SCIENCE AND TECHNOLOGY IN THE U.S. TODAY

Mr. J. Carlton Ward, Jr.

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Reviewed by: Tom W. Sills, Colonel, USA

Date: 16 September 1960

INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

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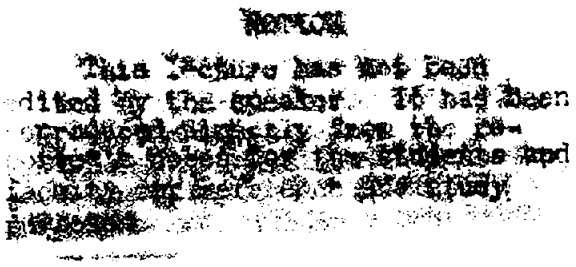
22 August 1960

CONTENTS



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Reporter: Grace R. O'Toole

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington 25, D. C.

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22 August 1960

GENERAL MUNDY: It has been our custom each year to open the academic year with a lecture to the College in a joint session with the War College by the Secretary of State on the world climate. We have had this scheduled this year, but the pressure of current business and the meeting of the Organization of American States, and what not, have caused the Secretary to postpone his talk to sometime in October.

So, as a consequence of this, we have moved an outstanding talk by an outstanding speaker in one of the series of these opening talks up to this position of being the starting lecture today.

I can't think of any speaker who deserves the honor more of delivering the first lecture from this rostrum in this new building to a class than our speaker, Mr. J. Carlton Ward, who will talk to us on the Science and Technology in the United States Today.

You have all read his biography, but I'd like to tell you that he has been a long-time friend to this College. His association began in the early thirties and has been continuous. Currently he is the Chairman of our Board of Advisers. This is a very important group of very important men. He has made a real, substantial contribution to the College.

Carlton, it is a real privilege to welcome you to the College and to congratulate you on this first. Gentlemen, Mr. J. Carlton Ward, President of American Vitro, and Chairman of the Board of Advisers of ICAF.

MR. WARD: Gentlemen, I have some degree of emotion in standing here today. I talked to the General before executing this assignment and told him I felt very strongly that this to me is a milestone, and I am sure it is to you.

First, I want to congratulate you. I want to congratulate you on having been chosen to attend this College and for the opportunity of exploring the curriculum.

I started my contact with the College as it was then organized in 1936, and the quarters which the College occupied had no similarity whatever with this rather palatial accommodation that you find yourselves in today. In fact, my recollection of the first lecture that I gave, which, incidentally, if I remember right, was on the Production of Aircraft Engines, was that the College had more columns in the room than it had students. I noticed all during the lecture, and it got my mind from time to time wandering off the problem, that first the student's head appeared on this side of the column and then it appeared on that side of the column.

So you see that, in looking backward in the corridor of time, this is indeed a milestone. It isn't just a physical milestone, because, even

in those days of the thirties, when America was essentially pacifist in its thinking, there were some of us who had lived through World War I--when I served in the Ordnance Department of the Army at Watervliet Arsenal--who remembered the economic problems that had hindered our military movement. I remember so well how we fought that war with foreign ordnance, and yet we had more time to prepare than you will ever see again. So I was very willing to put my head on the chopping block and come down to talk on the problems of industry in support of the military establishment.

Now, I lived also through the period of the war and then the postwar period, when your College, by official statute became, with the National War College, the apex of the whole military educational establishment. If it had had any aspects of training in the earlier days--and it was in many ways a specialist college for logistic officers—it had taken and struck out in a new direction of the highest professional education. And your charter, as you well know, specifies education for leading in combat. In other words, you will be military leaders, not specialists, necessarily.

The struggle for facilities I have witnessed, and I have even been on the fringes of that battle from time to time. I assure you that, in this period of stringent budgets, for this College to have the recognition that brought this building into being is a definite symbol that in the highest levels of our Government they recognize that, in this age of cold war, this College is performing a unique function.

I would like to add, gentlemen, that it is more unique than you know. There are some officers in the services who have been around the world and have attended other senior military college institutions around the world, and there is no counterpart of this College. You are envied for this opportunity.

I will close this brief introduction of my emotional distillation here by saying that a distinguished French officer, discussing the conduct of our theater commanders in World War II, said, "You know, when we first heard that we were to be commanded by American officers in these large European theaters, we thought back to the days of Foch and Pershing, and we felt that American military commanders were not sufficiently sophisticated. We in Europe had had a long history of warfare between nations, and we had made a study of each other. We felt that America was still somewhat isolated and not sophisticated. And yet, as the war went forward, we found your theater commanders to measure with the greatest military commanders in history." Why? How was this possible? This French officer concluded by saying that he felt that a large measure of sophistication had come about through the work done in the senior military colleges.

Gentlemen, you have an opportunity that even those World War II commanders never had; and that's the mission of this College in a cold war where economic warfare is the mode of the day.

I have just concluded a trip through all the NATO senior commands and our own commands in Europe, and I told General Mundy this morning in our little informal chat together that I was struck by the sophistication of our senior American commanders. Now, I talked with German officers, Turkish officers, French officers, and English officers--all part of NATO command. There was a time, and the General will tell you of the time, when he was a War College student, when he felt he was unsophisticated, and when the English officers assigned then to the War College showed a degree of sophistication which he somewhat envied. This is no longer true.

You have this opportunity, gentlemen, to survey world affairs from an aspect of observation which is still unique in the military system. I therefore envy you and I compliment you.

This is not the subject of my lecture, so I am eight minutes behind, and I'm going to have to steal that back somehow, but I have got something off my chest.

My subject is Science and Technology in the United States Today. Perhaps, in introducing this, it might be well to outline a few areas which I have put down as typical of this challenge. The first one is the biological and life sciences. I am sure that most of you don't feel too much at home in this area, but, if you were subscribers to the magazine, Science, which is the official journal of the American Association for the

Advancement of Science, you would find that at least 75 percent of the learned papers published today lie in this field. This has been brought about by the development of superior instrumentation and the knowledge of radiation and of isotopes. In a way, it is spawned by the atomic age. For the first time it is said that medicine has advanced further since World War II than it did in the thousands of years that preceded that period. Largely, this is attributed to the knowledge that is coming to us through the use of isotopes and radiation.

My second area is an obvious one, and you know more about it than I. This is space science. All you have to do is read the news of the last two weeks both here and in Russia to see the enormous improvement in space science. The challenge in space science is biological as well as physical in its inimical environment for man. In spite of the recovery of the dogs and the broadcasts of the last 24 hours from Russia, it is not simple. When you talk of interplanetary and moon visits and the like, there are still many unsolved problems in this field.

The next area I'd like to mention briefly is that of meteorology and weather control. Now, this sounds like Don Quixote tilting at a wind mill--to control weather. You are all familiar with the fact that the energy in a single tornado or cyclone is thousands of times that of our largest hydrogen bombs. How, then, do we control such phenomena? We control them by catching them in the seed form. But you first have to know where

the seed form exists. So, in this new aspect of meteorology, the world is confronted with the possibility and challenge that science can in a measurable degree change the weather. I don't have to tell you from a military sense what this would mean to you.

The next area that I jotted down is oceanography. This happens peculiarly to be an area in which your major enemy has been concentrating for some time. Many scientists are willing to admit that they probably lead us by a fair margin. At least, the volume of their work is far beyond ours, and we know that their capability is equal to ours. There may be some among you in this audience who would like to challenge this statement. I do not. If you are subscribers to the present magazine, which I think is the best of its kind, the Scientific American, in the June issue you will read the first article by a Russian that exhibits the most exquisite imagination in the entire field of science and experimental physics. For the first time in history we have the fourth set of forces--Newton having postulated the behavior of the first set, which is that between bodies; Dr. J. J. Thompson, an Englishman, having discovered the electron, which led to what we now call electronic forces (which after all is chemistry); and, lastly, the pre-World-War-II discoveries of the neutron forces or nucleon forces that lie at the heart of atoms. No one, no one had measured or had correctly defined molecular forces before. These are almost universally application, thumb prints on a plate of glass, mists

on a window, adhesives, surface forces--and without surface forces there would be no light--osmosis, and so many things that the list would be interminably long. No one had ever measured nor solved nor put a mathematical expression on those forces until the Russians.

So never discount their capability in science. If you are students of the history of science and go back to that of Catherine of Russia and to the National Academy of Science in Russia, you will find sophistication in pure science that was far ahead of our own civilization, or even, I might say, in the opinion of many, that of England as well.

