecy necessarily veiled all operations.

Former Fellows Who Worked on the Bomb

A check-up of the Smyth report shows that no less than 23 scientists who worked on the project (including Dr. Smyth himself) had studied in earlier years on fellowships supported by Rockefeller funds. Three were former fellows of the International Education Board, four were former Foundation fellows from Europe, and 16 were former National Research fellows from the United States. Every one of the 23 made valuable contributions to the work that produced the bomb, and several occupied highly responsible places of leadership.

One of these former fellows was in charge of the enormous government-supported university activity known as the Metallurgical Laboratory of

the University of Chicago - Arthur H. Compton. Dr. Compton held a National Research fellowship in 1919-20, being a member of the first group that went abroad to study under the plan for advancing the physical sciences in the United States, a program inaugurated under Foundation auspices at the close of the first world war.

Another former fellow was director of the cyclotron researches at the University of California which were so crucial to the success of the bomb development - Ernest O. Lawrence. Dr. Lawrence held a National Research fellowship in 1925-1927 which enabled him to pursue advanced studies in nuclear physics at Yale.

One of the key positions in the entire program was the directorship of the Los Alamos Laboratory in New Mexico where the bomb was designed and fabricated - and this post was held by J. R. Oppenheimer. Dr. Oppenheimer was both a National Research fellow (1927-1928) and an International Education Board fellow (1928-1929).

Another who had studied on an International Education Board fellowship was the brilliant theoretical physicist, Enrico Fermi, formerly of the University of Rome. He had fled from the Italian dictatorship in 1938 to find a warm welcome at Columbia University where he soon became a leader of American thought and experiment in the field of nuclear physics. He applied for naturalization immediately and became a citizen in 1944. Fermi's contributions to the achievement of the bomb, both in basic research before the war and in developmental research during the war, were of major importance.

"Fortune Favors the Prepared Mind"

Much has been said of our luck in beating the Germans to the attainment of the atomic bomb, but the first and principal ingredient of Allied luck

was our possession of what Pasteur called "the prepared mind." The list of prepared minds included thousands, not only research physicists and chemists, but engineers and other specialists who joined in the nationwide teamwork. It was also an international teamwork. Several British and Canadian scientists and engineers were active collaborators, among them Sir James Chadwick of Cambridge, the discoverer of the neutron. Another co-worker from abroad was Niels Bohr of Copenhagen.

Professor Bohr's laboratory, the Institute of Theoretical Physics at the University of Copenhagen, was the scene of many of the studies which laid the foundations of modern atomic science. It was one of the places which Wickliffe Rose selected as a key center for development back in 1923, when he made a tour of European universities with the view to drawing up the program of the International Education Board in its "scheme for the promotion of education on an international scale." Grants made by this Board to the University of Copenhagen in 1925 provided for the enlargement of Professor Bohr's laboratory, and this initial assistance has been followed since by appropriations from the Foundation for equipment and maintenance. Many of the younger men who worked on the atomic bomb project in this country had previously studied under Bohr at Copenhagen.

By a fortunate visit to the United States early in 1939, Professor Bohr brought the first news of the discovery of uranium fission. It was his report of the recent experiments in the Kaiser Wilhelm Institute near Berlin, and the speculations of himself, Otto Frisch, and the Austrian woman refugee then in Sweden, Lise Meitner, that spurred American scientists to repeat the experiments within a few days of Bohr's arrival. Professor Bohr had returned to Copenhagen when the war came, and, with the occupation of Denmark,

communication was shut off. Our scientists were in the thick of their "Manhattan District" project and were wishing that they had his "prepared mind" to help illumine some of the problems when, in 1943, Bohr was spirited out of Denmark on a small boat, picked up in Sweden by British agents, and flown to the United States. He was stationed for a while at the Los Alamos Laboratory, and was a close consultant on all those atomic subjects in which he is the acknowledged master.

Among the workers were several other refugees from the Axis; for example, Leo Szilard at Columbia (whose coming to the United States in 1935 had been assisted by a small grant from the Foundation), Emilio Segre at the University of California (a former Foundation fellow), and James Franck at the University of Chicago. The Europeans were not only valuable collaborators on the scientific problems, but as soon as the demonstration of nuclear fission was made it was they rather than their American-born colleagues who sensed the military implications of the new knowledge.

