SCIENCE AND NATIONAL POWER

1 October 1954

CONTENTS

Publication No. L55-32

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. John Carlton Ward, Jr., President, Vitro Corporation of America, was born in Brooklyn, New York, 21 January 1893. He attended Cornell University, receiving the M. E. degree in 1914. He was appointed to the position of development engineer, International Paper Company, 1914; became assistant to the works manager, Niles Tool Works Division, Niles-Bement-Pond Company in 1915. In 1918 he was appointed production engineer, United States Ordnance Department, Watervliet Arsenal. In 1919 Mr. Ward became works manager, Pratt and Whitney Division, Niles-Bement-Pond Company. In 1926 he was appointed vice president and general manager of the Hartford Machine Screw Company. During the period 1929-34, he was general works manager of the General Cable Corporation; was named vice president of the Rome Company, Inc., in 1934; served as vice president, general manager, and director of the Pratt and Whitney Aircraft Division, United Aircraft Corporation from 1935-40; became president of the Fairchild Engine and Airplane Corporation, 1940; and in the period 1948-49 served as chairman of the board of that corporation. He is a director of the Holyoke Wire and Cable Corporation and the Fiber Can Machinery Development Corporation. In 1942 hr was appointed a member of the War Production Board Mission to Great Britain, and is a member of the Engineering Council, Cornell University, the Newcomen Society, the Society of Automotive Engineers, the American Ordnance Association, and the Institute of Aeronautical Sciences. Mr. Ward has written many papers and articles on technical engineering subjects. He is a member of the Board of Advisers of the Industrial College of the Armed Forces.

SCIENCE AND NATIONAL POWER

1 October 1954

ADMIRAL HAGUE: Our speaker this morning, Mr. J. Carlton Ward, Jr., is one of the most valued members of the Board of Advisers of the college, for the simple reason that the Commandant can always depend upon him for good, sound, critical advice, but no orchids. He is a man of many geniuses--engineer, author, educator, and corporation executive. Because he has demonstrated all of these talents to a remarkable degree, he has been frequently called upon by the Federal Government to exercise them as a public-spirited citizen, serving on various boards and commissions. But through all these varied endeavors of Mr. Ward, there is one common denominator; that common denominator is technology.

I know of no one better fitted to give you the lecture that you are about to enjoy this morning, on "Science and National Power". When I was discussing the subject with Mr. Ward last night, he remarked on the richness of the subject. And it is rich, because in essence it is a survey of our scientific resources and brainpower, as contrasted with the scientific resources and brainpower of the Communist countries.

And, because the subject is so rich, and because you are going to have such a rich experience listening to Mr. Ward, I am going to take not one second more of his time. I will simply say that I am most pleased, delighted, and proud to introduce to this class Mr. J. Carlton Ward.

MR. WARD: That sure puts a fellow on the spot, doesn't it? I understand this is the kickoff for the technological section of your curriculum. This is a great challenge for me, for there are many men in this audience, I am sure, to whom much of the ground I am going to cover will be a sort of refreshment of your own ideas and thinking, with perhaps even a challenge here and there. There will be many others in this group to whom perhaps focusing on the technological aspects of this curriculum will be a new experience. So I am going to try to talk as though we are all about to enjoy a new experience together. I find that each time I take this point of view, it is very interesting to find that good, objective, new ideas crop up that will help to round out an appreciation of this strange development of man's evolutionary upgrading and his ability to master the forces of nature.

The scope of this lecture is considerable. It reads as follows: "The accomplishments of research as shown by such illustrations as the creation of atomic energy. How science has affected the conduct of war. In view of worldwide technological advances, is our position becoming stronger or weaker? Is time on our side? What is science doing to maintain the relative position of strength of the United States?" All in one hour--I have a great deal to say on this subject. You will therefore pardon me if I move very rapidly.

"How science has affected the conduct of war" is the second heading. But, before we reach that, we had better define science. This is not to be found in an encyclopedia; but to me, and I think for the purpose of your course, science is, in effect, the business of mastering the rules of behavior of man with his relation to the universe. Think that over. It includes the law of gravitation, mathematics, mineral resources, and other things--energy, man's capacity by himself, man as part of his own environment, his relation to his fellow men.

This definition is very broad. How does science differ from so-called education or academic instruction?--something for which you find a plethora of names. It differs essentially in one very important and somewhat subtle principle which you had better think of yourself. Essentially, science is that only branch of all learning in which you can put quantative evaluations on your conclusions.

I am sure the social sciences will raise their heads, but they are not really sciences. They are unorganized, incommensurate material treated scientifically. They are pseudo sciences; they are quasi sciences. In other words, man has learned that the value of the scientific approach is so great in the evaluation of his problems that he has used the techniques of science for exploring unscientific bodies of material.

Think, for instance, of military science. Is it a science? I don't think so. It is an art--the art of war. Military science is the attempt to search out the broad scientific methods and principles underlying the conduct of war and to treat them scientifically.

How many theater commanders think of themselves as scientists? Very few, I suspect. But they are artists, not to paint a picture, not to write a book; but they use those intuitive processes that differentiate an art from a science, in interpreting their personal experience; and that factor of experience which distinguishes man from all other animals--his ability to learn what his predecessors have learned, by speech, by written record. This cannot be said of that strange still unknown biological principle called instinct. It is a conscious process. It is a mental process.

So the military commander is assessing the situation attempts to use such things as number of troops as a scientific approach. But let me show you the fallacy of that. I am going to take as a comparable example the amount of horsepower in a power plant. One horsepower is the same in Japan and China, the same next year as last year. Who is to say that one element, one member of the personnel of a combat team, is the equivalent identically to all the other members of the combat team? Is the cripple, the mental inferior, the man with a low I. Q. -- one unit of the population to be sure--equivalent to an Eisenhower? Yet they are both represented on the chart as one unit of population.

Now you see the differnce between an attempt to apply scientifically the regime of statistical approach to an incommensurate body of knowledge and a true science. Since I can't dwell on this point, I want to leave this thought with you: What differentiates science from other bodies of knowledge? What differentiates the scientific approach from other approaches to knowledge?

You are all familiar with that old classic referred to by economics or economists as the law of supply and demand. You are fully acquainted with the fact that "law" was theoretically abrogated--wiped out, nullified, villified--during an administration of our Government. It was said by all the economists who advised our Government then that this was an early concept of economics which no longer applied. It is interesting to note that the swing in science and economics today is to "re-adopt" that law of supply and demand, which is not a law at all, but a fundamental phenomenon of economics.

You don't fool that way with the so-called law of gravitation. If you want to test that, just jump off the Empire State Building any day of the week. So you see the difference between a so-called law in a body of knowledge like a social science as compared with a law in the absolute fundamental physical sciences.

This is your introduction, then. It is not the manner that I would adopt were I part of your approach to this section of your curriculum. And yet you will find in many of the facts to be revealed in this section that you will be treating with incommensurate units--like the standard dollar, or a unit of population. I will produce some today for you.

But in the terms that you will interpret on some of the charts that follow, you must realize that a unit of population in China is in no sense of the same order of magnitude in certain respects as a unit of population in an advanced, mechanical, technological, scientific country such as ours. And yet in your study of the problems of manpower and the like you must treat them as people. And in other fields who is to say that in the eyes of the Creator they are all equal? We are not all equal. But we are dwelling on science and this is technology.

Now, what about engineering? By no stretch of the imagination is engineering a science. It is an intuitive art. This is what differentiates it from a science. You military men who must deal with engineers and scientists must not confuse these two concepts.

What the scientist does in approaching an application of a scientific principle is sometimes strange. This is a field of engineering, and scientists, in attempting at times to carry their ideas into the application stage, use strange techniuqes. I will illustrate.

When we undertook the project for the nuclear propulsion of aircraft, the scientists frankly looked down on all of us engineers and were supported in that by the services. We were not considered members of the team. There were not enough doctors in our group. I do not blame them. Nevertheless, this was a criticism that nearly did away with the entire project. We as engineers attempted to find a method of approach to the solution of this problem, which the scientists had declared to be not feasible in the public records and secret documents. Who were we, the new fellows in the schoolyard, to prove them wrong? History records that we did. History records that they were wrong.

In attacking the application of the nuclear propulsion of airplanes we did not atetmpt the scientific approach. The scientists said frankly: "Your powerplant will differ from all the other reactors, all the other nuclear power applications. You must carry it on an airplane. It must be small and compact. You must protect your crew. By doing so you will require a different energy level in the thermal neutrons or neutron velocities to make your powerplant work." We did not have the scientific data as to the behavior of materials under those critical velocity levels. Therefore the scientists said: "You must not tackle this problem until we have completely explored all cross sections"--a technical term--"all the scattered cross sections of all the materials that you might use in such a reactor."

This was like saying that you cannot spend time in computations until your complete book of logarithms has been calculated to X places. It was just as silly as that. So the engineers went to work and picked out what are called in engineering terms "optimum areas." There are so many parameters in the scientific design of an atomic powerplant that we had to sketch out what happens when each one of these important considerations varies from zero to infinity. That is the scientific approach also.

We found that at infinity the thing was absurd, and that at zero the thing was absurd. So we didn't investigate those. As you went inward from that, you found optimum areas where the thing began to look practical for the propulsion of an airplane. Out of that consideration a whole series of charts were drawn, which aligned the whole test. Then you were fighting on common ground in all of them. When you have a major job of science, it can be infinitely simpler and smaller than the engineering conception of how to solve that problem.

I use this illustration because I do not believe I have to tell you that to know there is a difference between engineering and science is nearly as important as to understand what the difference is. I will give you another illustration.

The Manhattan District was not going well because scientists were trying to be engineers. So engineers were imported into the project fairly early. The scientists did not feel that they knew enough to find a medium of exchange and communication on a proper level. So two school ties flourished.

The result was that the people responsible for the project became seriously concerned and asked: "How do you bring these two groups together? The scientist thinks he knows all about the subject, because it is a new science. The engineer knows nothing about it, because he hasn't studied it. Therefore they have to carry the problem into the engineering phase. The engineers say that when they do so, the results are really unfortunate. They never get anywhere."

So they tried to find a midwife. They tried first to educate the scientists into being engineers. But the scientists were true to their craft. Engineers take liberties with data. Scientists do not take liberties with data. They couldn't bring themselves to it. They were true to their craft. Gentlemen, it didn't work.

Then they tried to make scientists out of the engineers. Time defeated them, because the engineer, accustomed to taking liberties, was not able to take liberties in that field.

So then they said: "We have to find some strange creature in between these two. We are going to have to find someone with the valence of a scientist and also the valence of an engineer--a compound."

They searched the research laboratories, because it was said, "Here are engineers working in a field of science." They went out and tried to catch them young, so they could grow in this field. They went to one laboratory and said: "Have you got some young men who are engineers, who perhaps took a master's degree, who have a flair for science, and who are not too old?" They found a few and sent them out to Argonne, where they were to be hired, in the hope that they would be the midwives.