Another big area, to me, is solid-state physics. This is receiving major attention in the United States Government today, because it has been assessed by scientists as an area in which we are not leaders. Gentlemen, I don't have to tell you that nearly everything you do or everything you rely on depends on materials, and in outer space you have demands for materials that do not now exist, that are not available, with properties that we can define but not find.

So we look now to this vast field of solid-state physics, and our Government has come up with the rather disappointing conclusion that we do not even have enough workers in the field in the whole United States. So their first effort is help the selected three universities to start a program for training Ph. D.'s in this modern field of materials which involves the disciplines of advanced chemistry, of physics, of mineralogy, of engineering materials—men who are sophisticated in all four. We don't

happen to have many. This is an attack upon your basic problems in science. This can change much of the apparatus of modern civilization.

Another area and a very neglected one, both here and throughout the world, generally speaking--although I cannot speak for Russia, certainly--is mineral extraction. We have vast amounts of minerals in a highly diffused condition in the United States. The uranium prospectors discovered this. Uranium is very widely dispersed in the world. It is in all the New England granites. If you were the owner of a Geiger counter and you took it to church with you, a New England church built with New England granite, the Geiger counter would drown out the sermon. There is uranium and thorium in all granites, but it is only 20 grams per ton. And yet that 20 grams, in terms of energy, is many tons of coal. So, if you can find the ready means of getting it out, you can shut down your coal mines so far as fuel is concerned.

Now, this is a spectacular way of telling you that there are vast untapped resources, and this is an area for science and technology of great challenge.

I am not at the moment a political orator, and I don't think I ever will be. But this is the document called "Decisions for a Better America," by the Republican Committee on Program and Progress. Imagine my surprise when I started to toss this into the waste basket after scanning the first few pages to suddenly come upon the fact that a large share of this whole volume is entitled "The Impact of Science and Technology."

Now, when a political party is forced to recognize the subject of the assigned lecture today as the largest single component of its decisions for a better America, this College certainly has received another boost for its curriculum.

In the New York Times of last week--and you will hear more of this in your curriculum--is an article, "Soviet Steel Goal is 100 Percent Beyond That of the United States." That article, which appeared on August 16, was the result of a verbatim discussion between Khrushchev and the leader of one of our large American labor unions who went to Russia in spite of being admonished not to do so by his superiors in the AFofL-CIO. This is the Maritime Union. In this discussion Khrushchev set forth his present accomplishments and his goals. When I recovered from the shock of this--that by 1980 he will have a steel production of 265 million tons annually--remembering that our present maximum theoretical capacity is 150 million tons and we are running at somewhere around 80 million tons today--and the Russians feel that they will produce more steel than we in the year 1961--that's not very far off, gentlemen--two days later another article appeared in the New York Times of a Summary of Steel Production in East Asia. Now, China had almost no production. It was in the order of hundreds of thousands of tons. Today China has a very measurable production in the order of 15 million tons--an astronomic rise.

Japan, which in the height of her preparation for World War II,

when she controlled Manchuria's coal and iron, had a production of 7,600,000 tons. Today, with no Manchuria and importing coal and iron to a very large degree and scrap iron from the United States and other places, has today an output of 16 million tons. Fortunately, we count her on our side.

But now, as you go down through Indonesia, Siam, and India, you find stirring this same growth factor. Just as our growth factors were large percentage-wise--and of course they are infinite when you start from zero--their growth factors are very impressive. But I also must say, so is their actual quantitative improvement.

Gentlemen, steel is an excellent measure of technology in any civilization. It is one of the basic barometers, the other one being power. If you will look at any nation and you haven't time for a thorough study and you merely study power capability and the steel production in use in any given country, you will come very close to its economic capability, and, for you even more important, its capability in a military posture.

Now, so much for what I call an introduction. Now on to our subject. First we ought to define science and technology. There is a great area of misty misinformation in interpreting these two areas. They are not alike; they are quite different; and yet they are confused. In the earlier days, when the military establishment was becoming much more conscious of the role of scientists in their overall policy, they confused it. Within the Manhattan District, in the generation of the first bombs, this was one

of the most distressing problems of organization within that great effort. Let's go to the point of what is science. Gentlemen, in the sense in which we discuss it here, science is the behavior and knowledge of behavior of the materials and forces of the universe.

Lord Kelvin, one of the great scientists of all time, defined in a simple way that I think we can deal with/this concept by saying, "If you can't measure it, it isn't scientific." Let's think of that for a minute, because you are going to be dealing with the social sciences, and the social sciences are continually struggling with the inability to measure. This is why it has been said that, if you laid all of our economists in government end to end statistically, they would reach no conclusion. They use figures and statistical methods and mathematics in the development of the material from which they theorize, but, alas and unfortunately, the units that they use are in your old textbooks on arithmetic labeled incommensurable. Who is an average man? What is a constant dollar? What is a measure of gross national product?

Just think, in our calculation in the Commerce Department, gross national product was assigned a quantitive figure for the productivity of housewives. Does any one of you dare to measure the productivity of your housewife?

Gentlemen, social statistics are riddled with assumptions. For my purpose today I will overaccentuate this problem by defining a statistician, which is to say a social economist, as a man who draws a straight line

from an unwarranted assumption to a foregone conclusion.

Much of the data I am going to present for your attention today is social statistics, and I challenge you to look at these data and try to find the Achilles heel, because it's there. Yet I know of no better substitute , and you in your work in this College are going to deal with these figures constantly in one or another variety of forms. So I again warn you, remember that statisticians are human and that any attempt to find out what is the gross national product of Burma, for instance, with no great black boxes and highly organized senses and machinery, and with many of its citizens living in country that is inaccessible, will have perhaps a great area of uncertainty in any figures which you are going to derive. Nevertheless they are the best tools available. And all I can say for the social scientists—because that's what somebody has labeled them--is that they have a very difficult task. Under the impress of Lord Kelvin they are not scientists. They cannot measure.

I want to give you an example of what I mean, because science moves no faster than its ability to measure. In other words, it is instrumentation. It is one thing to put a monkey up in the air, but, unless you know what happens to the monkey up in the air, you haven't done much. So instrumentation is the means by which you can evaluate the monkey up in the air.

Now let me take a simple case. Why did we not know that there were forces in nature millions of times greater than any that man had ever had available until the atomic age? Such an obvious thing--millions of times

greater. This is a revolution, not an evolution, in science. As you know, one pound of uranium, in our imperfect technology today, will generate three million times the electricity that one pound of coal will generate. This is not an evolution, gentlemen. This is a revolution. Why did we not discover this before? A very simple reason: $E=MC^2$, which is to say that the energy equivalent of any mass, M, is that of its mass, multiplied by the square of the velocity of light, which you all know is 186,000 miles per second. You must turn that into feet for foot pounds. These figures become very difficult to handle, they are so large.

But, why did we miss it? I'll give you an example. Imagine on this stage a 5-ton iron ball--quite a large piece of machinery. Imagine under it a burning fire--that's energy. The fire is going to heat the ball from the temperature of this room to that of just before it melts, which is in the order of 2200 degrees Fahrenheit. So let's say that is is going to boost it 2100 degrees Fahrenheit--quite a boost.

Now, how much weight has the ball added by getting that hot? If $E=MC^2$ means anything, the ball with all that energy in it is heavier. Well, the ball weighs five tons. Five tons is 10,000 pounds. There are 500 grams, roughly, to a pound. So that's 5 million grams. There's a thousand milligrams to a gram, so that's 5 billion. The 5-ton ball will weigh roughly 20 milligrams more.

How do you find the scale that will measure 20 parts in 5 billion? You see, gentlemen, it isn't obvious. Science could not have progressed

until it could measure things as precise as that.

This is what the social scientists lack. They have no such accurate measuring devices, and they are, strictly speaking, not scientists. They use scientific disciplines on unscientific material, which makes your work much more difficult. And you should suspect all of your own papers when you draw them up for this College and for your graduation presentations. You must suspect mine, which I am going to show you, I hope, very shortly.

I define science, then, as the extension of knowledge of materials and forces. But you see science is sterile. It is solely an intellectual satisfaction. Then, how does it get into the stream of useful things for man? By the engineer. That's his job. Now you will immediately see why he is not a scientist, nor is a scientist an engineer. This is a confusion that I am sorry to say exists in many minds.

The engineer's sole job is to take new bodies of science and fashion them into the useful purposes of man. The minute he does he is in the field of social science. You can pity him, too.

