SCIENCE AND TECHNOLOGY IN THE UNITED STATES TODAY

22 August 1961

CONTENTS

Page

INTRODUCTION--Rear Admiral Rufus E. Rose, USN, Commandant, Industrial College of the Armed Forces..... 1

SPEAKER--Mr. J. Carlton Ward, Jr., Retired Chairman of the Board, Vitro Corporation..... 1

GENERAL DISCUSSION..... 73

NOTICE

This is a transcript of material presented to the resident students at the Industrial College of the Armed Forces. As such it represents the views of the author and not necessarily those of the Industrial College or the Department of Defense. Members of the College may quote it only in student reports or publications for use within the College. Other persons may not quote or extract for publication, reproduce, or otherwise copy this material without specific permission from the author and from the Commandant, ICAF, in each case.

Publication No. L62-5

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. J. Carlton Ward, Jr., Retired Chairman of the Board, Vitro Corporation, was born in Brooklyn, N.Y., 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 assist nt 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, general manager, and director of the Pratt and Whitney Aircraft Division, United Aircraft Corporation from 1935 to 1940; 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. From 1950 to 1953 he served as chairman of the board of Thompson Industries, Inc. He is director of Stanrock Uranium Mines Limited, the Aeronautical Chamber of Commerce, the Aircraft Industries Association, the Atomic Industrial Forum, and the Cornell Aeronautical Laboratory, and is a former trustee of Cornell University. He is also on the Secretary of the Navy's Advisory Board on Scientific Education. In 1940 he was chief of the advisory mission to the French Government on production of aircraft engines and in 1942 was appointed member of the War Production Board Mission to Great Britain. Mr. Ward is a member of many scientific and engineering societies and associations and has written many papers and articles on technical engineering subjects. He is Chairman of the Board of Advisers of the Industrial College of the Armed Forces and has participated in the Industrial College lecture program since 1946. This is his 18th lecture at the College.

SCIENCE AND TECHNOLOGY IN THE UNITED STATES TODAY

22 August 1961

ADMIRAL ROSE: Yesterday we heard two very interesting talks largely related to the political undertakings that the United States has and our position in the world related to political matters--national and international.

Certainly two of the great things that the United States has to be proud of, in which we are a leader, are science and technology. I cannot think of a better person to give us our first talk on this kind of subject than our speaker this morning, Mr. Ward.

Mr. Ward has had an engineering education at Cornell. He has been connected with companies, large and small, that have to do with the manufacturing of things and the developing of strength. He has also done a great deal of thinking about the United States. He is one of the very best friends that our College has. He is Chairman of our Board of Advisers, and naturally knows people in Government, in education, in business, and industry.

Without any further ado, I would like to introduce Mr. J. Carlton Ward, who will speak to us on "Science and Technology in the United States Today." Mr. Ward.

MR. WARD: Admiral Rose, Gentlemen: Mr, Leo Cherne's lecture of yesterday excited in me a good many thoughts and memories. Our subject today has a very direct connection with many of the implications of things which he said and conclusions which he arrived at. Reference is made to the role of science and technology in national power.

The first scoping as suggested by the faculty for this lecture reads:

"The major developments in the world of science and technology and their trend for the future. The significance of the great scientific achievements. An appraisal of the position which the United States has attained in these developments and the strengths and weaknesses in our capability for maintaining and improving our future position. Problems created by these rapid scientific and technological strides."

Now, it should be obvious to you all that that is quite a scope. In talking this over with your faculty, presenting an outline and asking them what should be omitted, it was decided to try to run the course. This means that you will get a break and then the talk will be resumed.

This brings to memory an incident in the French Cabinet. Two of the academicians were discussing the problems of speakers and one of them said: "There's nothing more disagreeable for a speaker than to have those in the audience hold up their wrists and look at their watches." An attempt to avoid this shall be made. There are means of avoiding it by shortening this address at any time that such an event might generally spread through this audience. But the other speaker replied: "Oh, yes, there is something worse than that. That is when they hold their watches up to their ears to see if they are running." You can be assured that we will not arrive at the later stage.

Now, in attacking this problem we know there are in this audience many who are much more capable of presenting facets of this problem than the speaker.