Fermi made the first move to interest the government. He conferred with representatives of the Navy Department in March, 1939. "The Navy expressed interest and asked to be kept informed." After a few months had passed with no further response, Szilard and E. P. Wigner called on Albert Einstein in Princeton and urged the importance of the subject. It was they who induced Professor Einstein to write the historic letter to President Roosevelt which prompted the President to appoint an Advisory Committee on Uranium. That act - in October of 1939, when World War II was a month and a half old - marks the official beginning of the atomic bomb as a project of the United States government.

Tools That Pioneered the Job

But superior brains alone could have made only theoretical progress. It was the possession of superior toods that enabled our scientists to plunge immediately into the subject, and start new and original investigations of their own. Two of the principal tools in these studies were the cyclotron and the electrostatic generator - and it is of interest that the inventors of both types of atom smashers were former fellows.

Robert J. Van de Graaff, who conceived and built the first high voltage electrostatic generator while serving as an instructor at Massachusetts Institute of Technology, was a former fellow of the International Education Board. His apparatus is used to accelerate particles to very high speeds, and considerable use has been made of it in experiments to bombard the atomic nucleus. The Smyth report records that two Van de Graaff electrostatic generators were installed in the Los Alamos Laboratory in New Mexico, the final workshop of the bomb research organization. During the war Dr. Van de Graaff was called upon to build so many of these machines that he assembled an extraordinary staff of co-workers at the Institute, a team of experts capable as is no other group in the world for this type of work, and as a result of these wartime activities the design of the apparatus has been greatly improved and its power increased.

The cyclotron is the invention of Ernest O. Lawrence, whose background as a National Research fellow was mentioned earlier. The Foundation began to contribute to the support of Dr. Lawrence's researches at the University of California in 1938. At that time he was working with a 37-inch cyclotron. In 1939 he completed the construction of a 60-inch cyclotron, then the largest in the world, to whose construction and operating expenses

the Foundation had appropriated $80,000. Then, in 1940, the Foundation made a grant of $1,150,000 to provide a still larger cyclotron - a machine of 184 inches diameter with a power in excess of 100,000,000 volts. On the day of the Japanese attack on Pearl Harbor the construction of this gigantic atom smasher was well advanced; and, as we shall see, it played a critical role in the attainment of the atomic bomb.

There were some twenty cyclotrons in operation in various university laboratories over the United States when Professor Bohr arrived from Copenhagen soon after New Year's Day in 1939 with his amazing news of uranium fission. Four of these machines were immediately turned to the bombardment of uranium - and thus almost simultaneously Columbia, Johns Hopkins, the Carnegie Institution, and the University of California were able to report that the news of fission indeed was true. In each experiment atoms had split into two nearly equal parts with the release of enormous energy. After that, bombardment of uranium became a primary interest in several laboratories, and the race for the controlled release of atomic energy was on.

Activities at Columbia and Princeton

Columbia University occupies first place chronologically in the listing of American institutions that contributed to the bomb development. It was there that the first moves were initiated to interest the government. The Columbia group was first to show that it was a special and rare kind of uranium, the isotope of atomic weight 235, that split under neutron bombardment. It is an additional point of interest for our story that the separated uranium used in these Columbia experiments was provided by another former National Research fellow, A. O. Nier of the University of Minnesota. Nier had

built a powerful mass spectrograph with which he was able to separate a microscopic amount of uranium-235 from the more abundant uranium-238. This trace of material, sent from Minnesota early in 1940, enabled J. R. Dunning and his associates at Columbia to determine that the 235 kind was the uranium that would be useful as an explosive. It was at Columbia, too, that the idea of using graphite as a means of slowing the speed of the nuetrons was first proposed - by Fermi and Szilard.