Let's take building a bridge. A town sits over here and a town over here and a river here. The engineer is called upon to build a bridge. Well, he first selects his materials from fairly scientific measures. This, one might say, is almost a scientific decision. Having selected the materials, he then computes a design. The design is fashioned on the elastic properties of materials and the mathematics of elasticity--

creak stress, thermal shock, and fatigue. However, because of the uncertainties in any complex of this type, there creeps in a factor of safety, called by engineers in their own profession the factor of ignorance. The factor of ignorance is present in most all structures. It simply covers up the things that the engineer can't measure and doesn't know.

But this is not his uncertainty. No, no. Now, how wide shall the bridge be, and what load shall it be designed for—because it is going to be paid for in a bond issue which has to be retired over 50 years? This is another way of saying the bridge must be useful for 50 years in order to retire the bond issue, or the money will not be loaned.

Now the engineer must take out his crystal ball, polish it with his best rouge, look into its depths, and decide who is going to cross this bridge 50 years from now, how many of them, and in what kind of vehicles, with what sort of axle loads, at what speeds. Speed affects design; axle load affects design. Total weight affects design.

So now the engineer is a social scientist. And God pity him, because, if he can pay off the bond interest and the amortization of the bonds, he has accomplished, in these days, a modern miracle. Now, this separates him from the scientist. The scientist is not geared to this, because the decision of that engineer is semi-intuitive.

Gentlemen, when you deal with engineers, remember, now, just as your decisions on the battle field are not done with black boxes and slide

rules and are intuitive, and come out of the whole wealth of your experience as military commanders with all the knowledge of your art, all feeding into the greatest and most wonderful black box in the world--and I hope it's your head—so it is with engineers. Out of that comes decisions. So the engineer must apply intuition. And no scientist worthy of his salt dares to apply intuition to his problems except in an imaginative sense.

I again refer you to the Scientific American and the paper by the three Russians to see one of the most elegant experiments, I think, of all time, applying more imagination than you will find in one scientist out of millions. It's a lesson as to the capability of your adversaries.

Now we have a definition for the technologist and for the scientist. Do not ever confuse these, gentlemen.

How do these things progress? They progress by research and development. Research is brand new. It was started in the United States in a practical sense in the year 1900. That's why I call it brand new, because I'm that old. The first laboratory was that of the General Electric Company, with seven scientists. We did not understand research. We understood invention, because we are an inventive Nation. Thomas Edison, the great symbol to the whole world, is the inventor. But this is the worth of a man, by persistence and imagination and cutting and trying. He tried, it is said in his memoirs, over 900 different materials before he finally hit one that would be a filament in a carbon lamp. And

it had to be discovered before he could make an incandescent lamp. That was discovery, gentlemen. Discovery is not research, although research can discover.

Research is the careful, concentrated attack of a group of correlated disciplines on a common problem, organized and, I hope, supported consistently. One of the errors that the military establishment has consistently made is treating research teams like procurement teams which you can turn on and off with budgets. You can't. If anything has damaged our military projects more than anything else I will lay as No. 1 the inability to support consistently or to create in the scientists' minds that you will support consistently a challenging effort. Remember, when the scientist leaves such a project he takes his black box with him and the new black box that comes in has a different personality and approach, and the lost motion is terrific, as well as the added cost.

So research and development, then, is the tool of science and of technology. Now, development is the section that concerns technology. Here again there is a great misunderstanding. I founded the project for propelling aircraft with atomic energy, and I lived through five years of it. In a few moments I can show you my scars. Gentlemen, that was one of the most misunderstood, mishandled programs in the whole military establishment, as far as I know, in the history of the country. That's taking in a lot of territory. I use as my authority for

that statement the first published record by the Joint Committee of Atomic Energy, which they finally made public after classified executive hearings for years and years and years. It is a perfect example of how not to develop something.

The elements of that study would be worth a whole project in a college such as this. Why have we no nuclear propulsion for airplanes? We've got other things that are just as difficult. You are going to have, now. Imagine my surprise when a document issued from the Defense Establishment, signed by two distinguished military men, both of whom had opposed that project through all its early history, who were then saying why we had to have it. This is very interesting.

So I will tell you again: This question of research and development is not always as simple as it seems to you gentlemen who are in procurement or will be in procurement or will be in charge of procurement. Let me say that development is not research. The engineer learns only by doing. Much of the argument on the ANP Program has evolved around the question of whether you should wait until you have a good, serviceable design that can go into a combat mission on a supersonic level--just think of it—as your first problem. This is like asking a child to run before it ever learns to crawl.

Because that was not a readily attainable objective, the project went along using money, using money, and time and time. This is an example of the difference between understanding development and understanding

science. The science has been moving ahead. In 1947 one of the most distinguished scientists in the world, here in the United States, wrote a document on feasibility for that project, and we haven't got it yet. He said in effect a very interesting thing as a great scientist: "Scientifically this project is feasible. I cannot speak for engineering. It is not my field." And of course the project was an engineering one of reducing the science to an article useful for man—in this case you, the military establishment.

So I now have defined a booby trap for you. Look out for the difference between development and research. Now, gentlemen, I don't have to tell you of the factor of surprise in warfare. All of your military indoctrination has emphasized that the nation with the element of surprise has a terrific advantage. But you don't have that.

On the other hand, there is no democratic principle or attitude of morals or otherwise that prevents you from surprising the enemy scientifically. Let me point out to you that it was the element of surprise that won the battle of Britain over the German Luftwaffe. They did not have a single airplane in the German Luftwaffe that had proper defensive armament, and the British had invented the Boatman-Paul revolving gun turret which let them get alongside and shoot them down like birds. To do so they had the radar which the Germans had not anticipated, which allowed them to be at the right place at the right time. All you want as a military man is to be at the right place at the right time. Remember General Forrest's

famous statement: "Be there fustest with the mostest." If you can be there and if you've got the mostest, meaning the best weapon system, you've got it made.

This is the element of technological surprise. I don't have to illustrate that. But let me say that this is the big area of conflict today between you and your enemies. They are very alert to this. So you in this Industrial College, above all the institutions in our whole military establishment, have an opportunity to study the element of technological surprise.

You must have technical intelligence to do this. Here again, we were very weak. I served on the first Hoover Commission. We took endless testimony and it came up over and over again that the CIA and the intelligence sections of our Army, Navy, and Air Force were highly deficient in technical intelligence and medical intelligence, two areas that are absolutely necessary for survival.

Now, I am not up to date with these great agencies today and I cannot say whether you have caught up, but I can say that if you haven't caught up you are vulnerable.

My third issue in this area is the education of military officers. Fortunately for me, I'm getting educated in serving as the Chairman of the Navy Board, which is considering the educational requirements for officers in the future. We have overhauled in policy the approach at Annapolis, at the Postgraduate School at Monterey, at the NROTC Program,

and at the postgraduate courses in the universities. I know that the same ferment is working in the Air Force and in the Army. Gentlemen, just as you represent a very sophisticated level of education, and you are getting more of it in this College, which your colleagues did not have even 10 years ago, it is vital that officers who come 10 years after you have an education that you never had. It must take into account science and technology and some of these sweeping areas which I have only introduced here.

Now for my last consideration in this summing-up. You will at some time in your career probably be faced--many of you will--with the decision of where your money goes--hardware or research and development. You've seen this epitomized by the B-70. I could name any number of other issues, but that has been so well publicized in the press. You are going to have to decide at some point on which of these two you want.

Years ago in the thirties I lectured at the Air University . General Orville Anderson was then the Commandant, and he was the famous exponent of pickle-barrel bombing. In other words, you could go up with the modern bomb sight and put a bomb right inside of a pickle barrel from maximum levels. This was his thesis and he was charmed with the concept. The result was that he was orienting his entire college toward the fact that in the pre-World-War-II budgets without enough money all the money should be put into bombers.

I didn't know this when I was invited to lecture, although I am a friend

of Orville's, and I got up and devoted an impassioned two-hour lecture, at their request, to the importance of research and development over hardware. At the end, Orville Anderson, the polished military leader that he was, got up on the stage, looked out over the class, and in a few well chosen words said, "Well, Class, now we'll go back to the bombing problem." I am an admirer of Orville Anderson and a lot like him who believe what they believe and fight for it. He certainly did, although as you know it caused him a lot of heartburn.

All right. Now we are going to have slides.

Slide 1.

Please look at this. This is one of your big problems. The best information I could get goes back to 1955, for which I apologize. Not even this College, with all its library resources, could get me anything more recent.

Please notice the USSR in degrees awarded in science and engineering. I am going to use only broad figures. Here you see 91,000 for Russia. United States 53. And here's United Kingdom, France, Germany, and Italy. Gentlemen, notice the total of these awards. The Soviets have less than the United States. Here are your allies.

Look at the percentage in science and engineering degrees in the Soviet. Look at it here in the United States. Do you want to see why they are overtaking you in many scientific fields? Here is the score sheet for you.