A large part of the spectrum of this subject has been spanned and therefore an effort will be made to put elements together for you out of an experience. In fact, if you could see my scars, you could readily see that the experience has been somewhat diverse.

First, my understanding of the meaning of science will be defined for this audience. Among you there are social scientists, humanitarians, and various educational backgrounds. To the scientist some of this may seem elementary. With no more apologies, but a definition--to me science is the study of the behavior of the materials and the forces of the universe. This, of course, includes the structure; it also includes man.

The peculiar thing about science for our discussion is that it differentiates itself from all other bodies of knowledge by virtue of the following characteristics. It is quantitative, measurable, precise, inviolable, and always consistent.

In human behavior we try very hard to use scientific techniques in other realms of knowledge, but this does not make those realms of knowledge scientific. An example that can be cited is that of the law of

supply and demand in economics. Many people refer to economics as a social science. This is a semantic distortion in a sense. It is a scientific approach toward unscientific material, because economics is basically unscientific. It reflects human motives, emotions, and behavior, which are not predictable. It is never repetitive.

Science is not subject to even these arbitrary definitions, such as "the average man." "A unit of population" is meaningless. What kind of population? At what level? Is one northern Australian aborigine the same as one highly cultured American university product? No. But they are both units of population. And so the poor social scientist has a struggle and a difficulty in trying to make this material look understandable. It was said of social scientists of the economic type that they all deal in statistics; and perhaps the way to describe them is by statistics and say that if you laid them all end to end, they would reach no conclusion.

There is a certain amount of accuracy in this statement, as witness the Rooseveltian era, when the law of supply and demand definitely was put aside. We cut the throats of little pigs and we plowed the crops under and violated a good many of the old Malthusian axioms. Today the law of supply and demand is becoming slightly respectable in economics again.

Now, a comparison will be made for you. This could not occur in science. Newton discovered what he called the laws of gravitation, and they stand today in the same framework where he first clearly defined them. The mathematics by which he described them is as accurate today as at the time of his description. Yet it cannot be denied that the Einstein era brought in a modification of the laws of gravitation in a refinement far beyond that which was possible in Newton's time.

This is an important thing for you to think about, for this reason: It is not fair to say that Newton's laws of gravitation are no longer accurate in the light of modern nuclear science. It is merely the fact that science moves no faster than the art of measurement. As Lord Kelvin put it, if you cannot measure it, it is not scientific. This is the essence, then, that separates all science from all other bodies of material.

Because of this characteristic of science, it requires a language that is precise; and there is no such thing as a precise language in a philological sense. The only precise language is mathematics. It means

the same thing to a Communist Chinese as it means to an untraconservative American professor. There is the same lack of ambiguity, the same precision of expression and description; and yet this is quite contrary to any other form of communication between humans. All you have to do is look up in a French, a German, or a foreign language dictionary the meaning of any given American word and you will find a great many synonyms; and there is a difference in meaning among them and the way they are used. So language has semantic problems which mathematics dispenses with.

Now, these are the characteristics of science; and it is not a belittlement of other areas of human knowledge--either the humanities or the social sciences--to point out that they are differentiated from science and from the body of scientific knowledge.

If we have a picture of science now, let us talk of technology. To many of you right in this room there is no doubt a confusion between technology and science. This occurred in the Military Establishment all through World War II and in much of the postwar period, and it is only now beginning to clarify. Many of you looked at engineers as scientists and scientists as engineers. This was the fundamental problem that plagued the Atomic Energy Commission, or prior to them, the Manhattan District. In fact it was a very serious problem.

These two crafts or professions are not alike. The engineer is differentiated sharply from the scientists--although he uses scientific knowledge for his craft--by the fact that he has to apply it for human purposes; and the minute he does, he becomes a quasi-social scientist and at that point he departs from all the rigors of true science. And he is motivated this way.

Let us take two examples to illustrate this, so we can get on with the subject matter. The first one is of science and of Lord Kelvin's definition. Why was nuclear science undiscovered until this century? Why through all the previous centuries has this enormous force--millions of times, billions of times, literally, greater than that of all the forces known in chemistry and physics--a thing so vast been undiscovered? How could we have missed it?