One of these chaps told me a story. It seems that when he arrived out there, a tired scientist gave him an interview. He used an M-plus-1-page questionnaire. At the end it said, "What are your hobbies?" He thought that was simply an inconsequential question; so he thought, "Here goes." He said: "I like to go up in Zeros. I like to ski, to camp out, to fish." The scientist went over all the things he liked to do and wrote them down without a speck of interest. But then the scientist said, "Is that all?" The chap said: "To be very truthful, although it is not important, I am also a member of the Society of Magicians." The scientist jumped out of his chair and said, "Boy, you are in. That is what we need." Enough, then, for the difference between technology and science.

Science as a technique in advancing knowledge is quite impressive. It can be divided into two fundamental aspects. One is man's process of extrapolation in his thinking to arrive at a new conclusion. It is true? Is it not true? Many extrapolations prove quite misleading.

Well, how do you prove it? You prove it by scientific experimentation and verification. This is what separates science from practically all other bodies of knowledge. Once you have concluded that the behavior under a certain law is so-and-so, you can set up an experiment in your laboratory; and, if it is well done, it turns out to be so-and-so or such-and-such. And from that you expand with knowledge your boundary of science. If the theory is proven wrong, you set out to find a theory that explains the wrong behavior. This is an important link in the scientific procedure.

You can't do this in the social sciences. I will pick on economics as a social science. You can't find out how much the average man eats, although you can compute it. You can't find the average man. He doesn't exist. He is a statistical myth. And yet you deal with how much the average man eats, how much the average soldier or sailor or airman eats. And you compute your logistic tables on this man. But you don't know how much goes into the garbage can. You can compute how many times a day the fellow can eat beans, but you know that people don't react to beans indefinitely. You have your problems. This doesn't occur in science. So there are no similar techniques of verification. They are all approximations, and they are not of the first order, like the approximations that we have in mathematics. They are very crude approximations.

What is the relation of all this to the military? That is the area with which you should be most concerned. For the purposes of today, I will divide this into five areas of function. The first of these is the research phase.

Gentlemen, the research phase is so complex that a whole talk could be given on it. You know the difference between fundamental, basic, and applied research, and so on. So we will call this the research phase.

Then follows the development phase. That is where your particular engineer gets his books of scientific information and starts to fashion them into something that will deomontrate the principles.

After you have done that, by a very complex series of considerations you arrive at the production phase. That is strictly engineering. I would like to stress, therefore, the fact that it is also America's defense. This is where we have our great national advantage in production. It is the only area where we can safely challenge other countries. Mass production was invented in the United States and it is the greatest single advantage that we have in minimizing the economic buildup in other countries. We are still masters of it.

The next phase is evaluation, which is a military function. I do not advise the military to interfere too much in these earlier functions, although the tendency is to do just that, because you furnish the money and you also write the scope of the problem. So you tell the other fellows what to do. Of course you given them the means of doing it, and the inclination is to tell them how to do it. Gentlemen, that is fatal. But the evaluation phase feeds back into the solution of the problem the necessary information to restore the extrapolations of the engineer to the true curve of behavior of whatever you are trying to do.

Then there is the last phase, that of modification through military use; this is the most important. Of what use is a wonderful flying airplane if it fails to accomplish a useful military mission? That is where you are supreme, just as you are in the evaluation and the writing of the scope of the problem.

So much then for the relation of technology and science to the military. I hope that you gentlemen will adopt that, so that when you get into positions of authority, you can direct your younger men--those who tend to follow the written handbooks and tend to tell the engineer he cannot use this steel or that material or substitute so-and-so for such-and-such. I hope you will see that there is a proper differentiation of responsibility. Just don't forget that when you are telling a fellow what to do. You are responsible for the result and not he, although I am sure you will have been relieved of your particular command at that point and there will be a new man come in who doesn't know what it is all about.

I am told next to cover the effect of science on the conduct of war. I consider this a little presumptuous. You gentlemen have studied military history. You know what Archimedes did with his pitch pots. You know how the first fellow trying to scale a castle wall must have felt when the boiling oil trickled down his spine. You know what happened when the bow and arrow was brought into battle for the first time. You know what happened when gunpowder first came into use. More important, you know what happened when the atom bomb was dropped. That is the best example I can give you in bringing you up to date.

I don't have to defend the fact that the dropping of the atom bomb was a humanitarian expedient. More lives were saved by the dropping of that bomb than one can calculate. A study of the records of the Japanese military authorities shows that there would have been an abundance of defensive suicidal methods just too utterly horrible to imagine. We had plenty of tests of the kamikaze situation from the Navy's point of view.

But, I don't think I should put more time of today's lecture into trying to impress military students, and experts, with the effect that science has had on war. You can generalize and say that early man fought with his hands and with the energy which was supplied to him by his own processes of metabolism and assimilation of food, using as weapons only the structural parts of his body. He socked somebody on the nose. Early he learned that he could be much more effective if he picked up and used a stick. He didn't know the law of the pendulum, he didn't know the law of momentum, but he found that the other fellow's skull cracked easier under this impact. He had discovered his first weapon.

From that time on it has been weapons directed by man rather than man himself. And that is the condition of war today. I think it was Nicholas Brown, once Secretary of the Navy, who said: "Gentlemen, we are about to witness the technological development of aircraft to the point where it will outstrip the human man. What are we going to do?"

The result, you know. We now design intelligence into the airplane--by electronics, by radar. We supplant the senses of man, unable to cope with his environment at 60,000 feet altitude, at speeds reaching the order of Mach one. In today's aircraft it is less than half a second that elapses from the time the man first sees an enemy with his own eyes and the time when he can do something about it. A man can't do that. We have built into the airplane--and it accounts today for 50 percent of the total cost of that airplane--nothing more nor less than a series of devices to take the place of man.

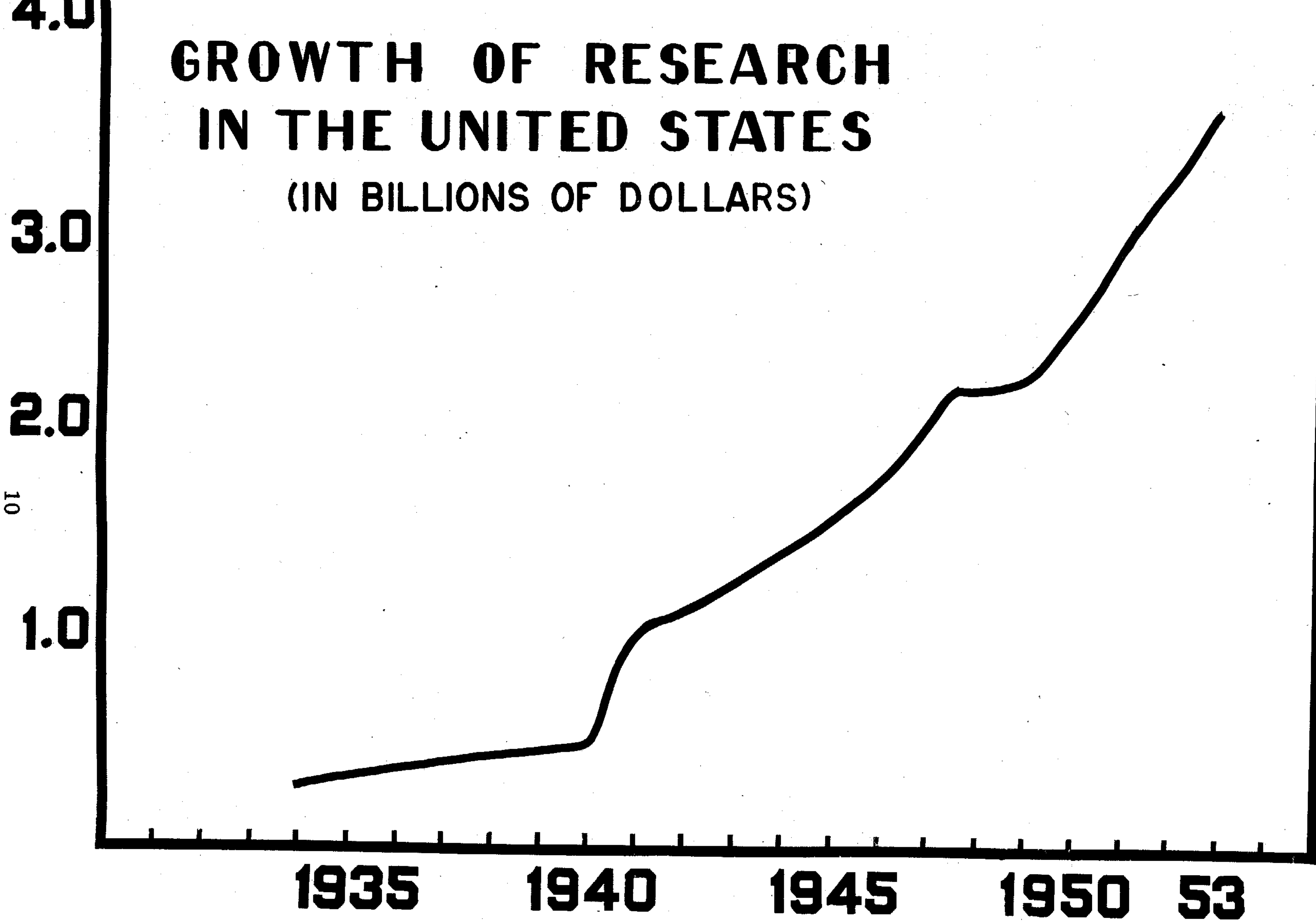
Radar is his new eyes. Radar can see wave lengths of light that the human eye cannot see--don't forget that a radar impulse is light. It is an electromagnetic wave, a vibration--simply a member of the spectrum beyond the biological evolution of the human eye to see; but it is light. So, in fact, we supplant man's own inferior organism, the eye, with a machine. And the cost of the airplane reaches staggering proportions.

You can extend that to ships and guns,--to all war materiel. It is occurring everywhere. So let us not dwell on the fact that science has an effect on the conduct of war. I think it is fairly safe to say that weaponry and weapon systems and the intelligent use and implementation of those today spell the element of power for a nation. I hope it does, or this lecture is going to fall very flat.

Are we weaker or stronger as a world power? That is the next question.

See chart 1, page 10.--The tool of science is research. Science is absolutely a void unless it is employed. The scientific tool for expanding its knowledge is research. There is something most extraordinary.

CHART 1


GROWTH OF RESEARCH
IN THE UNITED STATES
(IN BILLIONS OF DOLLARS)
4.0
3.0
2.0
1.0
1935
1940
1945
1950
53

Please look at how recently research as a function occurs in our advanced technological economy. I would like to point out that the first research laboratory in the United States was built by General Electric Company, with only three men in it, in 1902. There wasn't any research in the United States in an organized form whatsoever. What we had previously was the old art of invention, almost a design idea. Organized scientific research started in America as recently in our lifetime as 1902.

This is a most significant event: We learned in World War I that it was the lack of our research and development of products for war in our economy for peace that spelled our greatest shortcoming. We had the umbrella of being protected by our allies over us.

