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FRONTIERS OF THE ATOM

It is a great pleasure to participate in this seminar on atomic energy. I am particularly pleased to present some of my views to this audience which includes a number of the outstanding high school science students from the San Francisco Bay area. There is a growing need for just such students as you if the United States is to continue its place in the forefront of atomic development and other fields of science.

The outlook for science in the United States is the most far-reaching of any time in our entire history. Not only are the traditional fields of scientific inquiry of ever increasing scope and importance to us today -- new fields, new pursuits and new horizons have opened upon the scientific scene as a result of the advent of the atomic and the space ages.

But we are not alone in this mushrooming scientific and technological development.

The Soviet Union -- with vast natural resources -- is striving with great vigor to close the gap with the United States in science, in engineering and in industrial development.

We find that Russia is now producing more iron ore than the U.S. Russian crude steel tonnage has mounted steadily in comparison with that of the United States. In coal, as in iron ore, the Soviets have forged ahead of us.

The electrical generating capacity of the United States is the greatest in the world by a large margin, but again, the

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Soviets are gaining. In other basic commodities -- oil, gas, chemicals, cement -- Soviet production is making significant strides, advancing closer to the annual totals of the United States.

One reason for the Soviets' ability to make these material gains is the well-known fact that -- under their dictator form of government -- they can concentrate industrial effort in those areas which contribute most heavily to their basic industrial and military strength. The significance of this Soviet momentum must be recognized.

Science and engineering have telescoped time as a function of distance. Peoples once far removed from one another are now close neighbors by virtue of rapid communication and jet transportation. Deep ideological and political differences, however, separate us from some of our would-be neighbors more surely than distance has done in the past. Moreover, some of the leaders who do not share our deep regard for the dignity of man now have at hand unprecedented means of destruction. The Communists boast that they turn out nuclear weapons like sausages and speak confidently of the day when they will win the world.

Our own ability to strike back with devastating fury at the forces of any who would dare to attack us has held the enemy in check. This ability thus far has frustrated the Communist objectives.

But we cannot in the future maintain our present position of national strength and leadership unless we move ahead aggressively in science. We may no longer complacently assume that we will remain ahead in vital areas of scientific inquiry and technological and engineering development. The Communists are challenging our leadership. This challenge must be met. Most Americans are united in their firm conviction that so long as we face dictators who are dedicated to international aggression and spreading Communism throughout the world, we must remain ahead of Soviet Russia and Red China in scientific development and progress.

But we cannot, of course, succeed in this kind of national effort unless the boys and girls of your age -- the present and future generations of high school students of genuine ability and capacity -- become interested in science and enter into the professions which take them into these fields, including the field of atomic energy.

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It is here that the Atomic Energy Commission has a deep and abiding interest. As many of you may know, it is the Atomic Energy Commission to which Congress, by law, has entrusted the development, the use, and the control of this great new force in our lives. Congress has declared that the Commission shall carry out this assignment so as to make the maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security.

As a part of these responsibilities, the Commission also has been given the task of conducting, assisting and fostering research and development in order to encourage maximum scientific and industrial progress.

A few years ago but a handful of scientists were engaged with the atom. Now, many thousands of scientific people are devoting their careers to atomic activities for the Government and for private industry. Thousands more will be needed in years ahead.

Employment will be found in industrial firms and in college and university laboratories, about which speakers who are to follow me are more intimately informed. Some of these positions will be in activities conducted for the Atomic Energy Commission. Many of these will be activities financed entirely by universities or by private industry.

Almost every kind of scientist and engineer is needed, among them physicists, chemists, biologists, physicians, biochemists, mathematicians and mechanical, civil, electrical and metallurgical engineers.

Ahead for the new scientists and engineers are unexplored frontiers which even now are being pushed farther and farther back from the present boundaries of human knowledge. The programs for which AEC is responsible cover a great range of interest and involve some of the most fascinating scientific efforts man has conceived.