The answer lies in precision of measurement; and to give you an example of $E = MC^2$, a famous principle of relativity, imagine on this stage a 5-ton iron ball. Imagine this 5-ton ball over a red-hot fire. We

are now going to heat it from the ambient temperature of this room it might be 70 degrees, to its melting point, which we might say is 2200 degrees Fahrenheit. This is a lot of heat. If "$E = MC^2$" means anything, the energy--the heat--that goes into that ball in heating it must increase the mass of the ball.

We call it five tons. We use weight for mass in this case. How much more does that ball weigh--being five tons at ambient temperature--when with all that heat it is about to melt? Well, gentlemen, it weighs about 20 milligrams more. Let us see what a milligram is.

An ordinary postage stamp will transmit an ounce. You know what an ounce is. You can feel it in your hand. Now, try to imagine that you are feeling an ounce. A pound is about 500 grams for our purpose, and that means that an ounce is somewhere around 30 grams. A milligram is a thousandth of a gram. So if you will take one thirty-thousandth of the weight of an envelope with a sheet of paper in it and multiply it by 20, the 5-ton mass is that amount heavier with all that energy.

Now, do you see why atomic energy was not discovered? Because there was no such precision of measurement through all these previous centuries. It required the development of precise instrumentation to find that this was a fact. And remember now that science does not progress merely by the philosophical conclusions of man, which is the way in which the humanities progress. And the reason why the humanities are so lagging in terms of science is because they cannot test these philosophical objectives in the light of a cold hard physical experiment and determine whether they are right or wrong. But in science you must do this. And so when "$E = MC^2$" was announced by Einstein, it was disbelieved by the majority of physicists; and it was many years before there was any instrumentation to prove conclusively that that was a fact.

Let us turn to the engineer. What does he do? Let us assume that we are building a bridge from a city on one side of a river to a city on the other side. We might say that the design of that bridge and its construction are precise, and to an extent that is so. So we will examine that extent.

We choose a material--in this instance it is steel. We know what the strength and the ductility are, the creep resistance, and the corrosion resistance. We know all the properties of this steel. We say this is precise; it is in the realm of almost measurable, provable information. So we proceed to the design of the bridge.

The design is done by mathematical, rigorous treatment. We can calculate all the stresses in this steel structure. We will design these trusses. But for what? That is the catch. What kind of vehicles will cross this bridge? What is the density of traffic? What is the speed of the vehicles? And since the bridge has to be financed, and the engineer is a practical man, he knows that he cannot write off the bond issue in less than 40 or 50 years. The bridge therefore must be usable at the end of 40 or 50 years. Well, who is going to cross the bridge 40 years from now? What kind of axle loads? What kind of traffic? How fast will each of the two cities grow? How many lanes wide will be required on that bridge?

This is intuitive judgment, gentlemen. This is the crystal ball technique of the engineer, which is totally not present in true scientific work. A man who has the intuitive qualification is no more a man who makes a natural scientist than the thinking precision of the natural scientist makes the man who will step out and commit himself to intuitive judgment and to prophecy.

So please remember when we talk about science and technology together, we are talking about a marriage of two totally different professions--one of which merely tries to devise new knowledge and the other to use it usefully for the purposes of man. These are very different crafts. Yet we must treat them in a bracket in terms of the subject matter before you.

Let us now talk some about the historical significance of science and technology. It is difficult for me to talk on this subject without making brash statements.

The history of science was not even considered a respectable subject among the professors of history in their professional societies until the past several decades. And yet this statement is made with sincerity--the history of science has more to do with the history of mankind than all the histories you have studied. All the generals, all the kings, all the dynasties, all the migrations of people, all laid end to end are not as significant as the history of science. Let us see why such a statement is made. This is the meat of your lecture today. If you grasp this and understand it and are sympathetic to it, you will understand what is being said today.

Early man left no records, as far as we know. We start now with, Where did we come from and how did civilization get to a point where Russia and the United States are at loggerheads?

Man started by a process of evolution, which is scientific. The basis of it may even be radioactivity--and if there were sufficient time, you would be told the theory about how we came from inert chemicals into what we now find ourselves here in this auditorium. But we will skip it and merely say that the evidence shows that we evolved.