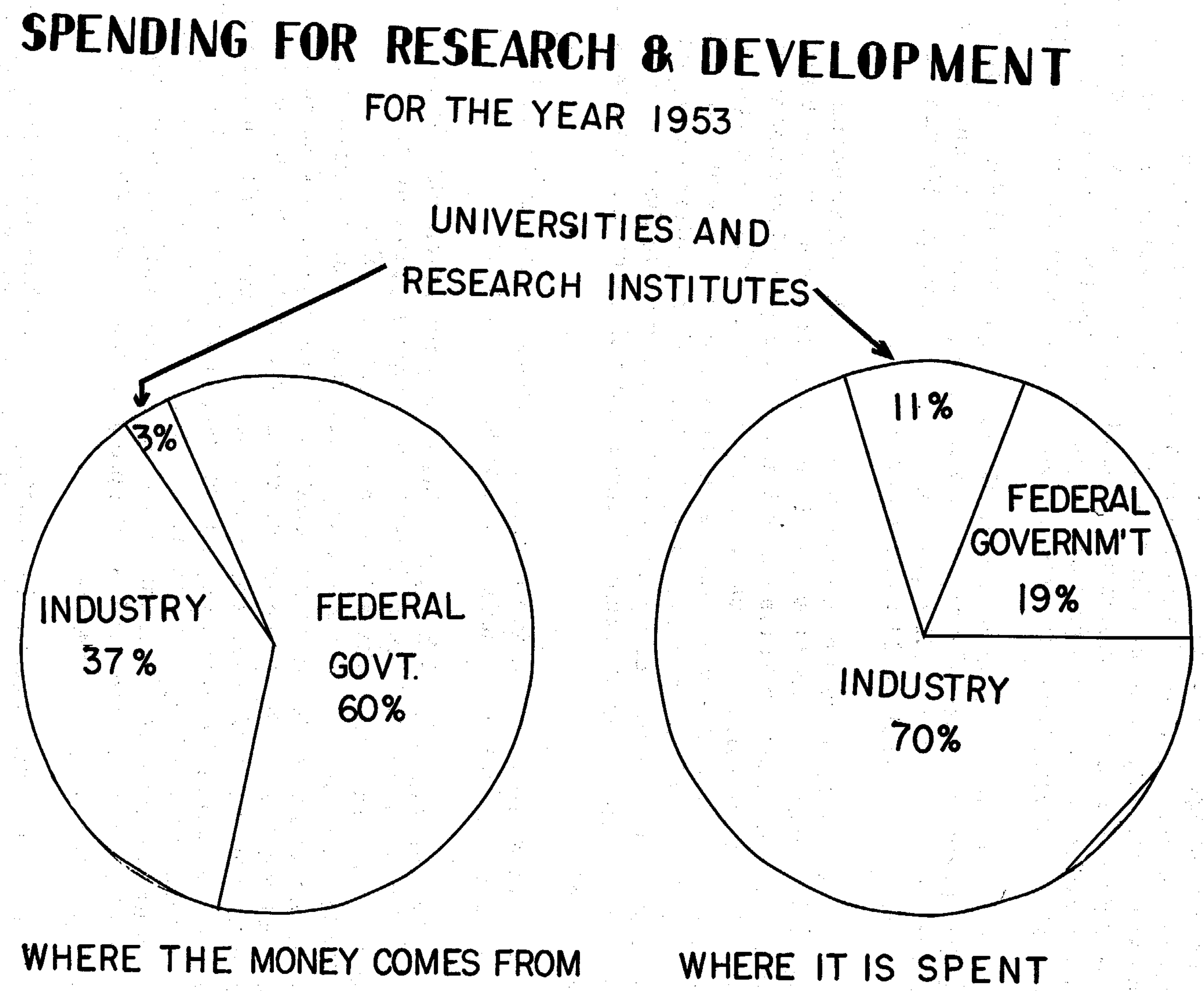
Look at the spurt that occurred in World War II. After having learned this lesson in World War I, look at the total level of 3,000 million a year for research in the whole United States--in Government, industry, and universities. Look at what World War II did. You can see it by the hump in that curve. Look at what Korea did. There is a tendency for the Government and industry to start relaxing after a war, and research is one of the areas of expense that always gets the first cut, because it is more remote from the incoming dollars or the end use of the military.

I can't dwell more on that curve; it is a whole lesson in technology and science as applied to modern economics and to war.

Chart 2, page 12.--Who spends the money for research? Well, you notice for the year 1953 the Federal Government supplied 60 percent; industry, 37; and universities 3 percent. Don't be fooled. That is a statistic. The implications are very inaccurate. That 3 percent supplied by the universities, for instance, could be more important than all the rest put together. These are no commensurate units. One unit of research, one dollar of research, is not equal to another dollar of research. This is something to think about and to analyze in your mind. Sometimes the placement of a "haywire" research contract may bring in more far-reaching results than the finest, most plush, most opulent, research contract for the research and development of what at the moment may be the military theory for weapons.

Let us see who does it. Fortunately, universities did 11 percent of it in this instance. Let me point out that this includes the nonprofit research institutions. This is completely new. The American universities are going through a subtle change, in which their primary purpose re-

CHART 2


SPENDING FOR RESEARCH & DEVELOPMENT
FOR THE YEAR 1953
UNIVERSITIES AND
RESEARCH INSTITUTES
3%
INDUSTRY
37 %
FEDERAL
GOVT.
60%
11%
FEDERAL
GOVERNM'T
19%
INDUSTRY
70%
WHERE THE MONEY COMES FROM
WHERE IT IS SPENT

mains instruction, but in which instruction is enriched by attracting scholars who wish to push the boundaries of knowledge outward and become inspired teachers. But that is a dangerous approach also. If a university attempts to do too much research, it tends to become a research institution rather than an educational institution. This is occuring in the United States in certain areas.

Chart 3, page 14.--You will see that the Federal Government does not perform in research anything like the way industry performs. The thing it does is furnish the money. This is of course a free enterprise phenomenon and would not occur in Russia. Notice the growth of industrial research versus Government research. The lesson is here. Before the fright of World War II, Congress and the military gentlemen did very little research. Look what happened when they got scared and needed new weapons. See the rate of growth in the two trends.

Follow it all the way through and see how it sagged back after World War II. Korea got us frightened again, and it started upward again. You will note that we are still frightened.

Chart 4, page 15.--These products on this chart are really ill chosen. They are simply some aspects of new things coming out of research--examples of what you get for your money.

There are some interesting angles to that. Butyl and buna rubber, which saved us in World War II, were products of German research. Of course we took the credit for them.

Neoprene is a complex organic product of a synthetic chemistry, the home of which was Germany and which made Germany prior to World War I the most aggressive power in the world. With the harnessing of synthetic chemistry, there was a whole new application of chemistry as a science.

It was the same thing in plastics. Don't think we don't do anything in these fields. We do. We are a nation of appliers. We are eagerly applying all the fundamental art we can distill from the older laboratories.

Nylon, orlon, dacron, rayon, acrylon--just think what these have done to the uniforms of the soldiers. Just think what they have done to the Paris fashions. Think what all this has done to weaponry. And every bit of it stemmed out of research.

CHART 3

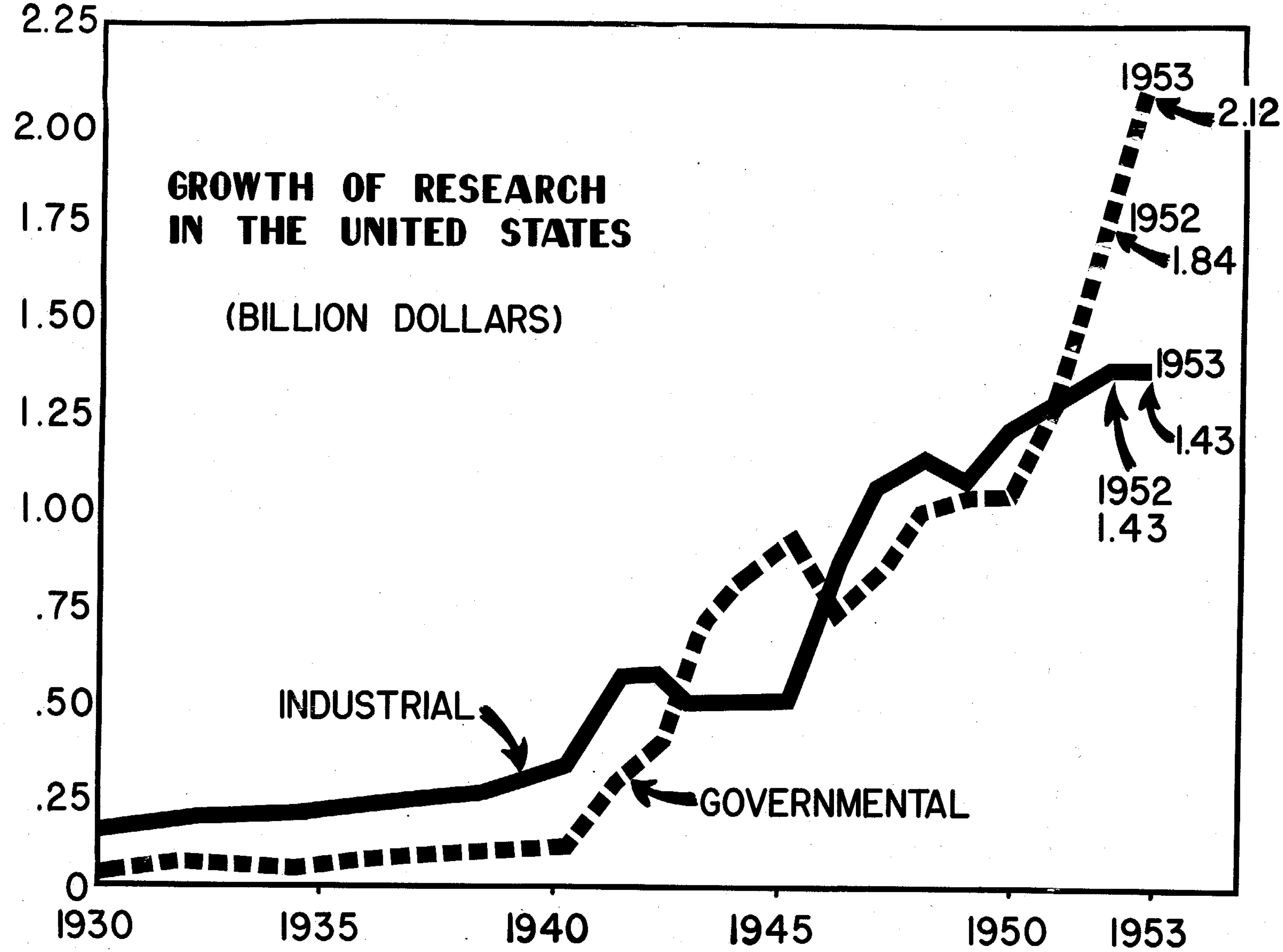

GROWTH OF RESEARCH
IN THE UNITED STATES
(BILLION DOLLARS)
2.25
2.00
1.75
1.50
1.25
1.00
.75
.50
.25
0
1930
1935
1940
1945
1950
1953
INDUSTRIAL
GOVERNMENTAL
1953
2.12
1952
1.84
1953
1.43
1952
1.43

CHART 4

NEW MATERIALS DERIVED FROM RESEARCH AND TECHNOLOGICAL DEVELOPMENT

BUTYL & BUNA RUBBER - NEOPRENE - PLASTICS

NYLON - ORLON - DACRON - RAYON - ACRYLON

UREAS - NITRATES - FORMALDEHYDES

ELEMENTAL METALS— RARE EARTHS

ANTI-BIOTICS - PHARMACEUTICALS

SILICONES - FIBER GLASS

Ureas, nitrates, formaldehydes--these are the fundamental bases for a whole array of plastics, of which we have only just put together certain ones. From this very platform the Du Pont Company several years ago, in explaining its research philosophy, said this: "It is amazing for us to realize that not so many years ago our laboratories were directed to find new materials, whereas today our laboratories have found so many new materials that our effort is now directed toward finding out how to use them." Quite an important lesson.