One of our frontiers is the search for answers to one of history's oldest and most basic questions. How is matter constituted? A few years ago we discovered that atoms were made not

merely of electrons and protons. We now have detected many tiny sub-atomic particles and have learned a great deal about their inter-actions. Congress appropriates millions of dollars each year so that the AEC may construct and operate huge accelerators to explore the atom by hurling particles at special targets at rates approaching the speed of light. The huge 31-bev Alternating Gradient Synchrotron of the Brookhaven National Laboratory, Brookhaven, L.I., produced its first beam last summer. This AGS -- largest machine of its kinds in the world -- is expected to extend the study of new particles which are of major interest in current physics and which constitute an important advance in our research on the nature of matter.

As many of you know, this year's Nobel Prize winner in physics is a young American scientist who has contributed greatly to research in this field. He is Dr. Donald Glaser of the University of California Lawrence Radiation Laboratory at Berkeley, who received the Nobel Prize for his work on the liquid hydrogen bubble chamber. Another scientist who has been closely associated with the atomic energy program also won a Nobel Prize this year. He is Dr. Willard F. Libby, who was an Atomic Energy Commissioner from 1954 to 1959 and now is Professor of Chemistry at the University of California at Los Angeles.

Atomic energy also has made significant contributions to the life sciences. Radioisotopes -- often called the most important research tool to be developed since the invention of the microscope -- have made it possible to identify and trace many of the complex reactions which take place in living cells. The increased understanding made possible by this basic research is being applied in medicine and in agriculture, and radioactive materials are being increasingly used in medical diagnosis and therapy.

Another frontier for further exploration is that of metallurgy. Here, for example, research is concerned with the development of new metals and alloys to withstand the ever increasing temperatures which are becoming commonplace in this atomic age. Progress in this area, indeed, is of vital importance if the development of important phases of the peaceful use of the atom is not to be impeded. Scientists and engineers must work together to extract from metals new abilities and capacities scarcely dreamed of heretofore.

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One of the more publicized areas of exploration is the quest for economic use of the atom in the production of electrical power. Today we know how to generate electricity from nuclear sources, and are doing so. However, we have not been able to reduce the cost of this power to competitive levels as rapidly as people once thought. More research and development is required than had been widely assumed. Therefore, we hear statements from time to time about a power lag. The extent to which there may be a lag is subject to varying interpretations and there are some differences as to timetables. But there should be no doubt about the fact that we are moving forward, and the day will come when nuclear power will be a sizeable enterprise.

Working toward that day, new reactor materials are being studied, higher reactor temperatures are being sought, and plant simplification has become a major objective. Nuclear energy still holds forth the long-range promise of abundant electrical power in later years when fossil fuels are no longer able to supply our rapidly growing demand for energy.

I should like to mention, as another frontier, controlled thermonuclear research. This research is directed toward the ultimate production of fully controlled power and heat from nuclear fusion of the heavy hydrogen isotopes -- a process opposite of that of fission. In the United States, the program is being spearheaded at four major laboratories -- Princeton, Oak Ridge, Livermore, and Los Alamos.

All of you here in California may be proud that an encouraging advance in the effort to achieve a controlled thermonuclear reaction was announced just last month at the University of California's Lawrence Radiation Laboratory at Livermore. As some of you may know, confinement of a heavy hydrogen plasma at a temperature of 35 million degrees centigrade within a magnetic mirror machine was reported by Dr. Frederic H. Coensgen. The confinement was recorded for approximately one thousandth of a second -- a duration much longer than anything hitherto achieved. Both the favorable confinement time and the high ion temperature are significant steps forward in this program.

There is also the frontier of space.

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In a chemical rocket, fuels burn and eject from the rocket, producing thrust. In a nuclear system, a light element such as hydrogen is passed over a nuclear reactor. The element becomes rapidly heated and thrust is produced with a higher specific impulse, which means a higher thrust per unit weight of fuel consumed than is true of chemical fuels.