The earliest evidence of our evolvement, as understood by me, is about 1.2 million years old as far as man is concerned; and there we were around a campfire with tools. In a moment that thought will be resumed, because the cosmologists tell us that our little home--the Earth--and our little family of astronomical neighbors--the Sun and Milky Way--all were created some 5 billion years ago. Science pretty well agrees on this today, with much objective knowledge to support it. There will be precision in this measurement--refined as time goes on. But let us accept 5 billion years, then as the birth date.

There are two theories about this birth date, which we will not go into here. One is that the whole universe was created in a matter of a few hours. Dr. Gamow, here in Washington, is one of the leaders of that school of thought. The other school of thought is that creation is going on continuously; it always was and always will be; that new milky ways are being born as old ones die and disappear; that "$E = MC^2$" is a reversible reaction and that matter is going into energy all the time and energy is coming back into the form of matter. Both of these things have been accomplished in the laboratory. So there is nothing unfeasible about this approach.

If that latter school is correct, then new milky ways will be born after ours has died. But the history of ours is fairly clear, and the earth on which you are living will be and can be a battleground for humans for at least 5 billion more years. It has been here approximately 5 billion years. And now let us see what the history of science has to do with us.

When man first appeared, his whole day was consumed in search of food, shelter, and protection against the weather and against predatory animals. His social organization was most sketchy. We can only surmise it by studying little groups of baboons, who have a very limited social organization and are the highest of all the animal species left on earth today.

Man in that environment was largely an individualist. How he procreated and what his family relations were--we do not know. They must

have been very elementary. But when he progressed, and only then, his progression was based upon solving some of the problems of the universe around him, such as the use of fire--a very important energy source. When he first learned how to use fire; when he learned to use the lever by which he could move objects far beyond the capacity of his own muscles to directly lift; and when he learned to use the wind for transportation, something very fundamental happened. For the first time in his life, he had time. He built himself a structure--a home, a shelter. By fire he prepared his food. He accomplished miracles by making himself comfortable, avoiding the ice ages and continuing to live, and carrying on in the face of all sorts of danger. By the lever he learned to protect himself at a distance, and warfare was born in a sense, other than hand-to-hand physical combat. And we get down to the period to where we can use the example of Greece by skipping some earlier civilizations.

Remember that language was invented only about 6000 B.C. We have nothing written of the earlier cultures, and the first languages betray a fairly high civilization. So in this time of Greece you find what many humanitarians call "the Golden Age of Man." It was not a golden age of man. It was a cesspool, except that it bred, through leisure, some men of tremendous mental capacity, who wrote and put down some of the finest thoughts that man has ever evolved. But the reason they did it was that those philosophers did not work. They never cooked their food. They never went out and foraged. They built no houses. In fact Aristotle taught that a Greek patrician or philosopher never soiled his hands with experiments. He never experimented, because to touch materials and to fashion things was the work of slaves.

And so this early culture of Greece was founded on the backs of slavery. Statistics show that it took about 20 to 28 slaves to support one patrician. You will remember that Plato's democracy was no democracy as we understand it, but required that the voters would be selected by the government on the basis of property and intelligence; and if anything is undemocratic, that is it. And this was the Golden Age of Greece, founded on slavery. Warfare was a daily diet, because as you ran out of slaves, you had to have a war to capture more slaves; and the slaves were your energy source. Corruption, according to their early writings, was rife. And while these great thoughts were born, it was far from what today we will accept as a great civilization, except insofar as some of the writings of these superior men are concerned.

Now we come to Rome. Rome won control of the then civilized world. And how? By engineering works. The Romans built the first great road systems. They built the great aqueducts. How many of you have ever read the account of some of the administrative mechanisms of ancient Rome, such as the water system, where every inhabitant of that city, which had people up to seven figures--a large city by today's standards--had flowing water? The water was brought to them in pipes and they paid the Roman administration on the basis of the size of the hole in the pipe. This was all calculated as to how much water they received. It was a very fine piece of engineering, let alone the method of gathering this water from distant points and bringing it in against the gravimetric problems of hills and wild country.