Elemental metals and rare earths. We are only now on the horizon or a tremendous development in this field. You will find these rare metals in the chemistry textbooks.

Chart 5, page 17.--I will now turn to the periodic chart of the atom. Let's pick a very interesting family. Any one of these is an interesting family, but here's the glamour girl--titanium. Let's take the titanium series. Remember now that in this periodic chart these elements are arranged so that those in each column tend to have similar properties. Don't be fooled. They may be similar in many of their major aspects but they have their personalities. They differ. Nevertheless, this grouping is of interest as examples of what I want to demonstrate.

Silicon is one that we know a lot about. It is the basis for a lot of these new fibers, plastics, and what-not. It is also used in antibiotics, in medicine. Strangely enough, you can have a silicon chemistry. We know a lot about carbon and its chemistry. We call that "organic chemistry." "Organic" means "containing carbon." But silicon chemistry is one of the things on the horizon that can be just as complex as many that we now understand. One of the silicon compounds has already found its way into weaponry to a tremendous extent.

Then there is titanium, named after the Queen of the Fairies--Titania. It is a fairy-like material. But, like fairies, it is elusive. You can find any amount of titanium in the world's crust, but it is in combination. I think it is the fifth most plentiful element, but try to get it out; it is like poking a fairy out from behind a bush. It clings to its compounds. That is why it costs four or five dollars a pound today in a form that we call elementary titanium sponge.

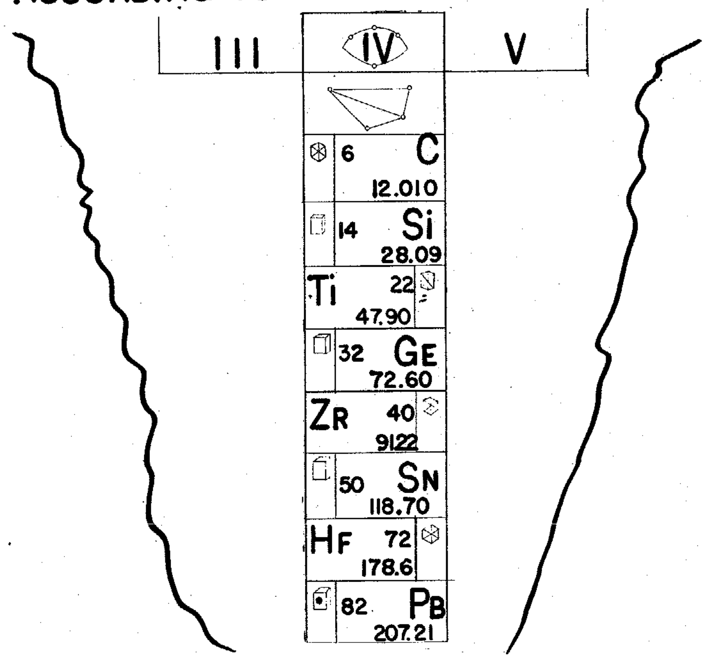
But you all know its usefulness to the military. You know its use is common for defense weapons--from the mortar carried on the back of the doughboy on up to the airplane. It is revising all those structures, providing new weapons of lighter weight. It has high-temperature There

CHART 5

REVISED EDITION 1953

PERIODIC CHART OF THE ATOM

THE ATOM GROUPED ACCORDING TO THE NUMBER OF ATOMIC (VALENCE) ELECTRONS



properties. It will be found in ship designs with other metals to convey the new high pressures. It has thermodynamic properties--a heat transfer medium.

Well, here's an interesting fellow--germanium. This is the metal of the transistor. Look at the gold mine coming here. Who remembers germanium when he studied high school chemistry? By name, probably but not otherwise.

Look at zirconium. You will have trouble getting a good atomic reactor with zirconium. What is it good for? There's a very plentiful, beautiful gem called the zircon. Your wife likes to have it set in platinum as a jewel. It is quite abundant. But that is not its prime usefulness. Its real usefulness lies in zirconium oxide, one of the most valuable materials for lining furnaces, because it will withstand high temperatures. Modern metallurgical chemistry goes to high temperatures. As an oxide it is useful for one thing, as a metal for another. It has a peculiar property. It is useful in an atomic pile. It has the structural properties of a metal like steel, and it has neutron properties which are ideal. It also has heat-resisting properties.

We come up with another one called hafnium. It is one with great possibilities. It is hafnium which provides the highest melting point of any known elemental metal. It is the very thing we need to get high thermodynamic efficiency in heat engines.

I can't spend any more time now on the periodic table, but note that it is the heart of man's future in many respects.

Let us talk now about some of the economic factors. We will slip into the next phase.

See chart 6, page 19.--These are developments in a broad sense and not products. "Atomic power" should read "atomic age," because power is synthetic here. Atomic synthesis or radiation synthesis is a new chemistry. You can take ethylene and put in it a tube, shoot atomic radiation into it, and you have polyethylene. Now you can abandon these big reactors,with their heat lines and everything, and just put a small synthetic polyethylene plant. All you need to do is push gamma rays into ethylene and it becomes polyethylene. Of course it is not that simple or we would all be doing it, but it is being done in laboratories and pilot lines now. It will come soon.

CHART 6

TECHNOLOGICAL DEVELOPMENTS HAVING FUTURE POTENTIAL

ATOMIC POWER

ULTRASONICS

COAL HYDROGENATION

OIL SHALE EXTRACTION

CHEMISTRY OF RADIATION SYNTHESIS

FOOD STERILIZATION AND PRESERVATION
BY RADIATION

— — AND OTHERS

As an illustration, one laboratory took standard lubricating oil and put atomic radiation into it. It turned out hard as wax. The wax was so hard, so unlubricating in its qualities, that they thought it was no good. But, instead of saying, "Oh, heck; this is terrible," they should have said, "Hurrah! it is wonderful," because gamma radiation can perform a new chemistry. We didn't see it then. Very few Americans see it now. But some scientists see it. It is over the horizon, a liberal horizon. Gamma radiation kills bacteria, finds flaws in steel, causes chamical reactions to occur, affects biological material. It has uses for communication, like Navy sonar. It is fantastic.

Look at coal hydrogentaion. This is just a simpler way of making lubricating oil out of coal. We took it from Germany. We have a big plant in West Virginia that is making it. It is also being done by the Bureau of Mines. This is all based on German science.

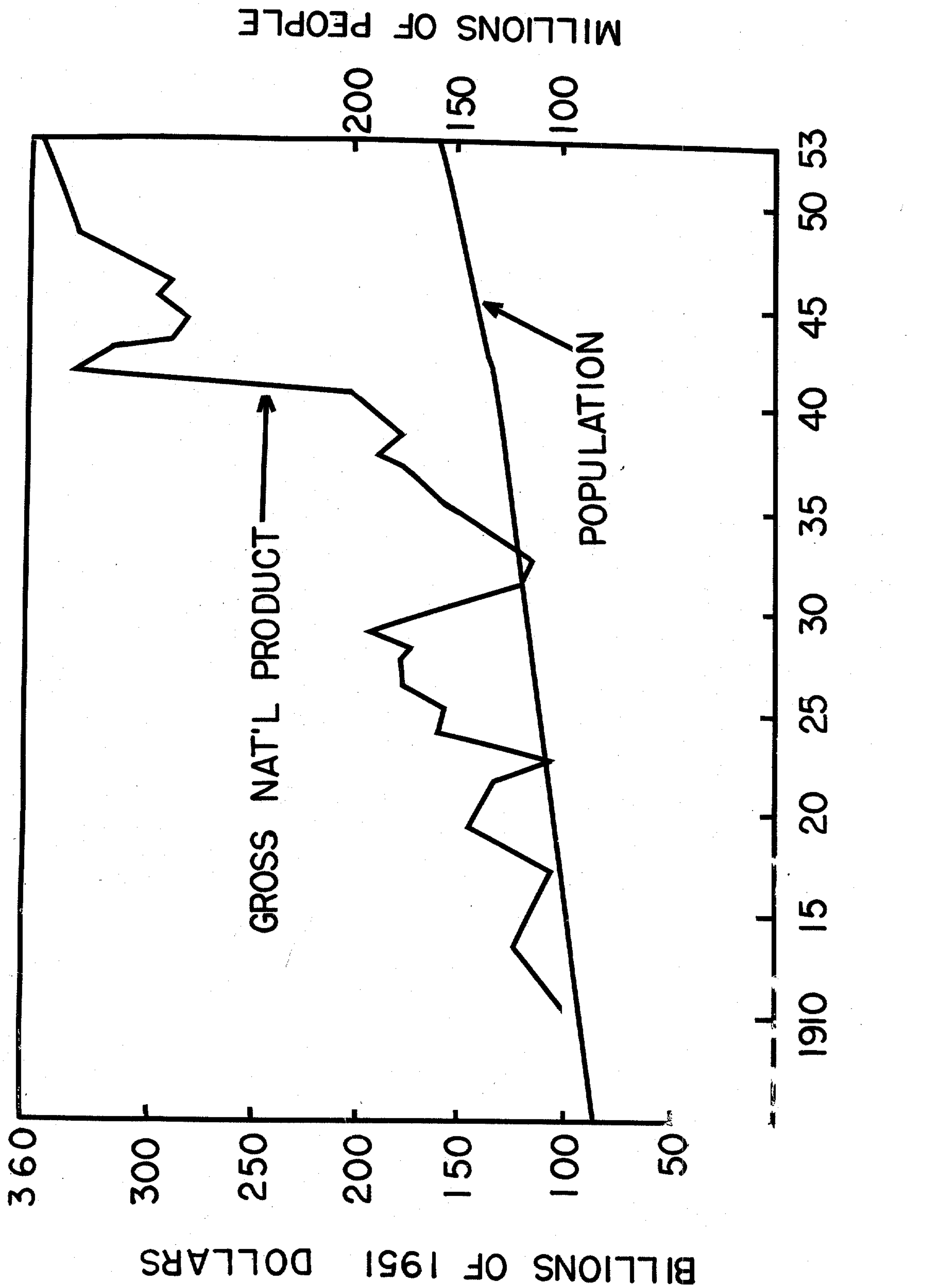
Oil shale extraction--this is also Bureau of Mines work and is taken from the German science. Much work is being done on that, too. Plants are being completed to tap our fossil fuel resources.