Nuclear energy offers to rockets the most energy per unit mass of any fuel source presently known. It is the key to space travel both for propulsion and for auxiliary power. Only nuclear energy will produce the energy needed for manned expeditions to the moon and for interplanetary explorations.

Finally, the Commission must continue to place great emphasis on maintaining our nuclear weapons capability and keeping it up to date. During World War II, Congress first provided for establishment of several major centers for weapons development and production, where many of our finest scientists are still at work. For more than a decade, nuclear weapons have provided this Nation and its allies with a shield against Communist aggression. A new dimension now has been added to our defensive capability by the nuclear submarine armed with a Polaris missile. Until a safeguarded international agreement to control nuclear and conventional armament can be reached and placed in effect, we cannot relax our vigil. Our atomic shield must remain intact if the Free World is to survive.

These are some of the major areas within this Nation's atomic energy program. The number of job openings is limited except for the talented and energetic graduates. However, the depth of scientific inquiry in this important field and the need for highly advanced technology make atomic energy a formidable competitor for the interest of the able student.

How does one go about becoming a nuclear scientist or engineer?

Let me say, first, that these are not fields for the casual student, the student who is content with average grades or who is capable of doing only average work.

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These are areas, instead, where a high degree of proficiency is required.

Not only academic proficiency, but a capacity for plain hard work is also needed. There is little room for the bright student who thinks he can coast through on his mental ability without the grinding work that is necessary for success.

The student who hopes to succeed should also have a true mathematical bent and an ability to collect data, organize facts and to analyze them.

Finally, he should have imagination, intellectual curiosity and patience. And perhaps most important of all, the atomic scientist should have ability to think for himself, to explore along non-travelled highways, to strike out in new directions.

Presumably, since all of you are now science students in high school, you already are reasonably conversant with the courses of study you should pursue in order to enter the general fields of science and engineering.

You should give very careful thought to your academic requirements for the truth is your future is beginning in the classroom today.

You should, if you are not already doing so, be taking the "hard" courses -- the tough ones that will prepare you for the scientist's exacting role. The atomic sciences are not for the lazy student.

A good rule is to take as many math and science courses as your high school offers without, of course, neglecting other important courses, particularly in the humanities -- such as English, history, Government, and the languages. Do not underestimate the importance of these humanities in the career of the scientist and engineer. They are the courses that help to teach the art of living.

Industry and Government are pressing the universities and colleges for scientists and engineers of advanced training and

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advanced analytical powers. They are also looking for men with a fundamental, integrated education in science, engineering AND the humanities, rather than for men too narrowly specialized in some field of technology.

It goes without saying, of course, that your grades should be good -- the best that you can achieve.

At present one of our most pressing needs is to stregthen and expand graduate education in many fields of science and engineering. In the last fifty years graduate education in the sciences has come to maturity in the United States. We have in this country as distinguished a group of graduate centers as can be found anywhere in the world. But their number is still too few and only a handful excel in more than one field of science.

I believe that the colleges and universities -- upon which we must lean for our supply of trained scientific and technical manpower of the future -- must substantially increase their capability to produce qualified nuclear engineers, scientists and medical personnel if the expected accelerated growth in atomic energy during the years to come is not to be thwarted by the lack of this trained nuclear manpower.

If it is to meet the rapid world changes and vast responsibilities we face today, the United States must summon all of its latent resources and all of its adaptability in strengthening education, in streamlining Goverment and in expanding industrial capacity. We must work at peak performance; we must be willing to make sacrifices. These are the requirements for both leadership and survival in a divided world of the nuclear age.

In only a few years these requirements will have to be met by you young men and women now in school. Some of you may be destined to be pioneers on the still unchartered frontiers of science that are constantly expanding before us as our knowledge of the infinite mysteries of the atom increases.

I truly hope so, for it is with you that the future of our country, and that of the Free World, rests.

Your Government, the colleges and universities and the great industries of your country stand ready to encourage you, to help train you and to enlist you for achievement and leadership in the great future that must be ours.