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UNITED STATES  
ATOMIC ENERGY COMMISSION  
WASHINGTON, D.C. 20545

No. S-47-68  
Tel. 973-3335 or  
973-3446

FOR RELEASE AT 8 P.M. EST  
MONDAY, NOVEMBER 25, 1968

Remarks by  
Dr. Glenn T. Seaborg, Chairman  
U. S. Atomic Energy Commission  
At the Third Annual Banquet of  
GOLD KEY of Nova University  
Fort Lauderdale, Florida  
November 25, 1968

#### THE FOUR HORSEMEN OF PROGRESS

I'm pleased to be back in Florida, a state I have always enjoyed visiting. And I hope you will appreciate the extent of that compliment, coming as it does from a Californian. Unfortunately, most of my stays in Florida have been rather brief--usually not more than 24 hours. But I should hasten to add that this has nothing to do with Florida--only with the nature of my job back in Washington. So there are many other places about the country that are happy that Glenn Seaborg is not the typical American visitor. Strictly as a tourist, however, I do a little better. In fact, I brought my family down here to vacation this summer and we had a most enjoyable visit, one that lasted more than a week--which is something of a record for our remaining in one state.

In looking back over the record of my speaking engagements in Florida I was interested to note that three of the four of those engagements were at universities. Tonight I'm particularly pleased to be speaking to a university-supporting group here in Florida, your "Gold Key" organization, one that is responsible for assisting the growth of an important new educational center here--Nova University. And I'm honored that the Board of Trustees of Nova University has elected me a member of the University's Advisory Board.

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Frankly I can't think of a better place to have a fine university than Fort Lauderdale. After all, if students find it attractive enough to flock here by the thousands during Spring vacation, why can't they spend four or more years here and make the trip worthwhile? I'm not suggesting you set up classes on the beach--or that anyone produce a new movie called "Where the Graduate Students Are." Few professors I know look good in a bikini. But I hope that in the years to come when students refer to Fort Lauderdale as a place "where the action is" a good part of what they'll be referring to will be educational--of course in the more old-fashioned sense of the word.

As I believe it is a subject appropriate to the aims and achievements of Gold Key, I would like to speak broadly on the relationship of four elements in our society--not some of the chemical elements I'm usually associated with--but larger ones with which I've also had some experience. Those elements--or perhaps I should more aptly call them "forces"--are science, industry, government and the university. I believe they are both the driving and the controlling forces of our society today. And I think that to a great extent the health of this nation--and of the world--will be determined largely by the vitality and growth of these forces and the relationship we can establish between them. That relationship is a most important factor. In fact, we need between these forces--science, industry, government and the university--more than the slowly evolving ties that have grown over the past two decades. We need a new kind of partnership--a kind of teamwork through which the whole becomes so much stronger and more meaningful than the sum of its parts.

But before I try to elaborate on this teamwork let me take a brief look at each team member. What do they have to contribute? What is their strength? What can they gain from each other?

To begin let's first look at science. Now most of you will agree it is easier today than ever to "sell" science to most people. Few doubt that we live in a scientific age, that its influence and effects will continue to grow. Actually, what most of us see and hear about science in the course of our day-to-day lives represents only a very small part of scientific activity--usually that part of applied science that has already been transferred into a technology. Computers blink away performing complex functions in fractions of a second, men receive the hearts of others to prolong their life, we prepare to visit the moon and probe the planets--and everyone (or almost everyone) says, "Isn't science wonderful?"

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But to a great degree science is like the iceberg, most of which is submerged and unseen by the casual observer. We still do not realize the full scope or potential of science--the great untapped force that can be brought to the surface. Science in a sense is organized intelligence. And as John Kenneth Galbraith has pointed out, "Organized intelligence is becoming a more decisive resource in modern society than capital itself."