Slide 2.

I got this from a logistics meeting at the Ohio University, where all of the leading logisticians of the United States attended a three-day meeting. They came up with this amazing chart. You will note that the number of engineers per thousand population has affected the living standard for the gross national product per unit population. Look at that correlation and tell me whether you think that's a sheer accident.

Gentlemen, that is no accident. It is the engineer who takes useful science and fashions it for the useful purposes of man, and this gives you your strength to wage a military campaign and support your military posture. If ever there was an amazing correlation here it is.

Slide 3.

Here is my next exhibit. Being an engineer, I have trouble with some of these conflicts in economic theory--all these things we did through the long period of our political history. To me, things are created by either people or people using machinery, and machinery uses power. So, in an effort to get to the root of things I am going to examine the amount of power which is readily available in the United States from the earliest records, which are back here in 1895--actually 1893. Then I am going to see what the economy, or the gross national product, or the standard of living--for this is all per unit population, to get away from population growth--has done in the same 50-year period.

I submit this, gentlemen, as my version of economics. It says this:

A nation's production in services, such as transportation and the like, and goods is a product of force and manufacturing capability on the theory, guided by men, of course. So this says to you, "If you want to examine a nation's capability, look at its power resources."

Slide 4.

Well, what are the sources of power? Energies. What are the normal energies today? We can leave atomic energy out. Here is the period going back before the Civil War, when you had wood-burning locomotives, and wood-burning steamships on the Ohio River, all moving military materials and what not. So wood, you see, has had some significance. Here was anthracite coal, and here you had bituminous coal. Here was water power. Here was wind. We have plenty of that unharnessed nowadays. Here are work animals. And of course, at the top, there are your forbears. They carried the water and pushed the plow and toted the wood. They really did something.

Now you see where our emphasis is today in 1960. I was once asked by a class like this: What is left now for people to do, in the physical sense of contributing toward their own satisfaction and civilization? For a moment I couldn't come up with anything better than motor-driven zippers.

However, this shows that work animals are fading from the picture. Wind power is gone. Sailing boats are of no importance. Wind mills are normally of no importance. You see that weather power stays in about

the same position. These are percentage charts. And, of course, natural gas, petroleum, and coal share equally--third, third, and third--with the sources of energy in the United States.

So, when you assess the power of another nation, particularly an early industrialized nation, look at the energy resources of that nation.

Slide 5.

I put this in because it is shocking, in a way. This is a picture of an oil refinery, and these are the first distillations--the cracking of the petroleum. These are the intermediates, which we will skip. Now we come to what you do with them: Resins, antifreeze compounds, dacron, orlon, dynel, acrilon, ethyl fuel fluids, polyethylene, detergents, paints, explosives, synthetic rubbers, nylon, lacquers, fertilizers, explosive paints, insecticides, and so forth.

Gentlemen, there is a whole bundle of things, and you haven't got a civilization if you have to go without them. They come out of the chemistry of oil. If you go on burning oil to get some energy out of it, and wind, and other sources of energy, you are going to face up to a problem before too long.

Slide 6.

This is an illustration of how the engineer learns by doing. This is the Nautilus. This is a new slide and somebody has sabotaged it. I'll have to talk to you from the facts and not from the slide. This proves this is not an exact science.

On the first voyage of the Nautilus she went 60, 340 miles, if I remember correctly, on her first atomic fuel charge. On her second charge she went 95, 000 miles. Somebody has added those together, which is where they pulled the boner. The point I want to make to you is that the second design of fuel charge for the Nautilus had a 50 percent greater capability--and all of this in a couple years of atomic knowledge. Now, the third charge, which has just been loaded in the Nautilus a short time ago, Rickover testified in Congress has been designed to go 135, 000 miles.

Gentlemen, the engineer learns by doing. This is the point I want to get out. This is what's wrong with the ANP Program. You will notice that in the brief time of the Nautilus the first fuel charge went 60, 000 miles, the second one 95, 000, and the third 135, 000. I don't know what the fourth will do. He testified that a submarine with this fuel capability can fight a five-year war without refueling.

Slide 7.

This is an example for you of how engineering progresses. This is the requirement calculated of expansion of our energy requirements in the United States. This is the sinew of the cold war with Russia. You will see, if you are mathematically inclined, that this wavering curve is an exponential one in which the volume of power doubles every 10 years. Gentlemen, these records go back to 1903, as I told you. If this curve is correct and if you go back to 1903—you see this is 100 instead of zero,

because zero is down here (indicating)--with this curve as an exponential curve, you will find that the power today has to be two to the fifth power, which is another way of saying 32 times. And so in that brief period your country's power capability in electrical distribution is 32 times what it was 50 years ago.

This is the period that of course we are competing with Russia on. She's down in this area here (indicating). Because of the characteristics of the Russian economy she can actually speed up this thing beyond the American speed if she chooses, because this is a response to the actual need of the economy, whereas Russia can do it by fiat.

Slide 8.

You will notice that the utilities are putting their hard money on the line and it is going to double in the next 10 years. This was done by Westinghouse--it's probably a little out of date, but it shows the point. The figures on this side are heat units. Don't attempt to define them. They go away up into fantastic figures. These are large heat units. This is the total amount of oil converted to heat. This is the total amount of coal converted to heat in the world. And this is the water power. The reason this is large is because it rains every year and you never use it up. The reason these things are limited is because they were put down 300 million years ago and we are using them up and we are just not putting down any more coal and oil. So they're gone.

So this looks pretty important. Now, if you add all the water power

and all the coal and all the oil, and you plot it over on these heat units, which are simply fantastic--they are a million times a million times a million B. T. U. 's--beyond any slide rule's capacity--and if you take those heat units, which are calculated to run our civilization until the year 2050, you need this many (indicating). The total called for in war time is this much (indicating). Your civilization is doomed--if it were not for atomic energy.

This is the point that the unscientifically educated journalists have never properly seen in perspective. It doesn't matter whether they think that atomic power is a competitive word for Diesels, carbon fuels, and fossil fuels or not. It is immaterial. Civilization goes back to barbarism. This is a scientific technological challenge in development.

Slide 9.

Here is electric power production in Western Europe and Canada, and total West. Here is the U.S.S.R. and her satellites and Communist China. This means you've got one terrific edge over Russia. But do remember that she devotes a larger part of this to war-making than we devote of ours to war-making. So it is not quite that simple. Like all statistics, you've got to look behind it. It's later than we think, but we still have a preponderance of capability, as measured by one of the greatest single indeces that you can use to support the kind of studies you are going to make, which in turn support the military effort, whether the professional combat people without your experience know it or not.

Slide 10.

This is just put in to be spectacular. There is the United States portion of the world population in 1960. This is the amount of power out of the total power that we've got in the world. So you see we still have an enviable position, if we don't lose it.

Slide 11.

This I put in again to prove to you gentlemen the theory that the engineer learns by doing. Don't get fooled. Thomas Edison in 1882 built the first electric steam station . As near as we can get from the records of that period of Consolidated Edison of New York, he used 19 pounds of coal to get one unit of electricity. By 1905, as you will see up in here, they used about 6.

Now watch what has happened through the years. When I graduated from college, which was a long while ago, this was considered fantastic. I listened to some papers in the Joint Engineering Society/Building in New York with my mouth hanging down, about the terrific strides in fuel economy that were being made to get this 3-1/2 pounds for fuel oil.

Gentlemen, we are down now to 2/3 of a pound, in a station that is being built out in the Ohio Valley, with 5, 000 pounds steam pressure and fantastic temperatures.

This shows you the engineer at work, and it shows you how the engineer has to keep going. He doesn't do like the scientist, suddenly have a vast break-through, and whammo, we're off. This is what the military is

English friends do not understand how the American Government works. Neither do I, but I have observed that it works very well, and I can only conclude that the common sense of the average American voter is superior."

I rest on that point. I am not a politician and I am not able to discuss the theory of the socialistic approach or choice, which is the planned economy. I can assure you, lastly, that Russia is departing more and more from it, although there is still a very large element of it in the Russian National Academy of Science, which is the biggest scientific body in the entire world and for whom incentives of tremendous scope are provided. So that even within their tightly packed bureaucratic mechanism of the Academy of Science they superimpose incentives.

CAPTAIN HYDE: Mr. Ward, we don't have time for any more questions but I am sure there are many more here. I thank you now for having given us a very fine speech, a wonderful question period, and an outstanding beginning for our academic year. Thank you very much.