Another asset which Columbia had was H. C. Urey and his staff. For nearly a decade they had been working on the separation of isotopes. Since it had been shown that only the U-235 was fissurable, and since in the uranium ore this isotope exists intimately mixed with the U-234 and U-238, it was early recognized that one of the main problems would be the extraction of U-235. The Rockefeller Foundation had been aiding Dr. Urey's studies since 1934, and, although he had worked primarily with the isotopes of hydrogen, his laboratory was the farthest advanced in equipment and experience. These resources were made available to the bomb research project, and Urey became a leading co-worker.

The problem of separating U-235 from its fellows of the same species is complicated by the fact that there is so little of it. In a mass of the metal as taken from the ore, 99.3 per cent is the heavy U-238, only about 0.7 per cent is U-235, while the amount of U-234 present is a negligible trace. The task was to get out the 0.7 per cent of U-235. Many methods were tried. Separation of the lighter atoms from the heavier ones by centrifugal force was investigated by Dr. J. W. Beams at the University of Virginia. (He is a former National Research fellow, and his high-speed ultracentrifuge studies have been supported by the Foundation for years.) Methods of separation by gaseous diffusion, by thermal diffusion, and by magnetic means were also studied.

Princeton early became a center of activity. It was to Princeton that Bohr came on his memorable visit of January, 1939, and the Princeton group heard his report of the European fission experiments first. One member of the Princeton physics staff was John A. Wheeler, a former National Research fellow who had spent his fellowship year 1934-1935 at Copenhagen studying under Bohr. The old master and his young disciple were soon putting their heads together on a theory of the mechanism of fission, and this Bohr-Wheeler theory was a useful tool of research all through the five years of investigation.

Several experimental studies were started at Princeton, particularly one to determine the neutron speeds at which uranium responds to impact. This work was conducted under Dr. Smyth, who later served as historian of the bomb project. H. S. Taylor of the chemistry department was also actively engaged. Back in 1925 the General Education Board appropriated $1,000,000 toward the Princeton endowment "to be used for advanced instruction and research in physical and biological sciences" and in 1929 it gave an additional $1,000,000 toward the building and endowment of the chemistry research laboratory. Princeton was well prepared, with both men and tools, and it rendered many valuable services.

Discoveries at California

While these studies were being pursued at Columbia and Princeton, the men at the University of California were striking new territory. They were discovering two new chemical elements, each a metal more massive than anything heretofore found in nature. Dr. Lawrence tells the story of this double discovery in a single paragraph of a recent letter:

"In the summer of 1940 E. M. McMillan and P. H. Abelson, using the 60-inch cyclotron (and funds provided largely by the Foundation), discovered

element No. 93, neptunium. Later McMillan observed the growth of an alpha-particle emitter from a strong sample of neptunium which he concluded was undoubtedly the daughter of neptunium, and which subsequently has come to be known as plutonium. Thus, McMillan and Abelson were the first to identify correctly a transuranic element, and it was this work that set the whole business on the right track and made the subsequent work on plutonium straightforward and inevitable."

Actually, what McMillan (a former National Research fellow) and Abelson did was to create two new elements. For nature itself, or at least the nature we know on this Earth, has provided only 92 chemical elements. Uranium is element No. 92, so designated because it contains 92 positive charges of electricity in its nucleus. Because it was the outermost element at the time of its discovery back in the 18th century it was named for the outermost planet, Uranus. By bombardment the two young physicists at California forced an extra particle, a neutron, into the nucleus of the uranium atom, and then by two successive spontaneous transformations the overweight uranium acquired first an additional positive charge, changing to element No. 93, and then another positive charge, changing to element No. 94. Since astronomers now know the planets Neptune and Pluto to revolve beyond Uranus, it was deemed fitting to name the two transuranic elements for the two transuranic planets; so No. 93 was called neptunium and No. 94 plutonium.

An important detail in this discovery came later. When plutonium was put to the test, it was found to be subject to fission. When a slow-moving neutron hit it, the plutonium nucleus split into two fragments, with the emission of neutrons and the transmutation of a fraction of its mass into energy. Thus, the creation of this new element provided the bomb-makers with

an alternative material. They could make their bombs of either uranium-235 or plutonium - _if_ they could obtain enough of either in pure form.