There are innumerable ways to show how the organized intelligence that is science expands the human potential, but one example which I think is quite graphic is the one that Dr. C. Guy Suits, former General Electric Vice President and Director of Research, gave in his presentation "Value Added Through Science." Speaking in January 1967 before the Panel on Science and Technology of the House Committee on Science and Astronautics, Dr. Suits explained how scientific research allows us to "get something for nothing"--or as he amends it "for almost nothing." To point out the "value added by research" he first explained that the most common material in the earth's crust is silicon, the chief ingredient of sand and rock. He then went on to show how the research that enabled us to purify silicon to semiconductor grade--and the tremendous number of uses of the semiconductor as the key to our miniaturized electronics, making the modern computer and most of our space equipment possible--makes the value of the silicon on the average city lot worth over a billion dollars! Of course the real worth of being able to produce semiconductor-grade silicon cannot even be calculated if we were to consider the value of the products and services made possible by the electronic marvels of our age.

Dr. Suits' example is just one of many that could be given to illustrate this "value added by research" concept. I have often pointed out that the discovery of plutonium, along with the technologies for transferring its fissionability into electric power, has a potential value of some 50 quadrillion dollars. But here again you cannot truly project a dollar value on this research-created power because the abundant, low-cost energy it may make available in the future could have an incalculable effect on our industry, our agriculture, almost every aspect of our lives.

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While we can readily see the effects of such research in the physical sciences, we are only beginning to conjecture on the effects of the biological research taking place today. Some people feel that the impact of the manipulation of physical forces will seem insignificant when compared to that which will be generated by our control of life--which appears inevitable if we examine the progress being made today in biochemistry.

But enough about science alone; let me move to the next force in our society--industry--particularly as it relates to science. To have the "capital of organized knowledge"--as Galbraith defined science--is one thing, but to have the incentive, the resources and the management to apply it successfully is what really makes the difference. And these are what American industry provides. It is the competitive spirit combined with ways of translating it into organized action that has made this country so productive--and particularly after American industry embraced science.

If we look back over the past few decades we can also see how dramatically our economic growth has been affected by industry's adoption of research and development and by the growing number of scientists and engineers taken into employment by our major industrial corporations. Science has proved a tremendous boon to free enterprise. That R&D is a basic element of competitive growth in this country is emphasized in the best-selling, thought-provoking book "The American Challenge" by the French writer Jean Jacques Servan-Schreiber. In one of the many examples that Servan-Schreiber gives to show to his fellow Europeans the basis of American economic strength through innovation, he points out that "The U. S. chemical industry...now considers it normal that half its business is based on products that didn't exist ten years ago." He also emphasized how our industry has shortened the time gap between the laboratory and the production line.

The interaction between science and industry is also responsible for another productive effect, one that might be viewed as a form of "spin-off" from broad scientific thinking. What I have in mind is the new level of rationality adopted by business and industry--the use of operations research, systems analysis and the various applications of programmed and computerized methods of planning and conducting business. This aspect of the science-industry relationships may well have the greatest beneficial effect on our society--particularly as it spills over into such areas as urban development and the resolution of environmental problems.

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And this brings me to the role of Government in the relationship of these four forces of society. That the Government's role is changing, and indeed growing, is not because of some mystique of bureaucratic expansion, or because of the working of Parkinson's law, as many who speak so glibly of "the Establishment" may tell you. The tremendous complexities of today's scientific-technological society demand that some element organize and coordinate the other forces at work so that all act in "the public interest." And we are realizing more each day that there is a "public interest" that touches us more closely than ever in so many ways. We can give all the praise we want to the dynamics of competition and the marketplace, but until there is a market value on such things as clean air, unpolluted rivers, more livable cities and greater social justice we will need wise and effective Government--and probably a growing amount of it.

Now at this point there are two things that I should make clear. I believe that private enterprise is responding in great measure to the call for a new social conscience. American industries, individually and through organizations such as the Urban Coalition and the National Alliance of Businessmen, are taking important steps toward resolving urban and social problems. They are cooperating in many efforts to reduce environmental problems. But because of the complexity of these problems and the costs involved in dealing with them private industry cannot do the job alone. Therefore, the Federal Government has a most important role to play in meeting the challenges of our time. It is a dual role that emphasizes both regulation and development. In this respect the Government is a force acting on industry in two ways--feeding it resources (both in funds and ideas) and directing its output to serve the greater public good wherever possible.

I think one of the best examples of this may come from my own agency, the Atomic Energy Commission. At the AEC we have the dual function to both develop and regulate the many applications of nuclear energy. From the development standpoint, this is done in a way so that when a new technology--such as the nuclear power station to generate electricity--has been proved safe, reliable and economically feasible the AEC withdraws its support and lets private industry carry on alone. Of course, our licensing and regulatory responsibilities--handled as separate functions--continue, in order to oversee the public interest.