Radiation synthesis--this refers to food preservation. That is of great interest to quartermasters. It is a waste product from every atomic pile in the United States. We have arranged with the Navy to give a classified contract to the Woods Hole Oceanographic Institute to find a place in the ocean where the stuff can be buried, where there will be no uplift in the ocean currents to bring it back to the surface. This is a reverse project--how to get rid of something. But, I don't think we are going to get rid of it. I think we are going to use it--to sterilize meat, food, milk. We are going to use it in synthesis to start chemical reactions. It is already being used in place of X-rays in the treatment of cancer.

Next, let us take the next phase of this lecture and call it "World-wide technical advances." Is our position here stronger or weaker?

Chart 7, page 21.--This is the gross national product in terms of population. Social science, gentlemen, you are in it. Now watch out--the gross national product must be talked of in terms of a constant commensurate factor, even for statistical purposes. So we introduce you to the standard dollar in this case a 1951 dollar. I suggest you go to the mint and try to buy a standard dollar, and see what you get. You would get no such thing. It is an artificial fiction. It is a useful one, but an unscientific one. At any rate, we have it and it is the best thing we can go by.

CHART 7


MILLIONS OF PEOPLE
200
150
100
GROSS NAT'L PRODUCT
POPULATION
1910
15
20
25
30
35
40
45
50
53
360
300
250
200
150
100
50
BILLIONS OF 1951 DOLLARS

But do notice that population growth. Important as it is, it does not explain the upward trend in the gross national product in our economy.

All right--if this is occurring here, what is its relation to our enemies?

Chart 8, page 23.--Carry that in your mind a little bit--equivalent of United States dollars. How many rubles are equivalent to a United States dollar? Nobody knows that. It is here. And the same for all the other currencies. So picture this, not as a true quantitative scientific chart, but as a trend chart. You will notice where the United States economy is. Canada is our closest neighbor and the next highest in economy to ours, because of the traffic back and forth across the border and the flow of our ideology and economics.

You will notice Sweden is another country which has a very high Nordic type of thinking. And I don't belittle the non-Nordic type of thinking one bit. But a temperate climate makes you want to work. Those of you who have lived in the tropics must know what I am talking about. You don't feel like climbing mountains in Panama. Sweden is a northern country, which has been in business for a long period of time, has a high order of scientific and engineering attainment, and a good economy. The people have a great feeling for the economic resources. It comes number three. Switzerland is another country with a history very much like Sweden. It falls into fourth place.

You gentlemen will study all the others in the other parts of your course. So we won't dwell on this except to point out where Russia stands. I am talking now about our position. Are we gaining or losing? It is obvious that our position here is good. It is good, because we haven't been attacked. That is the best proof that it is still good.

Now, the fact that this has come up from down in here in the time of the Bolsheviks is what we want to keep our eye on. Also how fast it has come up to here. What are the factors?

I won't spend any more time on this chart. I would like to go to the next one.

Chart 9, page 24.--How is this standard of living brought about? Is it some form of magic? No, it is not. This curve is the only one that I will take any credit for. It is original with us. It tries to do away

CHART 8

PER CAPITA INCOME

1952

(EQUIVALENT U.S. DOLLARS)

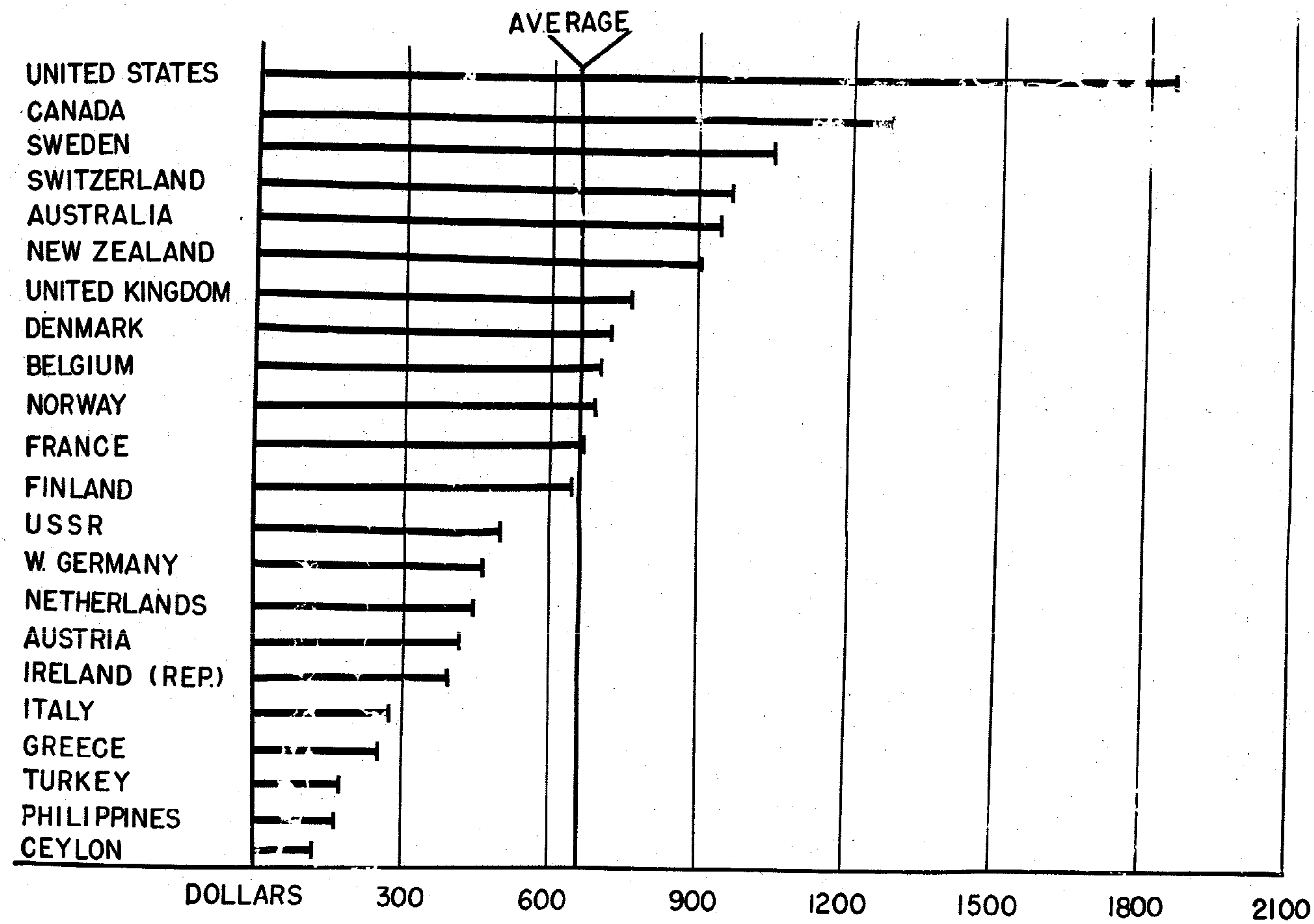
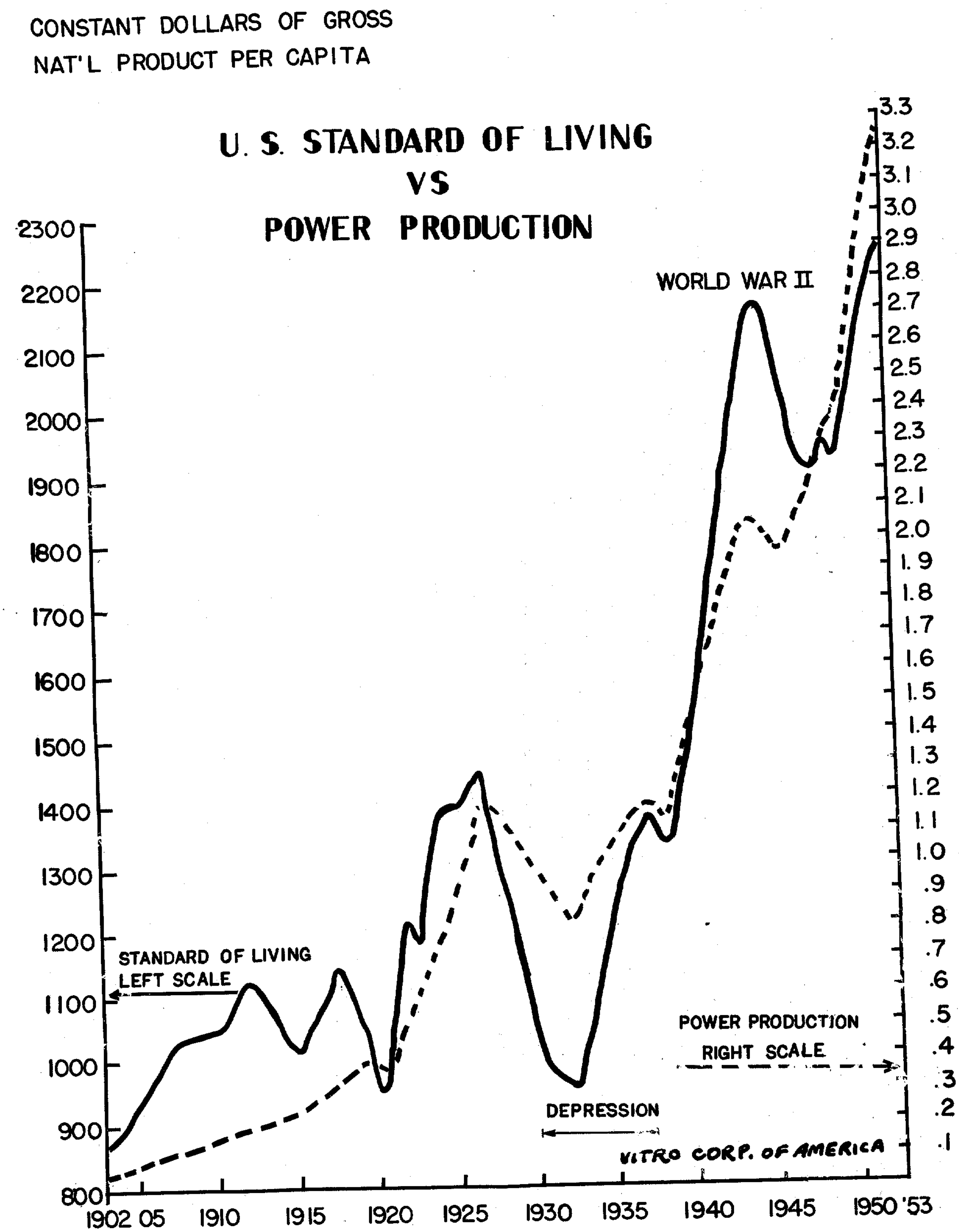


CHART 9


CONSTANT DOLLARS OF GROSS
NAT'L PRODUCT PER CAPITA
U. S. STANDARD OF LIVING
VS
POWER PRODUCTION
WORLD WAR II
STANDARD OF LIVING
LEFT SCALE
POWER PRODUCTION
RIGHT SCALE
DEPRESSION
VITRO CORP. OF AMERICA
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
1902 05
1910
1915
1920
1925
1930
1935
1940
1945
1950 '53

with one of the too many bland assumptions of the economists--one with which I do not agree. They pick some period of years and say, "This is unity."