MR. WARD: Gentlemen, let me say before I leave this platform that I am very honored to have made this first lecture. I wish that it were of a higher level than I can provide, because I think you deserve it. As for me, I am honored.

always looking for, looking for an engineering solution to a weapons problem that just revolutionizes the whole darn thing, and you've got a one-weapon war. No. It's done by evolution.

Slide 12.

Here's another curve just like that one. The fuel charges of the Nautilus convince you that it is done by evolution.

Slide 13.

Now, here is something that is of great interest to everybody in the profession. Here is Admiral Rickover's shipboard station. Unfortunately, the Admiral makes the mistake that I make and you make, as Americans. We are specialists in some fields and we all of a sudden think we are in everything. So he came out with the statement that the shipboard station proved that it was silly to talk about atomic energy competing with coal and oil. He wasn't speaking of things he knew about. He didn't know, or if he did know he forgot, or if he didn't forget he didn't choose to speak. Whatever it was--my firm is designing a station which in the year 1961 will have a fuel economy of 13.4--right plumb in the middle of the study made by two gentlemen, Davis and Ronalds of the ABC, in an effort to quiet this turmoil on world atomic power as being competitive.

Please notice the drop from here to there (indicating). I could plot a curve here of the improvement of economies, because the vacant station in Chicago is supposed to have an economy here, and there are stations now in the union which will have an economy here (indicating).

Either Rickover is right or the rest of the world is right. The point I am making is that that is the same curve you saw. It's the same one, with the Nautilus.

Do not discount the orderly process of engineering development.

Slide 14.

This is the number of reactors projected in the world. Look at them. People aren't insane all over the world. They are not just throwing this money away for fun. It's here to stay, gentlemen. It's here in a big way. This is going to be one of your studies at some point in this College not too far off.

Slide 15.

This shows you the growth of the aircraft industry. The reason I am showing you these things is to show you the attributes of science and engineering at work as they affect you. Here were the sinews of our first two wars. The Wright Brothers flew in 1903. It was not until 1914 that somebody conceived the idea that you could drop bricks from airplanes and hit people on their heads, and so forth. They were firing pistols at each other in the early days from one airplane's open cockpit to the other. General Mundy can tell you a lot more about these things than I can.

So we built an awful lot of planes in this period here, as did our allies. We went back to barnstorming. People went around in jennies at county fairs, standing on their heads on wings, and this kind of business.

There was no business.

Yet there were a lot of us in those days who agreed that it was here to stay, just as we believe today atomic power is here to stay. So it was a development by engineers. You can't see it on this curve, because we are down close to zero, but there was a steady upsurge here, percentage-wise, of the industry.

This period is the famous period of the airmail. The Signal Corps killed a lot of very fine officers who were not trained to do what by fiat the Government said they ought to do. It was a tragedy, but it did serve. Those men did not die in vain, in another sense. It served to highlight something.

So after the crash in the stock markets of 1929 here is where the airmail had gone. The New York financial markets said, "Oh, boy, let's get a bull." This was like the uranium early days and the financing of electronics in the early days, and the fire falls, and all these new things like rocketry and what not. The financial markets put this thing up and then when the 1929 collapse came and the money faucets were turned off the whole thing collapsed, but not back to zero. Call this a mental aberration.

By 1939, when we were still talking about peace, I was then running the Pratt and Whitney Aircraft Company. In this year, 1939, I was told by a political figure high up in the Defense Establishment that, since a very distinguished gentleman had gone to Germany and had seen liquid-cooled engines, there would be only liquid-cooled engines in our aircraft

from this day on, and he gave me six months to turn Pratt and Whitney's years of research and development on air-cooled engines, the best in the world at that time with the Curtis-Wright Company, into liquid-cooled engines which the war showed were not the best in the world. This was a political decision by a man who did not understand either research or development, or even the techniques of the art.

All I got out of that interview, which was the most unpleasant one I ever had, was a corncob pipe, which somebody had given him a bowl of when he was on a political journey. I still have that pipe.

Here is another lesson which I am going to set down only briefly to you. This is civil aviation, as apart from military. The reason I did not put aviation up to date on here was because it would require a hall two or three times the ceiling height of this one.

This is one of the great problems of these logorythmic curves. This, then, is the beginning of civil aviation here, in months and years. Demands resulted in recognition that air transportation and air transfer were salable and committed, and this industry did not go back down after the 1929 crash but kept right on going up and has been going ever since.

Now, I plotted on here something for your use. This is atomic power, and if you will take this and plot the atomic growth you will find that it follows the same general rule. This is the growth of a new science, by engineering and technology.

I am putting together another curve. This is the military use of atomic energy, and now the civil use, beginning. This curve is built organizationally, like you see for the civil aviation.

I want to emphasize an important point. I don't think that as military men you all appreciate the enormous effect what you do has on the civil economy. If there were time I would go into the question of how our civil economy has been reshaped by purely military development. After you get through with it, the civil economy sees that there is something new and harnesses this thing, and pretty soon they've got what the military has. It has occurred over and over again. Your contribution, instead of being a waste, as so much of the oratory in our legislative chambers is painted to be, is really the source of much research and development and enriches your whole economy.

I diverted to tell you this, because I am also a member of the National Planning Association, and they submitted a paper to me for critique the other day because I have lectured before audiences like this in the military colleges, on the importance of the research and development for military purposes on the civil economy. All this paper is is a two-year study, financed by a leading foundation and the National Planning Association, to find out the mechanism by which this military knowledge, such as is here, leaks over and is used by the civil economy here. They are already convinced of the statement I have just made that this is one of the great enrichment streams of our civilization. But they don't understand the

mechanism by which it is done. Who does it? How is it done? Are the classified papers finally declassified and do they get read by general engineers, or do the engineers migrate from classified to unclassified zones? What is the method by which this information generates these things in the economy?

Slide 16.

There is your electronics. It's the same darn thing as in aviation, except this is World War II. I don't have to tell you what the invention of radar and all these other things did to the whole electronics industry. You see the thing, "Bring the boys back home by Christmas." They came back to a continuation of the growth. It occurred exactly as I showed you in a prior slide. There are the same characteristics. Again military developments leaked over to the civil economy and enriched the civil stream. Here is the total of the military electronics. Here is the total of electronics. Already they have beat you out.

Slide 17.

This is a little hard for you, I am afraid. Gentlemen, this is a curve which in itself is extremely significant. It took me some time after I put it together to understand it. Here is the straight line from an unwarranted assumption to a foregone conclusion. This is what in engineering is called a shotgun diagram. In other words, here are all the little shots scattered around, and the line seems to go through the field. At the top you find our dear United States. It says that the gross national product per unit of

population is the greatest in the world. We know that. We've got the highest living standard. It depicts it on the chart. It also says that, strangely enough, we have done it by consuming more energy per population than anybody else. All I am doing is proving all over again what I believe anyhow. I am trying to prove to you that, if you want to investigate your military posture, for Heaven's sake, look at the power utilization. Again you see we use more power per unit of population and we come out with the greatest economic strength.

You see the countries associated with us, on the upper part of the curve. Then you see where the Soviet Union lies--away down here. You've still got time, but you've got to realize some of these science and technological factors. They are not political; they are not psychological; and they are not too easily understood.

Slide 18.

Here's another one, to give you a blast, to show you why I don't want you to fall for any one exhibit. This is the growth of population in the United States. At constant dollars--God bless me, I wish I had some--this is the gross national product. You will see there is no connection. It isn't due to the fact that we are growing a large country that our gross national product is going up. It is only a minor underlying influence.

Slide 19.

There it is per man hour. That's another way of looking at it. Again you find the characteristics of the exponential curve. This is another

way of translating the application of so-called automation--engineering tooling and techniques, mass production, and even the human resources, management, all combined to make a more virile economy.

Slide 20.

Now, gentlemen, there is the Soviet curve. This is the control system in the largest atom smasher in the world, at a place called Domnyo, outside of Moscow, that some of our scientists have been to. It is a monument. All of the representatives of minor nations and neutralist nations are carted through here and are shown the sophistication of Russian science. This is a pure scientific instrument. It does nothing for the military or the civil economy as such. It does exactly what Brookhaven tries to do in building its new higher energy machine. This machine is six times as large as our largest machine.

I wouldn't feel too bad about that. I think I know the Russians' purposes in these matters, and to separate propaganda from accomplishment is not easy. But the point is that the scientists who have seen it tell me that the engineering of the vacuum system, the high vacuum system, the engineering of the proton gun system, and the engineering of the electronic impulse system are engineering, not science. They tell me these things are more finely engineered than our best instruments.

This is for you to think about. Don't underestimate capabilities engineering-wise or any other wise of your adversaries.