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Such a process creates a new and important Government-Industry partnership. It does not stifle private initiative or innovation. To the contrary, it encourages it by creating and supporting in their initial stages projects that private industry could never undertake to start alone. For example, private industry could never have developed alone the nuclear power industry which now is responsible for several billions of dollars of business in this country and employs more than 100,000 people. Government-sponsored national laboratories, Government-owned production plants--such as the Oak Ridge gaseous diffusion plant--university researchers under Government contract and Government-sponsored demonstration plants all had to play their part in creating this multi-billion dollar industry that will ultimately supply most of this country's electric generating capacity.

One thing we must realize then is that it is the American taxpayer, through his Government, who is largely responsible for what Dr. Alvin Weinberg calls the "Big Science" of today. And it is this "Big Science"--in terms of such things as our nuclear projects, our space program and our Government-supported efforts to conquer disease and hunger--that is helping us take so many of the great strides we are making today. Unfortunately, we tend to overlook such strides unless they come in the form of dramatic "breakthroughs." But most of our progress today is based on the accumulation of many less dramatic successes, on the teamwork of many scientists and engineers and on the day-to-day work of talented administrators and managers.

There are many people now, and I am among them, who believe that if we could get both Government and industry to bring the spirit, resources and talent involved in our "Big Science" approach to bear on our current urban and environmental problems we could solve them more rapidly and efficiently. I think we are bound to see more of this approach used, much of it dependent on the spirit and talent of many of our young people today.

And this brings me to the fourth element in our society that I would like to highlight this evening. That is higher education--more precisely, the university. Above all the things I have discussed so far, I believe that the extent of our system of higher education in this country is responsible for most of our progress. There is no doubt in my mind, and I'm sure not in yours, that our investment in education is our best investment in the future of our country and perhaps

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the world. All progress begins with learning, and as R. L. Kenyon stated recently in the American Chemical Society publication "Chemical and Engineering News," "The motivating spirit...of an innovative society begins in the universities..."

The importance of the university in this country as a force for human progress was very well stated by an Englishman last year when Lord Bowden delivered his Graham Clark Lecture. In pointing out the historic influence of higher education in the U. S. Lord Bowden said:

"The Great American West was conquered in the laboratories of the Land Grant Colleges, and their graduates tamed the continent. We owe two-thirds of all the food which is grown today in the United States to new crops and new techniques which they developed and to students whom they taught. They studied the Mechanic Arts, their ideas and their graduates transformed American industry, they transformed the very nature of the university, and they helped to create the world as we know it."

As one who has been closely associated with American universities in one capacity or another most of his adult life, and has seen the results of their efforts, I agree wholeheartedly with Lord Bowden's feelings about them. I also believe that the role of the university is even broader and more significant today than ever before and that it will continue to grow. We need from the university today not only the basis for the advances in science and technology that will move our society forward, but we need the wisdom and guidance that can help us put those man-made forces to the most productive and humane use. The university is the logical institution to generate the thinking-in-depth, the research and the insights into problems large and small, that industry and Government can then pursue and help translate into meaningful action. The university is also the training ground for future leaders--and, just as important, for the informed and enlightened citizenry that will select and support good leaders.

Our nation has often been criticized for its materialism, its emphasis on machines, hardware and gadgetry. In a superficial way there may be some truth in the charge, but I believe if anything disproves it in essence it is the emphasis that we place in this country on the education of the individual. We believe, perhaps more than most other nations,

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in the power of the human intellect--its creativity, its inventiveness and its ability to grow and influence growth. If I may again quote Mr. Servan-Schreiber; "All cliches to the contrary, American society wagers much more on human intelligence than it wastes on gadgets--This wager on man is the origin of America's new dynamism."

It is on the basis of this wager that I believe our Government-University partnership is so strong and will continue to grow with each party counter-influencing the other. I have often devoted entire speeches to this particular subject and, as a matter of fact, will be giving such a talk next week at the Eighth Annual Meeting of the Council of Graduate Schools in the United States in which I will discuss in some detail Federal support of higher education. But this evening I just want to reassure you of my belief that, in spite of occasional lags in sufficient funding, such support will generally grow, as will the benefits that can accrue from the Government-University relationships. They must, if this country is to continue its overall growth and leadership.