There is no such thing in all the history of man as a period of unity. I can pick a period of years and you can pick one. We will all draw the same chart, with the same set of rules, and get three conclusions, because that assumes that I know what series of years to pick; that in some way becomes magic. This chart makes no such assumptions. This chart covers the entire recorded period of over 50 years of experience without reference to anything except trying to equalize the dollar. What does it give you?

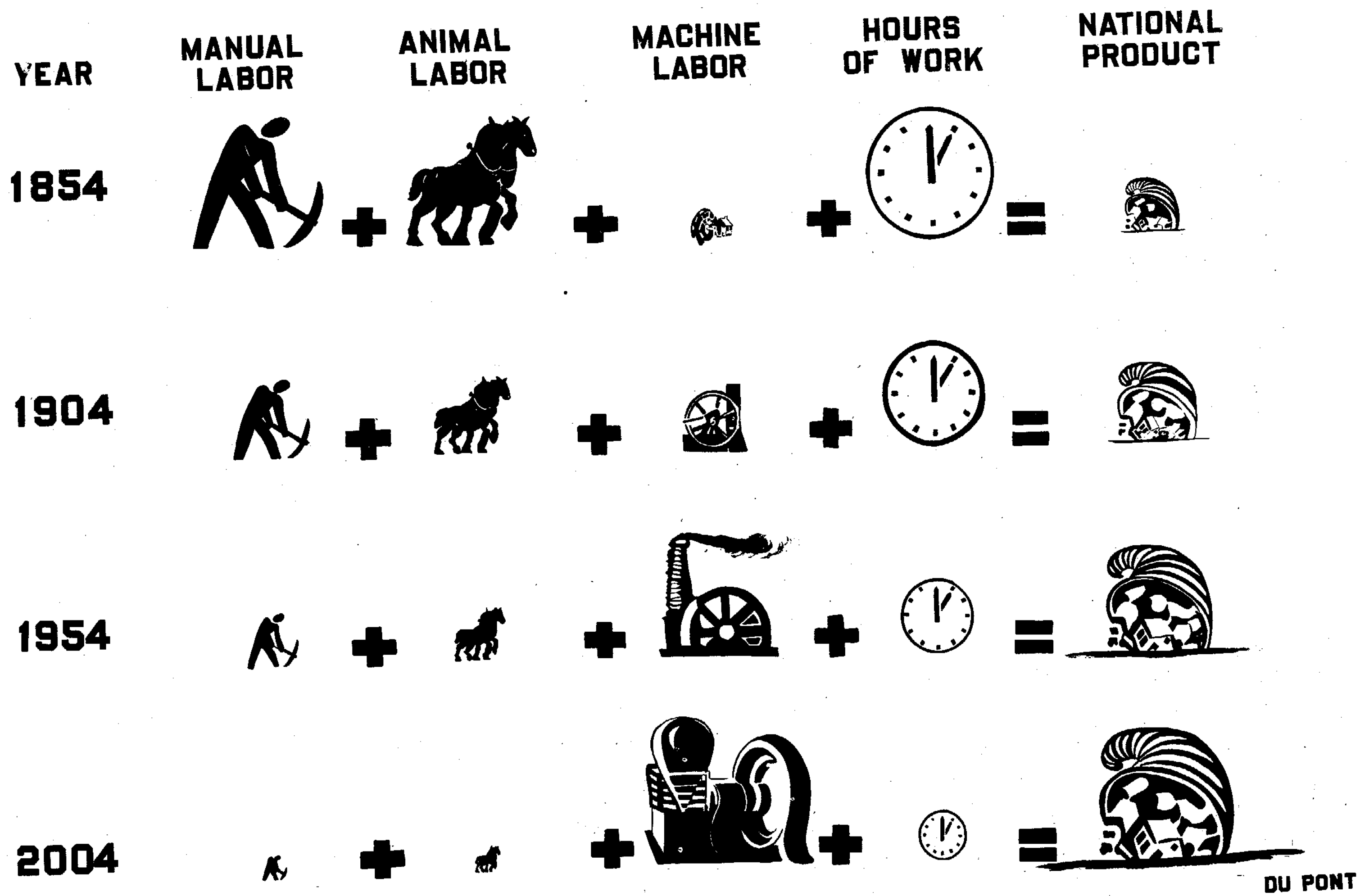
Kilowatt hours do not change over the years. So we have no trouble with the scientific side of this picture. It is the social side of the picture where we have our trouble--the dollar.

In an attempt, then, to see what happens, we went back to 1902. We overlay that chart, which is the gross national product divided by the population--the standard of living--laid it over what engineers would recognize as the cause of your standard of living. And what is that? It is the energy that man has to use to create goods. Goods divided by population is standard of living. Dollars do not have a thing to do with it. They are no more than the poker chips you throw out in a poker game. You can make them worth 50 dollars, 50 cents, or 5 cents. But you cannot make a kilowatt-hour anything but a kilowatt-hour--the equivalent of the output of 20 or 30 men working for an hour. You can talk kilowatt-hours as long as you want and they will always be the same.

Now we are plotting man's capability to use the forces of nature, to use energy. What do we find? It is our standard of living. This is fantastic, because it is so very obvious and simple. And yet books have been written about how to get the standard of living up. Laid end to end, they would reach no conclusion.

Chart 10, page 26. --This is the contribution of the machine. The height of the man under "manual labor" represents the amount of manual labor that an individual did in 1854. You will see now what is wrong with our muscles when you look at 2004. Look what man had learned to use as the principal energy source in the 1850's. It was animal power. He had to feed his animals oats; chain them to a plough. Look where the poor old horse is now. He is going to be found only in museums, and in a wonderful industry which says it is devoted to the upbreeding of human and horse flesh, namely, racing.

CHART 10


YEAR
MANUAL LABOR
ANIMAL LABOR
MACHINE LABOR
HOURS OF WORK
NATIONAL PRODUCT
1854
1904
1954
2004
DU PONT

Machine labor--there is an interesting thing. Look at the position of the machine in 1854. Look at the machine today in terms of the horse and the man.

And now look at the clock. In 1854 people worked 12 or 14 hours a day. Steel workers worked 7 days a week, 12 hours a day. Look where the clock is today.

So with those hours of human labor, that little fellow over there, taking this into his partnership, produces per man this amount of goods, as compared with what he did in 1854. Pictorially this is merely the proof of the previous chart--that the energy that man uses in machines--machinery plus energy is what we are talking about--determines your standard of living. And, gentlemen, you know your standard of living determines your economic potential. Your economic potential determines your weaponry and your logistic support. Your weaponry and logistic support determine your combat posture. Your combat posture determines your fate. That is how simple it is.

Chart 11, page 28.--This shows the electric power in the United States and its allies, as compared with Russia and its satellites. If your war potential is the same as the ability to use energy, then this represents your war posture, provided you have the morale and you have translated the energy into weaponry in a balanced proportion to your economy.

You see 880 billion for the West as against 202 for Russia and its satellites--amazing. You would have to starve the Russian people in order to wring out of them more than that--the Chinese too--to get enough production to carry on a protracted world war. And I don't care what their manpower is. You would just have to wring it out of the economy, that is, the civil economy, the supporting economy. This is Russia's greatest weakness.

What is the element of progress? Are we gaining or losing? This is merely a chart of today. We don't have time to put in anything with regard to what it was 10 years ago. It is true that Russia is gaining on us. We still have a little time--not too much, but we have it.

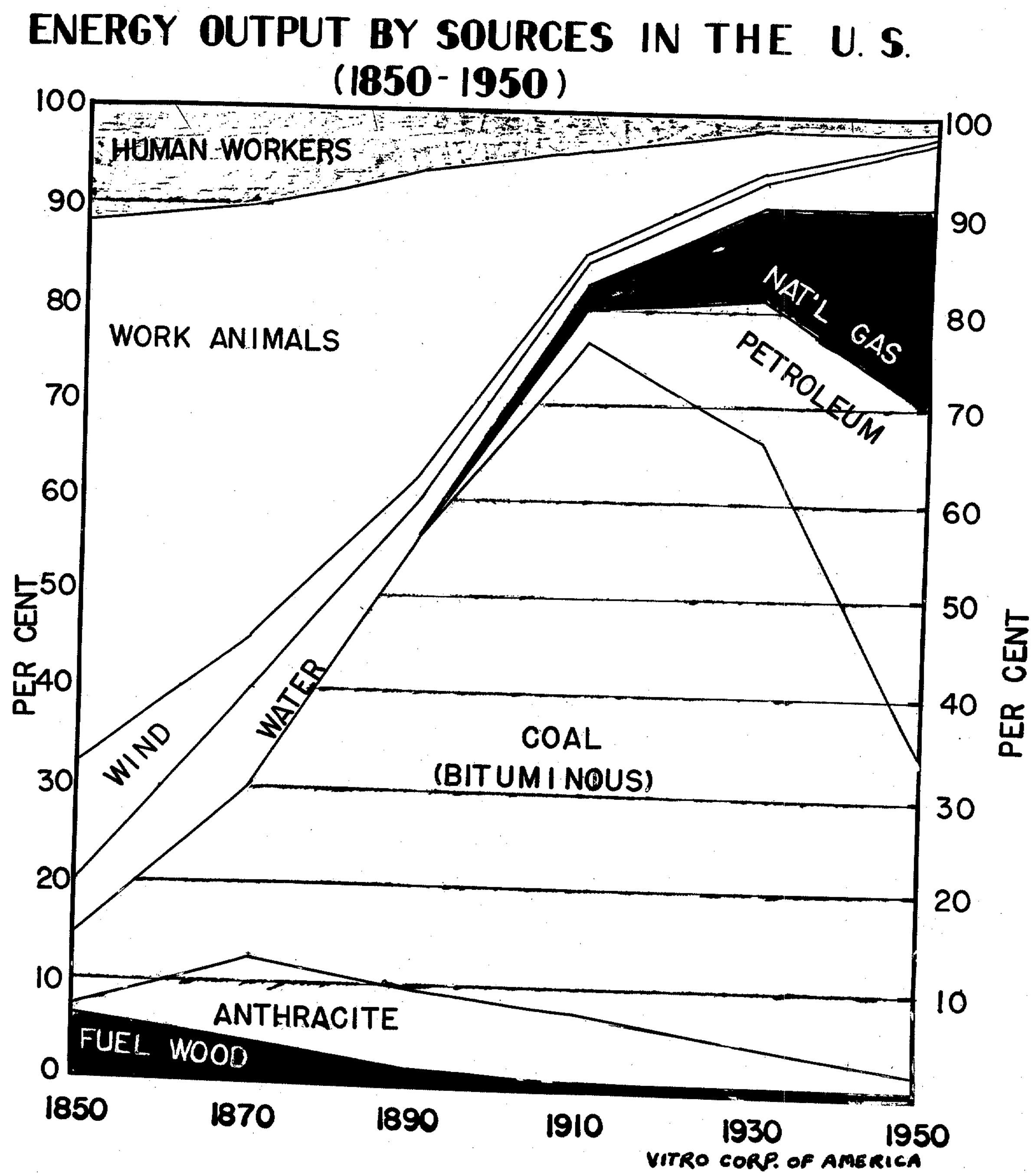
Chart 12, page 29.--This is a little chart that we made up and I think is quite illustrative. This is energy output by sources from 1850 to date. Here again you see the human worker pictured as he was on another chart. Here you see the work animal like on the other chart.