That's the last chart. Admiral Patrick asked me also to comment

briefly--which is difficult, as you see I am not brief--on the excellence of Russian technical education versus ours. Here I am not the expert. I cite some experts. A study will reveal to you these characteristics.

1. The Russians do not force people to be scientists; they encourage them, encourage them in the best way that is known--money. If you are a Russian father and you have a son in the secondary system of education, he is rated with every other person. And remember that Russia has less illiteracy than we have. There is more nearly universal education in Russia than here. You don't dare be a truant in Russia. You do here. Go down among the Mexicans in New Mexico and see how many of them go to school. In Russia you go to school. Furthermore, when you go to school you are measured, and, when it comes to the attention to the State Bureau of Education that your measure is high in mathematics and science adaptability, a gentleman calls on you, and says, "Son," or "Daughter," as the case may be, "You are qualified for a free education at the expense of the state, plus a salary or living expenses. You may pick the university or college of your choice, and you may also pick the course of your choice, provided it is in science or engineering. You don't have to take this offer. However, if you take the offer you not only get this free education and automatic application to the college of your choice but a guarantee that upon graduation, if your marks are above the assigned state level, you will get a job at from 2 to 3 times the prevailing wages, with fringe benefits in addition."

Now, what Soviet son or daughter is going to turn that down? So you see the motivation that prompted the first chart that I showed you.

2. What is the quality? Our National Academy of Science Foundation has made a study of this. Professor Carroll has made a study of it in his great work at M. I. T. They have come up with the fact that Russian engineers, about which I will speak only for the moment, have an education equal to ours, superior in some respects, and inferior in some respects, but overall equal. They are five-year college graduates instead of four, and only a few American universities today require five years for engineering. They are not heavily indoctrinated politically. In other words, they don't waste their time in college with political lectures per se at the expense of their studies.

These Russian engineers, men and women alike, with no line drawn, come out as finished products, ready to go to work--which ours do not. I think there we have the advantage. Generally speaking, our education is broader. Generally speaking, theirs is narrower and deeper. A mechanical engineer doesn't come out necessarily as a mechanical engineer; he comes out as a refrigerating engineer, or an air-conditioning engineer, or a boiler engineer. Ours come out as mechanical engineers.

So our boys take a year or so indoctrination in any given industry in which they attach themselves before they become practicing engineers. But they have a greater potential for leadership. Russia has discovered this.

This is the Achilles heel of her system. But don't underrate the whole man.

I cannot devote any more time to this today. I have run over my deadline. I merely wanted to discharge the request of Admiral Patrick and to say that I feel as strongly about this as I feel about any of these other matters.

We must look to American education, just as you in this College must look to your military efforts to maintain our position in this world cold war.

Thank you.

CAPTAIN HYDE: Gentlemen, Mr. Ward is ready for your questions. If you will indicate your desire to be called upon by a show of hands, not all at once; you can ask the question whether I acknowledge it or not.

QUESTION: Mr. Ward, from your lecture we got the distinct impression that in some respects we lag behind the Soviet Union insofar as the output of scientific personnel is concerned and that we are currently ahead insofar as the output of engineering personnel is concerned, and that Mr. Khrushchev has stated that by about 1980 the Soviet Union will have surpassed us in gross national product and that in part this prediction is based on his anticipation of continued growth in connection with scientific and engineering personnel output.

You stated in the course of the lecture that we still have time. The

question now is: We have time to do the thing that we know we have to do but how are we going to do it and what is it? I am speaking now with respect to increasing our output of scientific and engineering personnel.

MR. WARD: To go back to your first remarks, I do not know that they are ahead of us in either science or engineering, other than in volume of graduates and that the graduates are good. I know that the total number who are processed is only about equal with ours now. In other words, you see, they had a big deficiency to make up. They have been catching up on that deficiency by graduating more than we do, only since the war, because, prior to the war we graduated more than they did. This is a postwar development and their rate of catching up is frightening.

The reason I made my comment that we have time is because, even at this late date, the total number of scientists and engineers available to us and if you throw in our allies is still a blanket over Russia's capability with her allies. This won't last.

Now, I hope you all noticed that on that chart there was a better recognition on the part of our allies of the role of science and engineering and college education than there was with us. I am using, of course, the percentage on that chart as my commentary. So, all of those allies, including Italy and countries that many Americans think might be more inclined toward the arts, all appreciate this need and this problem.

How do we combat this? Let's look at the present scene in the United States. It's a rather tragic thing that the number of engineering

applicants for enrollment in engineering schools has declined in the last few years. Instead of going up it's getting worse. However, I am told by educators that one reason for this, if not the reason, is the fact that more of them are taking science. They are confusing science with engineering. Gentlemen, the educational fraternity confuses science with engineering in many areas of present-day education, particularly those areas that lie outside of those two disciplines. One leading American engineering school recently took a physicist as its Dean of Engineering, and other engineering deans have come to me and have said, "Oh, dear! Are they turning their engineering school into a science school?" This shows the preoccupation within our educational institutions.

There is no easy answer to your point. There is time. Now, how do we motivate our people, what incentive can we give our people, that corresponds to this incentive that the Russians give? You are not going to do it that way unless the United States Government, as in the case of solid-state physics and materials, tend to the conclusion that I have come to, and then offer national scholarships in profusion in sciences and engineering as opposed to liberal arts. Of course there would be the greatest old hornet's nest to face our educators who are still talking up the idea that liberal-arts educated people really know how to run the world whereas the scientists and engineers are so preoccupied with their tinware that they are sort of sublimated chemists.

I am not making fun of anybody here. This I know, because I am

dealing with academic people. It is a real point. You've asked one of the most difficult questions in the world, sir, and I can only add to your complexity by going slightly further and saying that on the campus the truth of the matter is, if you look away down inside of the viscera of the educators, you will find that the liberal-arts men are afraid of science and engineering, because traditionally American education was dominated by the Church, and up until the Civil War and the passage of the Morrill Land-Grant Act all American universities had curricula in which Latin, Greek, and the Classics were the central theme, and the so-called honorable professions were law, medicine, and the ministry. Engineers were educated in a kind of an A&M sort of picture that you find in some States, a limited educational trade school.

This wasn't upset in the United States, gentlemen, until the Civil War, when the first university taught engineering for the first time. Mechanic arts was the name for it. Of course West Point was the outstanding example, because it taught civil engineering, or taught it as military engineering.

In terms of a nation, this is a short period we are looking at. So I don't think anybody can change this picture in a year, and I am afraid what you've got is the fear of these liberal-arts educators that science is becoming, through space, monkeys, and all this stuff, the star attraction for youth, that it is going to pull the students away from their entrenched areas. They're just like you are; they're human, and they fight for their disciplines,

and they fight in between their disciplines, just like Army, Navy, and Air, in many instances. There's not a big difference. They fight for dollars, fight for buildings, and fight for professors. So you have this battle going on.

Now, there is something very appealing to people who are not scientists and engineers about the general statement, namely, that only people, only people, who specialize in the study of history and the humanities are fit for leadership.

Gentlemen, I love to discuss this. You've opened Pandora's box. In the first place, I read the History of the Revolution in a typical American school. I was up in Canada and I had some time on my hands, so I picked up a book, and it was a Canadian history. I read about the Revolution in that and it was not the same war at all. This is not a science, and yet history is labeled as a social science, in Yale University. This is a complete miss of understanding. I'll bet a cookie that the State Department representative here has much trouble with the semantics and different interpretations in different countries with different civilizations and different backgrounds on simple concepts.

This is what riddles the studies of humanities and sciences. This is why they are having so much trouble in Africa and other areas. All sciences, all humanities are not those of these other civilizations--certainly not of the Chinese.

Gentlemen, your question is: How do we change this situation?

You've got the classic inheritance of the higher education pattern of America fighting for survival against the attractiveness of science and engineering to youths who like their rocket guns and all these toys that you see on every counter and in the Five and Ten Cent Stores--if there were such stores.

So educators, after Sputnik I, found themselves faced with a revolution. You may remember the immediate reaction of Sputnik I. Now that's become a little old hat; so there is a movement under way to do away with Deweyism in our secondary school system. This is heresy, gentlemen. If there are any educators in this room I expect to be shot or stabbed in the back on my way out. Deweyism came into our secondary school system to promote the education of people to be people--so they said. This meant the whole man. This destroyed the discipline of our secondary school system. It wasn't meant to. I am sure Dewey didn't mean to. But this is what Columbia University's Teacher College, which is given the credit or discredit for this, has done through the years. So you've got to undo this whole wheel that I am describing.