This proviso was a very big "if," however. At the time these experiments were performed the amounts of plutonium that had been produced and of U-235 that had been separated were microscopic. The total stores of both elements in pure form in all the laboratories would not fill the head of a pin. To construct a bomb, many pounds would presumably be necessary. And inasmuch as the plutonium had to be made artificially, and a means of producing it in quantity had yet to be worked out, the most immediate prospect for obtaining explosive material in 1941 seemed to lie in uranium-235.

How to get the needle of U-235 out of the haystack of U-238? - that was the problem. It was under investigation in several places, but the results were not very encouraging. There was an urgent need for enough separated U-235 to enable the laboratories to make more accurate measurements of its properties. Beyond that, there was the yet unsolved technical problem of separating the material on a large scale. It was these necessities in 1941 that argued for the completion of the giant magnet of the 184-inch cyclotron.

The Giant Magnet Goes into Action

At the January, 1942, meeting of the Executive Committee of the Foundation a request was received from the University of California for $60,000 to be used "for expediting the construction of the giant cyclotron, and for the purchase of certain associated equipment." Less than two years before, in 1940, the appropriation of $1,150,000 had been made to provide for the construction, housing, and installation of this apparatus. Trustees who now wondered why the university was calling so soon for additional help were

told: "Circumstances have arisen which make it important that the giant cyclotron be available for use as promptly as possible. By working three shifts a day it is estimated that the cyclotron can be ready in four months, whereas the present rate of construction would make it available in eight months or more." The officers who presented the request gave assurance that the need for speed was urgent, but there could be no discussion of the specific reason, and so the appropriation was voted pretty much on faith. Nothing more was heard from the matter until August, 1945, when the explosion of the first bomb was announced. Then, being free to speak, Dr. Lawrence addressed a letter to Dr. Weaver:

"At long last I have the very real pleasure of writing you, and through you the president and trustees, something of the vital part played by The Rockefeller Foundation in the development of the atomic bomb. I shall never forget how you and President Fosdick responded so promptly to our need for additional funds to expedite the completion of the giant magnet, and I am so glad that there is now a story to tell that is in a measure a recompense for your extraordinary support."

What had happened was this. Back in 1941, when all the separation methods that had been tried were able to supply only microamounts of the pure U-235, and investigators in several laboratories were almost frantically begging for quantities sufficient for their experiments, Dr. Lawrence and his group decided to see what they could do on this problem. An obvious way to separate atoms of different weight is to reduce the material to a gas, pass the gas through an electric arc, and then shoot a stream of these electrified atoms between the poles of a powerful electromagnet. This method of separation had been tried by other investigators and rejected. The yield was poor

and some said such was necessarily the case because of a technical effect known as the "space charge." Lawrence and his men felt that this limitation might be overcome by neutralizing the space charge. And since they had the most powerful magnets in the United States they felt that they might be able to get results even though other able workers had failed.

So they proceeded to strip the 37-inch cyclotron down to its magnet, and converted this 85-ton magnet into a sorting machine for separating uranium. The idea of electromagnetic separation is simple. Under the pull of magnetism a stream of electrified atoms is bent into a curving path. But since U-238 is heavier than U-235 by three units of weight, its greater inertia will resist the influence of magnetism more than the inertia of the lighter U-235. Therefore the two kinds of uranium will pursue slightly separated paths, and by placing a container at the end of each path the U-238 may be collected in one, the U-235 in the other. This work began at California in November, 1941.

"Before the year's end we not only had enough uranium-235 to meet immediate needs for research purposes," says Dr. Lawrence, "but also this early work showed that space charge could be neutralized. Thus the possibility of large-scale development of the electromagnetic method was opened up."

This demonstration of the value of the electromagnetic method was made with the 85-ton magnet, and its success spurred the Californians on to try the 4200-ton magnet of the 184-inch cyclotron on the problem. That was the idea that activated the request to the Foundation for the additional $60,000. With this appropriation, plus certain funds procured from other sources, Dr. Lawrence hastened the winding of the big magnet to completion, and it got into action in May, 1942. After that progress began to hum. The

rate of yield increased by a factor of many hundred. There could be no longer any question of the practicability of the method. The government took up the process, it was rapidly developed on an industrial scale, culminating in the great electromagnetic plant at Oak Ridge, Tennessee.