CHART 11

ELECTRIC POWER PRODUCTION
1953

	(BILLIONS KWH)
UNITED STATES	513
WESTERN EUROPE	302
CANADA	65
TOTAL WEST	880
USSR	133
EUROPEAN SATELLITES	60
COMMUNIST CHINA	9
TOTAL SOVIET BLOC	202

CHART 12


ENERGY OUTPUT BY SOURCES IN THE U. S.
(1850 - 1950)
HUMAN WORKERS
WORK ANIMALS
NAT'L GAS
PETROLEUM
WIND
WATER
COAL
(BITUMINOUS)
ANTHRACITE
FUEL WOOD
PER CENT
100
90
80
70
60
50
40
30
20
10
0
1850
1870
1890
1910
1930
1950
VITRO CORP. OF AMERICA

Here you see the wind. You didn't see that on the other one. Here you see water. It is pretty clear that the total waterpower of the world is no basis for civilization.

Look at what happens to bituminous coal. Look at petroleum and natural gas. Look at the ratio of this to technology and science. This is the part it plays behind the scenes as a method of generating energy. Here is fossil fuel. Here is anthracite, used for heating. This represents one stage in our civilization. In 1854 80 percent of our useful energy came from burning wood. That chart is interesting merely to show the effect of the new technology on your energy sources.

Chart 13, page 31.--There is your gross national product for us and our enemies. Look at Russia--total West 1136 and Soviet bloc 222. This is merely another way of interpreting how we use energy. What is the end product of the use of energy in these two economies? This is it, gross national product.

I would suggest that you study this chart a little bit. Break down the effect of this on the Soviet Union and its satellites and on us and our allies and then pose yourself this question: What will happen if we get high hat? General Albert Gruenther discussed that very ably in his lecture recently at the National Security Industrial Association. What will happen if we make enemies of some of our present allies, like France? You will find it gets pretty serious. Just start shifting these blocks around. Imagine that Russia has the capacity to overrun western Europe and we lose our friends. See how this ratio changes. But that is a military analysis, which I am not trying to talk about here.

Chart 14, page 32.--What does it take besides energy to advance technologically? It takes men of science and men of engineering--scientists to broaden the horizons and engineers to put their results to work. What is going on? This is recent information. I cannot support these estimates for the future at all. I don't think anything ever happens on a flat line, it is just an expression of ignorance.

I have a paper here that I was going to read from. It is frightening. I don't agree with the author in everything, but you must all have heard of him. He is a most distinguished educator and scientist--Dr. John Dunning--who performed the first fission experiment in the United States, out of which the Manhattan District got its name. A wonderful fellow and a wonderful educator; a man of very many talents. But you get a much darker picture now for the race between Russia and ourselves

CHART 13

GROSS NATIONAL PRODUCT 1953

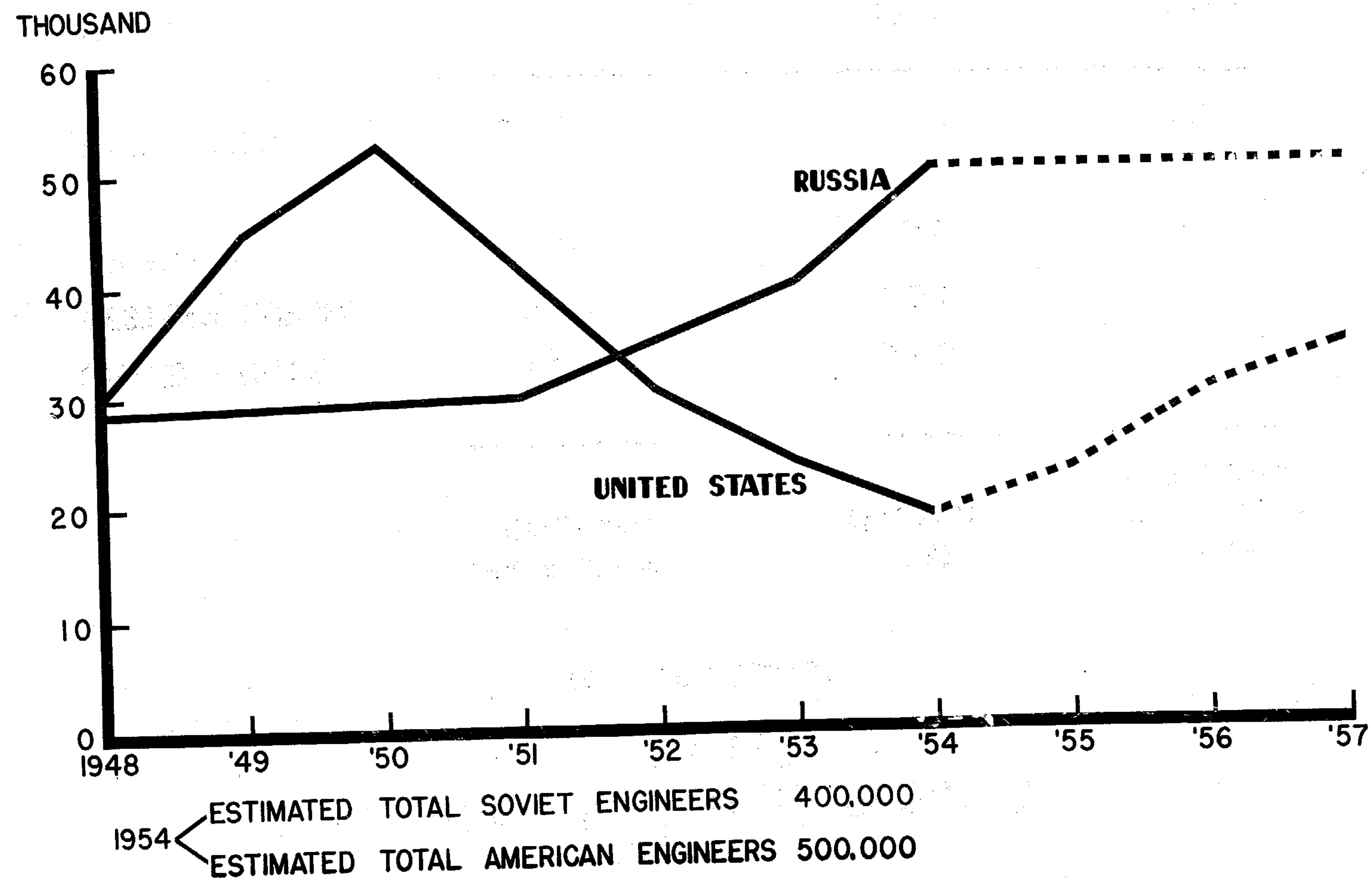
(U. S. DOLLARS)

	POPULATION (MILLION)	GNP (BILLION)	GNP PER CAPITA (DOLLARS)
UNITED STATES	160	360	2255
WESTERN EUROPE	332	191	577
CANADA	15	24	1581
TOTAL WEST	507	575	1136
USSR	211	106	502
EUROPEAN SATELLITES	95	40	421
COMMUNIST CHINA	475	28	58
TOTAL SOVIET BLOC	781	174	222

CHART 14

ENGINEERING GRADUATES

(BACHELOR DEGREE OR EQUIVALENT)



to provide that technology with which to combat the differences in economic power.

There is in Russia a mechanism called "teknakon." It is a Russian word, and I don't know how they pronounce it. The teknakon is not to be found in the United States. There are 35 or 36 teknakons in Russia and they are in a twilight zone between an engineering bacca-laureate curriculum and a technical high school. They are much better than our technical high school, reaching up toward our bacca-laureate engineering courses.

Those teknakon figures have not found their way into this chart for it is not being done that way here. The Russian curve, relative to ours, is frightening. This even goes so far as to say that as early as 1959 we are licked. Russia indicates it will have a bigger well of manpower than the United States in the scientific and technical fields.

I will not necessarily hold to that; but I will say this is something for you to be, like myself, somewhat frightened about. You do see the trend of the Russian and the trend of ours. And it is not good.

You have to realize that this is the number of graduates per year. You must take into account also the well of graduates that exists. We do have today far more graduates than Russia has, because she was just coming up when we were already up. She also started late. This is part of Uncle Joe's work. It is interesting to note that Malenkov is an engineer and Krushchev is an engineer. The top men of the Russian Government are engineers. They know the importance of engineering and science in this struggle. Were they lawyers, as most of our top people are, were they professional educators, were they businessmen, what would have happened? That is a question. But they are not. These men are engineers. And in Russia they can tell what students are going to become engineers. They do not leave it to the whimsey of educational advisers, parental prejudices, childish ignorance.

I don't know how to combat this. I have no prescription for it. This is a problem I will leave to you gentlemen.

Well, that is what we are talking about in a sense. Are we gaining or losing relative to them in terms of war potential? I will try now to construct my formula for war potential. What is it? You know already that total combat troops, airmen, sailors, are not the answer. Also the total excellence of weapons is not the answer. Logistical supply must be coupled into it. This means we have to take the civil economy and weld it into what is now the concept of modern or total war.

In a democracy this is very difficult. Politically it is very difficult. Try to tell the laboring man he is going to go to a different town and work where there is a very urgent need. Try to tell Mr. Smith's son that he is a scientist and stays in his laboratory, while Mr. Jones' son goes into the Army and carries a rifle. What would happen? Mr. Jones would go to his Congressman and say, "Isn't my son as good as Mr. Smith's son?" What a Congressman can do with that kind of stuff!

Mr. Malenkov has only Mr. Malenkov and Mr. Krushchev to think of. That is a far simpler problem. But we do have some advantages. One of them is this: It is one thing to order people into their walks of life and another thing to get the same degree of response from them as from the man who selects his walk of life, the fellow who can tell his boss where to go, and frequently does. There is a difference in the output. There is a difference in the response.

I don't propose to tell you that we can evaluate that. All we know is that it exists. This is a social science statistic. Many meanings can be put upon it, such as the inability of the Soviet to make Moslems respond to agnostic requirements. He has not assimilated his Moslems. He has spread them. He has moved them around. He has destroyed their centers of culture. Thus gentlemen from the sunny Crimea frequently find themselves in the icy wastes of Yakutsk.

I don't think those men respond as readily as an Indianan who moves to California. I think that this ability to live where we want to live, to do the things we want to do, is a tremendous advantage. But I don't know how to tell you how to measure it. I think we had better call it our ace in the hole. Look at the quantitative factors which you can deal with.

I am going to try to bring this thing to some sort of summary close, or neat little package, if I can.