I have no patent remedy. I don't have a bottle in my pocket from which you can take ten easy drops and you're cured. I can only tell you that there first has to come about an understanding of the picture I hope I am giving you today. You are fathers. You are in communities. You are interested in more than dropping a sword. If enough people study these questions, and if enough people understand what your question is, that's the way

in America we get an answer. We have not got it yet.

I submit, sir, this is not a good answer.

QUESTION: You stated that the lack of assurance of continued support was a source of disturbance to research teams and possibly to the rate of accomplishment also. Do you think this is due in large part to our budgetary process in many echelons of review? If you do think so, do you have any hope of improving that?

MR. WARD: Yes, to both of your questions. It is due to the budgetary review and it is due to another thing you haven't mentioned--the two-year limitation of appropriations in the Congress. In starting this program that I mentioned to you, to educate more Ph. D. 's in materials, this became an insuperable barrier. Not a single university would respond to the needs of our Government to put in a two-year facility for educating these Ph. D. 's in this advanced field. The reason? They cannot get professors to come on a campus for two years.

I have always said to my Board, for many years, that the Government can do anything it wishes to do and it cannot do anything it wishes not to do, and it can still be within regulations in both cases. You may want to challenge me on this, but I have plenty of material to fight you with. So the Defense Establishment could not get a university to develop Ph. D. 's on a two-year program. So, what happened? They have guaranteed these first universities support for between five and ten years. How did they do it when Congress says only two? Don't ask me. I don't write the rule

books. But that's what they have done.

Now, this is what is needed in R&D. You know, away back in the dark ages of the thirties, I got my biggest order of aviation engines and it took more than two years to finish the contract. This was when Ma Perkins was riding high and was revising our labor picture in the United States under a benificent dictatorship. I couldn't forecast the cost two years afterward and so said. So when Navy were procuring this order and they said, "We have a constitutional limitation. We're sorry," I said, "Oh, that's what you say. How do you build a battle ship? It takes five years." They said, "That's different." I said, "What is the difference?" They said, "A battle ship isn't an aviation engine." I said, "I know, but it's the same under Navy law." They said, "We know, but Congress understands this." I said, "Well, it's your job to make the Congress understand this, because this is a fact of life."

At that time I got an order from the Army. You didn't have an Air Force them. This was from General Burns's office. If some of you present here knew him, he was a very wonderful gentleman. This order was a duplicate of the Navy's. So I went to the Army and I said, "All you've got to do is to give me a contract that runs longer than two years with an escalator clause to protect me against modern government policies on labor." They said, "Oh, we can't do that. In the first place, that's a variable price. We can't buy them on a variable price." The General didn't know that I had this contract from the Navy, you see. So I said,

"Well, General, this is unfortunate, because my fine print on the contract says that I've got to furnish the same price to the Army as to the Navy on any identical article. I can't do it." He said, "You've got to do it. That's the law." I said, "No, I don't. Not unless you put me in jail I don't. I can't furnish you any engines." He said, Why not?" I said, "The Navy has given me a contract, so I can quote them a lower price than I can quote you, because I have an escalator clause." He said, "Well, let me have it." So he took it to the Judge Advocate General, and the Judge Advocate General wrote a learned opinion, and the opinion said, "This is not possible under American law and cannot be done." So I mailed him my Navy contract. I got another letter from the Judge Advocate General , forgetting the first letter, and I got my Army contract.

If you are preserving the United States of America, don't hide behind regulations. If you've got regulations that tie your hands, for Heaven's sake, bring them out to the policy people.

Now I am going to tell you one more brief little story on policy which I heard only this weekend. I had as a guest the Dean of an engineering school in Hartford, and he was complaining about problems within the university. They were not the ones we have discussed; they were other ones. In the course of it, he said, "It's these damn policies." I said, "What policies?" He said, "Did you ever hear the story of the centipede with sore feet?" I said, "No." "Well, here it is," he said. This poor guy suffered immeasurably. He finally talked to the rest of his friends

and they said, "Go to see the wise old owl." That seemed to be a good idea, so he made the long and sorefooted journey and came to the old owl sitting on the bran ch. He said, "Wise Old Owl, I need some good advice. I have sore feet. How do I get rid of my sore feet?" Well, the owl flapped his wings a little bit and said, "Give me a day to think it over." So the poor guy made two journeys more on his sore feet. He came back to the owl and asked the wise old own for his decision. The owl flapped his wings and looked very pedantic, and he said, "Now, I have observed that mice have only four feet, and I have never known a mouse with sore feet. Why don't you change yourself into a mouse?" The centipede thought that was a pretty good idea and he started to walk away. All of a sudden, something hit him, and he want back and said, "How do I do that?" "Oh," the owl said, "Don't ask me. I only speak for policy."

So my answer then is policy. I know no other answer.

QUESTION: You were talking about the Soviet surpassing us in certain instances, talking of the volume of engineering and the volume of scientific endeavor. What are your thoughts on the channelization of this scientific endeavor or engineering? For example, years ago a mechanical engineer took care of heating. Today he can switch over to mechanical ventilation or air conditioning. What about channelization?

MR. WARD: Your point is well taken. In the Soviet there is some emphasis on channelization, by the same system of percentage. You may remember that it was Khrushchev who twisted Eisenhower's leg

at the Camp David conference by pointing out that more and more the Soviets were using incentives, although it was supposed to be a Communist state, and that the United States was going toward socialism, although it was supposed to be a free enterprise state. Of course this is true. The answer, then, is incentive. The Soviets, as far as I have any personal knowledge, do not order these people to do these things--you used the word "channelize." They offer an incentive when there is a need. Either it is a better living, a fringe benefit, or an out-and-out salary.

You know that in our own country people respond to those kinds of incentives. So I don't think there is any magic in this thing. I think the question answers itself. If there is an American need for more engineers and scientists, there are two things we have to do: First, you have to popularize your problem. This is a democracy and people will do things purely independently. After you have stated the problem so it is understood--which it is not--then can come the incentives. I'll give you the incentives.

In one college in which I am intimately involved, last year the average engineering graduate across the board in several different disciplines got an average starting salary--and I am using the word "average" now--of $535 a month. Here's a fellow with no experience. The College of Liberal Arts graduates got a salary over $100 below that figure. But, how many boys know this? How many parents sit down with their children and outline where the opportunities are, where the challenges are?

One of our problems, gentlemen, is that in this free democracy of ours we give children so much freedom. They learn that engineering is a lot harder than other things. I have a grand nephew now who has had two years of electrical engineering under his belt. He has come up and talked to me on ways to shift over into liberal arts. I said, "What made you take engineering to begin with?" He said, "I liked it." I said, "What's the matter with it now?" "Well," he said, "I've got four roommates. They can go out weekends and evenings and afternoons, and I've got to go over to the darned laboratories and write reports."

This is your problem, gentlemen. How do you get in the United States a stronger motivation? I am not using my grand nephew to expand from the special to the general, but I think you will find this problem underlies a great deal of what we've been talking about. Engineering is harder. Science is harder. Secondary school systems have fallen down tremendously on the earlier indoctrination in the sciences. Here's were Russia gets the head start on quality. There science and mathematics courses in the secondary school systems are over a university year ahead of us. You know that the statistics from the educational boards here in Washington in the Department of Education show that a frightening minority of high schools in the United States teach physics at all. They haven't even got physics labs. When the local school board tries to raise bonds to build a new school and it comes out that the laboratory for physics is more

expensive than the recitation room for the study of marriage counseling or something of the sort, the latter gets the money.

So this is your problem. The first problem gets right back to the secondary school problem. You see, we don't have a Kremlin. We can't order our secondary schools. Every school board and every community has to be indoctrinated.

QUESTION: Is it true that in Russia the scientist and the engineer has greater prestige and respect from the general public than in the United States? If so, what do you think is the reason?

MR. WARD: Yes he does, and the reason, of course, is deliberate. Russia was a serf-ridden country when the Bolsheviks took over. I don't know how many of you have studied the history of Russia. I read a book over in the War College on the History of Russia and I found it very illuminating. It filled in a lot of gaps in my knowledge. The role of serfdom in Russia is very interesting. It isn't all onesided as it has been made to appear. Anyway Russia had a serfdom-ridden civilization. We shipped them goods. I built machine tools in World War I before I got into the Ordnance Corps, and I remember the Russian inspectors. I remember the machine tools we sent over there. It was common knowledge among the mechanics who built these tools that those boys would wreck the machines, that they had no background in mechanics, that they were going to be taken off the farms to run precision shell lathes, and that it was just a crime to send the machines over to the factories there and let

them murder them.