"Now I am sure," writes Dr. Lawrence, "that we would not have gone ahead with the electromagnetic separation work here with such enthusiasm, if we had not had the 184-inch magnet which provided immediately fairly large-scale facilities. It was indeed the existence of the great magnet that made it seem possible that we might be able to get somewhere on the problem in time to be of value in this war. Actually, although the electromagnetic method was the last to be started in development, it was the first to get into large-scale production of material for the uranium-235 atomic bomb. I believe it is true that it was the assurance in 1942 that this method at least would "pan out" that gave Dr. Bush and Dr. Conant final confidence in recommending the necessarily large-scale expenditure of funds. Moreover, it seems clear also that your willingness to appropriate $60,000 to expedite completion of the magnet, saved months in the over-all undertaking, thereby shortening the war.

"As you can see from the above account, The Rockefeller Foundation indeed played a vital role, and I hope this story can be told as a dramatic example of the far-reaching value of the Foundation's support of pure science to our nation and to the world."

The Metallurgical Laboratory

At the time the University of California was beginning its studies of electromagnetic separation in 1941, a group at the University of Chicago was already immersed in the problem of how to achieve a self-sustaining chain

reaction. Other aspects of the problem were being investigated simultaneously at Columbia and Princeton, and by the end of 1941 the results were sufficiently conclusive to convince the scientists that "there was a very high probability that an atomic bomb of enormous destructive power could be made." It was therefore decided to step up the program on all fronts, and as the central agency for research on the chain reaction problem the University of Chicago was selected. Early in 1942 the university set up an organization under the cryptic designation, the Metallurgical Laboratory.

The Metallurgical Laboratory was organized in January, 1942. Within a few weeks Fermi and his associates at Columbia and Wheeler and his associates at Princeton moved to Chicago, and the groups were consolidated into a unified staff under Arthur H. Compton. Other former fellows who worked with Compton, Fermi, and Wheeler at the Metallurgical Laboratory were Samuel K. Allison, Gregory Breit, Richard L. Doan, T. R. Hogness, F. H. Spedding, and Edward Teller. The departments of physics and chemistry at Chicago, which provided the core for this expanded staff, were currently receiving financial aid from The Rockefeller Foundation; the grants made over the years by the Foundation and the General Education Board total more than $1,400,000.

The Metallurgical Laboratory began operations in university buildings but it soon outgrew these, overflowed into outside structures, and into specially designed quarters. At the height of activities the University of Chicago had on its payroll 4,000 scientists, technicians, and other laboratory workers.

The primary task was to determine how to obtain a self-sustaining chain reaction in a mass of uranium. Such a reaction requires a sequence in which the fission of one atom discharges neutrons which set off one or more neighbor atoms, and each of them in turn sets off one or more additional

fissions, the process continuing in rapid succession until all or most of the atoms have split. Doubtless many chain reactions are started in every mass of uranium ore hourly, but they are quenched by the preponderance of impurities, or of non-fissurable atoms, or by other circumstances. One condition that reduces the number of successful hits is the high speed of the neutrons - hence the concern with blocks of graphite and other moderating material to slow the particles and bring them down to a speed that would enable the struck atom to capture the colliding neutron. It was necessary to determine the minimum amount of uranium that would support a chain reaction and the arrangement and amount of graphite that would provide just the right degree of neutron retardation.

These problems were solved in less than a year. On December 2, 1942, the Chicago group erected a curious contraption on the concrete floor of one of the squash courts of Stagg Field. It was a structure of several tons of graphite blocks in which were embedded lumps of uranium. The blocks were piled one on the other in the form of a lattice. The men who worked on this assembly knew that they risked their lives every moment of the experiment. Theory predicted that the chain reaction would start spontaneously as soon as the pile reached the critical size, and the investigators had calculated the critical size and determined the amounts and spacing of the material accordingly. Actually they had underestimated, and the critical size was reached earlier than they expected. However, as a precaution, sheets of a steel alloy had been inserted at various parts of the pile to screen off certain lumps of the explosive. "This was fortunate," laconically remarks Dr. Smyth, mindful of what the completed bomb did to the New Mexican desertland two and a half years later.