One of the most subtle things that now must be given some consideration, and one which I must say I have had quite a bit of experience with, is an intelligent assimilation of the scientific advisers into the military echelons. This has not really been accomplished to date. I think great progress has been made. I remember Hap Arnold and his attempt to create Project Rand. I remember the conditions at that time. I want to assure you that a great deal of progress has been made since then.

But I would like to leave with you this problem: It is only people like you who can do it, and I am not pointing my finger now at any non-Industrial College graduate within the military service. I say "people like you." You have to come here and learn this relationship and apply it in your policy decisions subsequently or you have to come to these conclusions elsewhere.

The scientist cannot create a new body of science by a military order. He must have a desire to do it. If he has a gripe--and they do have gripes--you must deal with him, not on a military basis, not put him in the guardhouse on bread and water, but you have to sell that guy. This is not part of the military tradition. You don't have to sell a noncommissioned officer on the fact that he should execute your command. But you do have to sell these scientists.

Your skill in recognizing his role and keeping him out of roles that he doesn't belong in is just as important. He is just as human as you are. He is an empire builder, too. He often likes to get over into your province; don't let him--he is inadequate there. There are rare exceptions, but usually he is inadequate. In his own field he does not work like you do.

This has all too frequently not been recognized by military people in high-policy areas. It is only people like yourselves, who come here to study this relationship, and get from it that understanding which is part of your team, who can do it. It is not only a question of devising weaponry and even weapon systems and assessing military problems, but also going out and perfecting their use. You can hand out a manual on how to use a complex radar, but you can't hand out with it the brains, the understanding, of what happens when that radar system has a limitation or a breakdown, and whether you can do something on the site or whether you have to ship it back to the factory and fight under a disadvantage. And the military commander should not try to do it. So you have to integrate these boys into your picture. This is one of your most difficult problems.

In attempting to anser your lecture scope, namely, "What is science doing to maintain the relative position of strength of the United States?" we must consider our scientific potential. I don't have to explain the meaning of "potential" to you. You have it all through your own documents. You know what is meant by "using our production potential." In addition to that, and most important of all for the future, is the skill with which those factors are integrated into the military potential of our country's forces. Thus it can be assumed that this lies behind the objectives of the Industrial College, and in particular that section of the curriculum which is devoted to technological progress, to which this is merely an introduction.

COLONEL WALKER: Gentlemen, Mr. Ward is ready for your questions.

MR. WARD: That is quite an assumption, but go ahead.

QUESTION: Mr. Ward, are you recommending that basic research be done entirely by universities and industry, rather than by the Government?

MR. WARD: I don't think industry is very good at basic research. Industry talks about it, but I don't think it does very much research, although there are some isolated examples. As a matter of fact, so-called basic or fundamental research is best done by people who are completely free of any direction, who are doing something that has captured their imagination, and who are very advanced scientists.

Let me give you an example of what I would call basic research. The nature of the forces that combine atoms into molecules is not known. Their behavior, therefore, under gamma radiation to form new compounds is observed by people--they do not understand it.

I would like to see in the United States an attack on that problem. It cannot be done in industry. It can't be done in the Government. It has to be done in the university atmosphere--as part of a graduate school environment, to which men will come merely because this problem is being attacked and for no other reason--by men who are not interested necessarily in the salary, but who are intensely interested in making a contribution to the problem.

We have not gone far enough with the problem in universities. There is a gentleman in London University who has written on this subject with great erudition. We have two Nobel Prize winners in California, one who has done great work in the field of chemistry and the other in the field of theoretical physics, who agree that this is one of civilization's greatest challenges. They say that, in spite of their preoccupation with other lines of research, this is such a vast challenge that they will give of their time and of their prestige in attacking the problem. Gentlemen, we have everything all set but the money.

We cannot go even to the Office of Naval Research and say we would like money to support this project. I think it would be very difficult for people in Government to get anything like it through Congress, because these men will not come in unless this can be their lifetime work. They will not come and work on an annual budget. They will not come unless they are moving their families and themselves, and their future is secure in a friendly atmosphere, noncommercial and nonpolitical--something which indicates that they are carrying out their ultimate mission within their lifetime.

I don't know that I can make this wholly clear to you all. Many of you know this. These men cannot be bought. Professor Werner Heisenberg of Germany, who enunciated the mathematically stated uncertainty principle which is the basis of much of the quantum behavior of atomic science, was in the Russian area. The Russians did everything to influence him and his family to go to Russia. He refused. For anyone to refuse Russia when he is in their power is not simple.

I use this illustration to point out that these men are above the motivations of ordinary human beings. Heisenberg won't come to the United States either. He is going to pick his own environment. He is going to work in that environment, on his own ideas. He is one of the great scientists of the world.

There were other German scientists with the same attitude. These are the men we are talking about in fundamental research. Of course there are lesser men and also lesser research projects. This is where the importance of that pie chart comes in, which shows the relative proportion of research that is done in universities and nonprofit institutions. It is only in universities that you can build the environment for this kind of thinking. These men won't even to go most of the universities. In fact, there is not a single American university that can stack up with the traditional great universities of Europe in which this kind of work is done.

This is the Achilles' heel of our leadership for the future. It is the Achilles' heel in our generating within our environment the advanced technological knowledge which up to now, frankly, as a nation of doers and pioneers, we have imported. It is a foreign commodity. Many of the great professors who deal with these things now in the United States have been imported and are now American citizens.

So I can't answer your question other than to say that this is not a Government function, except that the Government can supply the money. I don't know if it will, because it implies continued support; and you know the congressional limitation on appropriations.

Where will the money come from? Universities don't have that kind of money. It has to come from enlightened American industry. If the Du Pont Company, for instance, recognized that its great opulence of today came out of Germany, it should support, in peanut terms, among other big American corporations, this kind of effort inside our country. Unless we can break this pattern in our universities--and I think all universities can reach out with their resources to do it to a greater or less degree--we will not have within the continental United States the long-range security of our Nation.

QUESTION: Can the National Science Foundation help in this; and what is its relation at the present time to this whole effort?

MR. WARD: I do not know the Foundation's relation to it, but I know it can help.

Let's look at a test case. On my own initiative I wrote to a great university explaining this challenge that I mentioned to you. It came out of my work on NEPA as a byproduct and had to do with radiation synthesis in another form. I said, "What are the forces that cause some compounds to behave as they do under gamma radiation and others not to behave in that way? What is the mechanism?"

I explained the scope of this problem to that university. You would be interested in what it said. The vice president, a very well-known man nationally, said, "We are doing this kind of work." Well, he missed the point.

A professor, the chairman of the physics department, to whom I sent a copy of that letter, wrote back to me, " For six years I have had as a dream one facet of this problem and how to get it started." The president of the university wrote to me, " I don't know what you are talking about, but it sounds awfully good."

I know five trustees of that university who also don't know what we are talking about, although they think it is awfully good. They are in some of our great corporations and may support some of this movement. They are looking into this thing.

This is a typical example of the problem in which that chairman of physics has interested his fellow colleagues. He hunted all over the world for papers written in all the languages bearing on the problem. He tried to find a young man in an educational institution who would serve as the starter. This is what it takes: Funds to support five scientists in five separate regimes of science, to act as a nucleus or team, through which there can be spread throughout the world the fact that this problem is being attacked here in the United States, and that it is a permanent effort within a graduate school framework. That is where it stands.

I don't know that this answers your question. But if the Science Foundation could pick this up, if it were known that it was interested in such a project, the prestige of the project would move forward.

One of the gentlemen who is going to associate himself in this project is the president of the American Physical Science Association today, which is one of the top scientific bodies. I think it needs that kind of support. But it really needs money and an assurance of the continuation of that money, so that it is not the whimsey of a board of directors of X corporation or an appropriation committee of Y congress.

QUESTION: Perhaps you went to fast for me, Mr. Ward, but I seem to find a discrepancy between your approval of the freedom of a worker to go from here to California and your apparent disgust with the right of the graduate of a high school to choose his own college career. You called it childish ignorance.

MR. WARD: No. Not at all. I am afraid I wasn't clear. I thought I said this: In Russia they order the young man where to go and what to study. They do it by educational tests and an I. Q. equivalent. They start him out with some type of psychological test. They don't do it blindly. They use the techniques that psychology teaches and that education teaches. The man falls into a class and that is where he goes. I said that in the United States this isn't true. I will illustrate our weakness.

A few years ago, I believe, "Life" magazine published an article in about 1950, sometime before Korea. The article was by a man at Toledo University. The article said there was an oversupply of engineers in the United States.

As witness, "Life" had sent, presumably, one of its all-seeing and all-knowing correspondents, probably from a school of journalism, who had never studied physics. He went to this university and came up with the remarkable social statistic that only 38 percent of the students of Toledo University in engineering had secured jobs at graduation, implying that the remaining 62 percent were going to be on the town, so to speak, and would have to work as bank runners or something.

Before that article appeared, it was submitted to several educators, whom I don't wish to name. One was a speaker before your college, who became incensed and said that in his institution 68 percent of the engineering students had taken jobs, and the other 32 percent could but didn't choose to, because they wanted to have a last vacation before they put their heads in a noose for the rest of their lives--that was normal. Therefore he said, "A number of things will have to be extracted from the Bureau of Labor Statistics' figures." The statistics were correct, but the implications were incorrect. They had used these statistics to come to the conclusion that there were too many engineers in the country. That is a typical example of how you can take a general fact and come up with a completely inaccurate conclusion. But out of this they produced the article.

What happened? The enrollment in every engineering school in this country fell off the next year. That is the power of the written word in the circulation of a great medium like "Life."

Now, this dean of engineering rushed to Washington and sat down with the Bureau of Labor Statistics and showed it the fallacy of its statistics. The Bureau revised its approach and the implication in its report. Alas, the article was all set. The dean warned "Life" not to publish the article. But its representatives said, "The presses are all ready. For goodness' sake, we did the best job we knew how, let it go."

So a committee of educators was formed. They attacked this problem here in Washington. It was very grave. The dean became consultant to General Hershey, a gentlemen who in the past had been very brusque about this question of using technical talent for technical purposes in the military machine. And the educational institutions went to work. The barn was then locked, but the horse had left. We suffered for two solid years in the engineering colleges for one "Life" article and all of its ramifications. We learned that vocational directors of secondary schools were telling their students: "Don't go into engineering, my friend, unless you are absolutely sure it is the only thing you ever want to do. There are too many." So, much of the good material went elsewhere.

My comments were directed toward that kind of process, not toward the fact that we have freedom in this country. Everything I said was to show that the Soviet is inferior to us by the lack of freedom. But the very freedom means responsibility. And this is a case of responsibility. It is so important. People say to us, "Our freedom has strength and not irresponsibility." I hope I have corrected any false impression you got on freedom.

QUESTION: I think what you said was that you wanted a more informed and enlightened choice.

MR. WARD: I did. I would like to have the facts behind the story that we discussed this morning more clearly understood outside the college. But I am talking to the college.

COLONEL WALKER: Mr. Ward, I know I speak for all of us when I say that we have certainly enjoyed having you with us for another year. You have given us another one of your outstanding presentations. For our Commandant and all of us, I sincerely thank you.

(29 Nov 1954--750)S/gmh

A33998