Specifically in the scientific and technological area I think we will see an expansion of the relationship between the national laboratories and universities or associations of universities, such as we have established between some of our AEC research facilities and numerous educational institutions and associations. I also believe that relationships like these can have a tremendous regional impact and that the business community in a local, state or even interstate area would do well to lend encouragement and support to such alliances.

There is also the alliance between industry and the university to consider--and particularly in terms of the local and regional economic impact of universities and centers of graduate education. As you well know, there is a direct relationship between education and economics today. This relationship can be seen all the way from the economic problem of a single high school dropout through the beneficial economic impact of a large, high caliber university-research complex on a specific area. In terms of the latter, one has only to look around the country to see the effect of strong centers of education on the economics of an area. The Harvard-M.I.T. and Berkeley-Stanford complexes are perhaps the outstanding examples of higher education centers about which a myriad of new industrial concerns have clustered.

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Why such educational complexes have acted as a magnet for industry--and help keep such industry viable and healthy--is no secret. We live in an age when the lifeblood of industry is a combination of innovation and technical competence of the highest order and where the fruits of basic and applied research quickly find their way into the market. In addition to turning out the caliber of scientific and technical manpower necessary to generate this kind of growth, quality centers of higher learning create a focal point for continued development of new ideas and tend to keep around them, or nearby, much of the best talent they produce. In short, they create a stimulating, self-sustaining climate of creativity and growth that is hard to beat.

This is one of the reasons that I would encourage the fullest support of Nova University as a center of higher education in this area. Every effort to make this educational complex an outstanding university and center of graduate education will be repaid manyfold by the benefits that will accrue to Fort Lauderdale and Broward County. I can imagine no more potent magic for economic growth than to add the creative and intellectual climate of a successful Nova University to the wonderful physical climate that nature has already endowed to this area. That is why I hope you will do everything within your means to make Nova University a "center of excellence."

For a number of years I have stressed the need for developing a growing number of these "centers of excellence"--education and research centers of the highest caliber which could be the focal points of intellectual growth, scientific progress and social and cultural advances within our country. The Government has for some time recognized the value of such "centers of excellence." And today an even broader, and somewhat more direct, role is envisioned for them as both Government and large organizations of the private sector, such as the Urban Coalition I mentioned before, are turning to them for cooperation and guidance in seeking solutions to some of the most pressing problems of the day.

Finally, I believe there is another role of the university that must be brought to light. It is a rather awe-inspiring one because indirectly it is one that could well determine the destiny of this nation--if not the world. What I am alluding to is the responsibility of higher education--of the university environment, its administrators, faculty and students--to set the tone for our entire society, to give us

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not just the intellectual resources and trained specialists to help run our country, but to develop and propagate the abiding philosophy, the climate and spirit essential to the health of this new global civilization that has evolved in the twentieth century. In this context, what takes place within our "centers of excellence" during the coming years may well determine whether this civilization--ours--will be a great and enduring one, or whether it will be one that merely reached its moment of glory and declined--to be recorded and written off by some latter-day Professor Toynbee as "an age that could have been..."

I have tried this evening to present some personal reflections on what I consider the four major forces of our society--science, industry, government and the university. I spoke of them as partners and as a team that could accomplish great good in cooperating, supporting each other and working together. Many years ago--centuries ago--men spoke of another team, another group of forces in the world. There were four of those also, but they were destructive forces that ravished the Earth and Mankind. I speak of War, Famine, Pestilence and Death--the Four Horsemen of the Apocalypse. Unfortunately, these Four Horsemen continue to ride in many parts of the world. But perhaps our new team of forces can challenge and prove more than a match for their devastating and ruthless opposition.

In fact, I feel that such a challenge is already well under way, and it is a challenge which none of us can afford to turn from. So let us all become involved in this common struggle, though each rides with the Horseman of his choice. Whatever we can do, as individuals and through organizations such as this group meeting here tonight, to help our Four Horsemen bring victory that much closer and that much sooner, will be worthwhile. And this will be true even if our reward is only a footnote in the pages of history that generations hence may find and read with some small measure of understanding and approval.