After demonstrating that a self-sustaining chain reaction could be set off in a system using uranium, the Metallurgical Laboratory adapted the pile technique to a system for making the natural radiations in a mass of uranium convert the U-238 into plutonium. Out of these studies came the building of the vast plutonium production plant of the Hanford Engineer Works on the shores of the Columbia River. A third problem solved at Chicago was the utilization of fast neutrons in a plutonium chain reaction. This made possible the design of a super bomb.

The Los Alamos Laboratory

The findings of these various projects at the universities and the industrial products of the production plants in the states of Washington and Tennessee reached their application in New Mexico. Here, about 30 miles from Santa Fe, on an isolated plateau whose only approach was a winding mountain road, the Los Alamos Laboratory was established in the spring of 1943.

Unlike the projects at the universities, this one had to start from scratch. Three carloads of apparatus were sent from Princeton; Harvard, the University of Wisconsin, and the University of Illinois each lent necessary equipment; other requisites were bought, subsidary laboratories were built, and today this establishment in the desert is probably the best-equipped physics research center in the world.

It was brilliantly staffed. J. R. Oppenheimer, the director, had another former fellow of the International Education Board, George B. Kistiakowsky, as chief of his explosives division. (Kistiakowsky's researches in chemistry at Harvard have been a subject of Foundation support since 1932.) Fermi moved to Los Alamos and became chief of its advanced development

division. Hans Bethe, a former Foundation fellow from Germany, now professor at Cornell, was chief of the theoretical physics division. There were physicists and chemists from universities all over the country. This final research outpost had the pick of American science - for its job was to put together the jigsaw puzzle of all that had been learned, and design and construct a successful atomic bomb. The efforts reached their climax early in the morning of July 16, 1945, when the first man-made atomic explosion was detonated. Kenneth T. Bainbridge of Harvard, a former National Research fellow, was in charge of the detonation. Over-all supervision of the test was cared for by Dr. Oppenheimer, assisted by many of the other scientists mentioned in these pages.

Medical Aspects

One of the crucial problems was the risk to health. For, quite apart from the fission explosion which occurs under the controlled conditions only when several pieces of the material are suddenly brought together to make a bomb of critical size, the plutonium and the uranium are both radioactive. This means that every second a certain proportion of the atoms are discharging alpha particles, beta particles, and gamma rays similar to those emitted by radium. It was necessary to make sure that no one in laboratories or industrial plants was exposed sufficiently to endanger health. Elaborate systems of remote control were installed, and robot mechanisms were devised to handle the material.

Men on the job carried in their pockets fountain-pen-shaped electroscopes which recorded the degree of radiation they had encountered during the day. A piece of sensitive film was inserted in the back of each worker's

identification badge, and periodical development and inspection of this photographic film was another means of check-up. Radioactive contamination of the furniture, walls, and other structures was detected by means of a specially designed instrument called "pluto." Laboratory coats had to pass the scrutiny of a detecting device before they went to the laundry. It was impossible for one to leave laboratories or factories with contaminations of radioactive material in clothes, shoes, skin, or hair, for concealed in the exit gates were instruments which sounded an alarm whenever minute traces of such substances approached. The final precaution was a periodical blood test, for the first biological sign of overexposure is a reduction in the number of white blood cells. The air within the factories was checked for radioactive dust by a special device known as "sneezy." The use of large quantities of Columbia River water to cool the plutonium production piles raised a question in plant and animal ecology; for the scientists had to make sure that the waste water, returned to the river downstream, did not heat up the Columbia sufficiently to endanger the health of fish, vegetation, and other life which was accustomed to the normal river temperature.

The man in charge of medical supervision was Dr. Stafford Warren. Dr. Warren was commissioned an Army colonel for the period of his services with the bomb development, but in peacetime he is a researcher in radiology at the University of Rochester Medical School, where his work has been assisted since 1931 by grants from the Foundation. Another Foundation-supported project which contributed to the health program was the Roscoe B. Jackson Memorial Laboratory at Bar Harbor. This establishment maintains a mouse breeding section which is a principal center for supplying the little animals to laboratories throughout the country - and 30,000 Bar Harbor mice were used to study the biological effects of uranium and plutonium radiations.