This was evident to the Bolsheviks. This led to the formulation of their modern-day educational program, which I am told--I don't know this of my knowledge--started in 1932. They came out and said, "If Russia is going to convert itself to a world power, it must first do it by education." Furthermore, they meant education in the sciences and technology. This is why I am not shocked that we have found such a high percentage of Russians in those areas. This was a deliberate Kremlin policy. Having become a Kremlin policy and it being a monolithic government, this became, of course, a requirement of the secondary school systems.

I didn't tell you about the role of the thing called the Technicum. The technicum is what you might call a two-year college in the United States. These boys and girls who go to the secondary system and have some aptitudes, have one or two kinds--either a mental aptitude for math, physics, chemistry, and the like, or a tactual application of laboratory work, woodworking, and metalworking. They are separated by the education department into two groups, and the secondary group with the tactual capability is shot over to an institution called the technicum. The technicum gives them a two-year university education modeled specially to them. When they come out, those fellows do the work that we hire four-year engineers to do.

This is another point that, given time, I would expand on. This was

particularly prevalent in my industry, the aviation industry, during the war. We did not have what you call technicians working with engineers and doing the simpler phases of the work. We had four-year graduates doing them. We were accused of hoarding engineers. We did hoard engineers.

Now, in the Soviet they recognized in advance that there was a lot of youth coming out of this background of a serf-ridden civilization who could run machines, become draftsmen, become technicians, and work for engineers and do the work at the direction of engineers that otherwise engineers would have to do. So there are over 3,000 of these schools in Russia. I believe now there are 3,000,000 people in the technicums. This vast array supplements your four-year professional graduates.

We have in the State of California more of these schools than we have in any other State. This is probably because of the great growth of aviation and electronics and the area of weapon systems, and the like. In electronics you find a well accepted position in American industry for technicians. You find a lot of schools that will train these prople. You in the Army, Navy, and Air Force all have your technical schools for electronics people, and when they come out they become, many of them, technicians.

So we have done in an indirect sort of way what Russia did in a direct way, but nothing like the extent to which the Russians have done it. Supplementing their four-year graduates, they have this vast array of technicians who are graduates of the technicum.

One more point is that, if a young man who goes into a technicum does outstanding work, along comes the Ministry of Education man who says to him, "Ivan , you have done very well. You may now be registered in a four-year university for a degree." And he is allowed to move over and become a four-year graduate, or a five-year graduate.

This shows you the flexibility . It is not nearly as rigid as we like to think the Russian system is. They are smart people. Bolsheviks or not, they are smart people. In dealing with their problem of emerging from a serf level of economy to a highly sophisticated mechanical, technical civilization, they have said, "Education," and they have provided it.

We have done it the other way, by a free choice. Then we went overly liberal. We got so preoccupied with courses in high schools on how to drive an automobile, how to pleat a skirt, and how to prepare for marriage. These used to be things for the parents. We took them over into the school system. Remember now, the American mother who is working is not home. So there became a pressure to do these things in the school system that are not really education. They are the simplest forms of trade-school work.

You see how broad your question really is. I can't answer your question. It is one for the whole Nation to decide. Before it decides it must be informed.

QUESTION: In looking at your shotgun chart, I am somewhat confused.

You stated that you think there is a direct relationship between power generation and the national strength of the Nation, and yet, in looking at that chart, we find that Red China is down with Portugal and Spain, and Russia is not in much better a position than Austria and Switzerland, and countries like those. Certainly Russia has marvelous propaganda in the world.

MR. WARD: That chart shows only the gross national product per unit population. You have to multiply all these by population. You take China which is away down. Remember she has 650 million units, whereas Switzerland has only a couple million units. If you want to draw an overall chart as to the total strength of those countries it will be totally different. I am merely showing you an index there to relate use of power with production of goods and services. To convert that into a county's product you've got to take the whole resources of the country.

This you will do I am sure a little later on in this curriculum and when you write your final papers this is what your teams will be examining in detail. It will be very interesting to you to get a whole series of shows, such as not all of us can, in looking underneath some of these countries. I am sure that the teams that went to Africa and looked at the state of African civilizations found that it is not all tribal dances.

QUESTION: Do you feel that in order to meet the challenge of Russian technological progress the United States must have a more centralized control and correlation of research and development effort

in both industry and government, with government-directed incentive? Or can we rely on the current system of essentially free enterprise?

MR. WARD: This is going to be quite a class. When you bat up questions like that you are batting up questions that have perplexed all the wise heads. Let me say that there are two schools of thought. One of them says that the free choice of individuals in a free economy is more efficient than the specialized planning choice of a few individuals in a regulated economy. You can believe one or the other. I am not going to make any converts here today. One is the socialistic philosophy and the other is the non-socialistic philosophy. I do, however, want you to dwell on Khrushchev, who points out that, whereas they started from the latter concept, that you can do everything by a few intelligent individuals planning, they are getting away from it more and more and using incentives.

A certain Russian miner named Staffinov broke the mining tradition when he voluntarily produced more product than anybody else. In this country the labor union would have throttled him. He would have gone home the most bruised fellow you ever saw that night. In Russia he was made the national hero, was given the Lenin price, and there arose a whole program called the Staffinov Program, which was incentive--minded. This is the very thing our country grew great on, which we are abandoning for restrictive labor union practices--only a certain amount for a certain man. You have differences between people who are all equal.

You are reaching to the very core of one of the toughest problems this College will have to consider. You'll hear a labor man on this platform and you'll be won over to the idea that we're all equal and we've got to be treated equal. But if you hear people like me they'll tell you no; you give up your birthright. Not even Russia can afford that solution.

So I say that the collective intelligence of you all as individuals, responding to good information, is a far better future for any country than a few elected or hired individuals who are bureaucrats sitting in a tight room deciding on what this whole Nation should do.

I said something that ought to be a clue. These are economic questions that you are devoting yourselves to. I pointed out that if you laid all the economists end to end they would reach no conclusions. Gentlemen, this is true. If you talk with Galbraith of Harvard you will come out a socialist. But, on the other hand, if you talk with George Burns or with Saulnier, the Chief of the President's economic advisers, you will come out on the free industry side, the free/collective opinion side.

Now, you'll have to state where you belong, because emotion enters into this thing. There are so many people who eternally want to do good, they want to think of people as doing good, and they are absolutely slaves of the idea that because this is the right ideal in Christianity, in religion, and in ethics, all you have to do is to throw this challenge out and humanity will respond. It won't. It never has. This has been tried in the earliest recorded civilizations.

I'll bet every man in this room at some time or other has heard the famous quotation: "Aw heck, you can't change that. That's like the law of the Medes and the Persians." How many of you know what that means? How many of you know what the law of the Medes and Persians was? Well, here's what the law of the Medes and Persians was, as history tells us--and of course I have questioned the authenticity of history more than once: The Medes and the Persians saw a wide difference between people with and people without in their civilization, and so they said, "We are going to have an end to these profiteers, these money changers." That was the name for Wall Street back in those days. "So we will have a code of law and this law will come from all the history of the Medes and the Persians." It set forth the price of a scribe writing a letter. Everybody could write in those days. They had to do it with a chisel and a block of clay. Second, it set forth the price of a haircut. Third, it set forth the price of a measure of wheat. It was a new deal. It wasn't new, because before they wrote things they had new deals, but it was the first new deal that has come down to us clearly documented.

It failed. It absolutely failed, just as our New Deal failed. No, gentlemen. You may say, "I believe today that the failure of history in attempts to plan whole economies by a few intelligent people planning the fate of everybody, determining prices, and OPA's and the like, might do in times of war, when we've got to throw severe restrictions around

free exercise of will." But, gentlemen, in times of peace and in the building up of nations it has never produced a top-grade nation.

In the industrial revolution in England they attempted to do this in industry, and it was one of the classic failures of all time. So this can be going on.

A historian should be talking to you, not a blooming engineer, and presenting this issue, provided he is not tainted with too strong a feeling on the other, which I am afraid he is likely to be. But you ought to hear the two sides of this problem. That's a very potent project.

My answer is, I hope I never will see the time where the fate of us, we Americans, is planned right here. I think our collective individual brains are the best guide for our future.

Lord Bryce arrived in the United States prejudiced against our form of government. He was an Ambassador for a long period of time. He wrote a book which is famous, in which he said, "This American system of government should not work, because everyone has a vote." England in his age was ruled by men who were products of Oxford and Cambridge, carefully selected from the best families and with the best education. These were gentlemen. He arrived over here and everybody had a vote. He said, "No government can exist with such unintelligent voters."

After he had been Ambassador here for a while, he wrote: "My