Finally, there is a Foundation grant of $100,000 made to the University of Chicago in March of 1943. Trustees who were present at the meeting which voted the fund may remember that it was "for research in industrial medicine." And that's about all the information provided, beyond the statement "we have the most competent and urgent assurance that this is important." Now it can be told that the $100,000 was for the medical section of the Metallurgical Laboratory. A check-up shows that only $10,931 of the appropriation has been used, because most of the health problems were cared for by government funds. But that $100,000 was extremely useful to those charged with safeguarding the health of the laboratory personnel. Whenever a problem arose, if there was any government delay because of red tape or for other reasons, the fact that the medical men had available this unrestricted fund usually spurred the authorities to prompt decisions and adequate action. It was a useful anchor to windward, that never failed.

Moral and political aspects of the atomic bomb are rightly a subject of acute human concern. No one, and least of all we of the United States, can afford to ignore the awful responsibility imposed upon society by the success of this war-inspired project for the national defense. Confused - even terrified - by the problems raised by both the military and the civilian aspects of the new age which is thrust upon us, we may well wonder whether we are glad or sorry that atomic power has become a reality. But we must remember that its realization was an inevitable part of the forward march of man's conquest of nature. And we can take satisfaction in the fact that when the nation makes an emergency call on science, it turns out that the call is answered with superb competence and that much of the leadership is furnished by men whom the Rockefeller boards selected in the past for training and help.

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A LIST OF FORMER FELLOWS WHO WORKED ON THE ATOMIC BOMB PROJECT

Men trained on fellowships provided by the International Education Board:

- ENRICO FERMI of Columbia University (fellowship, 1924, Leiden)
- GEORGE B. KISTIAKOWSKY of Harvard University (1925-26, Princeton)
- J. R. OPPENHEIMER of University of California (1928-29, Rijks)

Men trained on Natural Science fellowships provided by Rockefeller Foundation:

- HANS BETHE of Cornell University (1930-32, Rome, Cambridge)
- EMILIO SEGRE of University of California (1931-32, Hamburg)
- EDWARD TELLER of George Washington University (1933-34, Copenhagen)
- VIKTOR WEISSKOPF of University of Rochester (1932-33, Copenhagen, Trinity)

Men trained on National Research fellowships provided by Rockefeller Foundation:

- SAMUEL K. ALLISON of University of Chicago (1923-25, Harvard)
- ROBERT F. BACHER of Cornell University (1930-32, CIT, MIT)
- KENNETH T. BAINBRIDGE of Harvard University (1929-31, Bartol Research Found.)
- JESSE W. BEAMS of University of Virginia (1925-27, Virginia, Yale)
- GREGORY BREIT of University of Wisconsin (1921-23, Leiden, Harvard)
- ARTHUR H. COMPTON of University of Chicago (1919-20, Cambridge)
- EDWARD U. CONDON of Westinghouse Electric Co. (1926-27, Göttingen, Munich)
- RICHARD L. DOAN of University of Chicago (1926, Chicago)
- THOMAS R. HOGNESS of University of Chicago (1926-27, Göttingen)
- ERNEST O. LAWRENCE of University of California (1925-27, Yale)
- A. O. C. NIER, of University of Minnesota (1936-38, Harvard)
- J. R. OPPENHEIMER of Univ. of California (1927-28, Harvard, CIT, Leiden, Zurich
- HENRY DeW. SMYTH of Princeton University (1921-24, Cambridge, Princeton)
- F. H. SPEDDING of Iowa State College (1930-32, California)
- EDWIN M. McMILLAN of University of California (1932-35, California)
- LOUIS A. TURNER of Princeton University (1924-25, Harvard)
- JOHN A. WHEELER of Princeton University (1933-35, NYU, Copenhagen)

The institutional connections noted above are those which existed at the time the men became associated with the bomb research project. In several instances changes have taken place during or since the war. Fermi and Teller are now on the staff of the new Institute for Nuclear Studies at the University of Chicago, Compton has become chancellor of Washington University, St. Louis, and Condon has been appointed director of the National Bureau of Standards.