Now, Rome's engineering capability, in structures, in bridge building, in roads, in aqueducts, in communication, conquered the then-known world. These are not the leadership of even a great Ceasar, a great general. These are the products of technology. It is the technology that made Greece what it was--in the use of slaves as an energy source and the administrative use of these capabilities--just as it was Rome which easily overpowered the Greeks by superior engineering technology and brought about the vast expanse of an empire through communication, road systems, bridge structures, and the like.

If any of you have ever been over the Roman wall in northern England, which was the outermost boundry of that great empire, and looked at the structures of forts and seen what the University of Leeds has done in bringing back to life the structure of those forts, their administration, their details, the wonderful reservoirs, the latrines, the public bathing places for troops, the granaries, the storehouses, you see what those Romans accomplished as the result of their technology. You will see how watertight reservoirs were made out of stone blocks carefully insulated with lead joints in a very unique way, and the lead mines developed within a fairly near distance and roads constructed to bring the products of the mines, which were smelted and brought in for these structures. This was a high order of technology, which you probably did not read about in your books. And it was not necessarily the Caesars and the Roman emperors who did it. It was the ability of the architects, and the technicians to utilize the forces of nature and the materials of nature, from which this empire was able to subjugate all of these peoples, many of them even more vigorous than the Romans.

Now, you can come down to modern times. Let us take England and the discovery of the steam engine by Newcomen.

In the 1700's England took the steam engine and overnight became the power of Europe. The industrial revolution of England is now studied by every civilized historian. But it is the end product of technology at work, the fashioning of steam engines, which required precision manufacturing. When we tried to make our first locomotives in the United States, we could not bore a cylinder within a quarter of an inch round. Can you imagine the steam that would leak through such a cylinder? And the technology of developing the methods of fabricating these steam engines and the looms and the machinery and the power drives and then the industrial organization--these are all products of technology. All in turn could not have been done without the scientific work which had preceded it in the time of Newton and the great scientific giants.

You will remember as recently as 1600 Galileo had his fight with the Church on whether science or religion should dominate. When he had built his telescope and proved that Copernicus was right, the Church had imprisoned him for his views; but, the news had leaked out over the rest of the world and they were forced to release him on the promise that he would not teach what he knew. But by then science had spread its word; and never from that time to date has the Church opposed science. You cannot oppose man's knowledge. The Pope within a very few years ago made an astonishing statement in which he said that there was no quarrel between the Roman Church and science. He recognized that the modern findings of science would indicate that out in the great heaven beyond there lay innumerable territories much like the earth and that, if so, there would be high forms of life undoubtedly on all of them, meaning like we have here--maybe higher, but high forms of life.

This, then, is the distance we have come, where humanitarian principles have had to live side by side with new science. I cannot avoid telling you that my personal acquaintanceship with the great scientists simply reinforces the fact that with all of their knowledge, most of them remain highly religious. There is no conflict in this matter of, we will call it, the soul and the technology and the scientific knowledge. The more deeply a scientist penetrates into this knowledge of our universe, the more he is compelled to recognize that its simplicity, perfection, and basic order can hardly be a product of just odd chance.

We now see England rise to a world power by the steam engine and by industrialization, and the applications that the English made. There was a small island country, with very limited resources, dominating most of the world's territory through technology--not through British prime ministers, not through the British system of either law or government, great as they are; and we owe to Britain all that we have today in common law. And it is not to belittle or compare these developments of man. It is to point out that the law was only possible because of the developments of science and technology in creating a civilization in which this law could be applied. You would never have the British system of law if we were living today as our ancestors first lived when their day was consumed in getting forage, protection, and shelter.

Just remember that the hen and the egg problem is involved here. Depending on your personal sympathies and your own studies, you may say the hen came first and not the egg. I submit that without the benefit of science and technology there would be no national power of any kind. There would be no civilization of any kind. And this did not follow from political ideas. Technology created the atmosphere out of which political ideas generate. And what we need is a political framework which can even begin to catch up with the developments of science and technology, of which you have hardly yet seen the boundaries.

Now, let us consider Germany. It was a country of some 65 million people in World War I, with very poor resources, no colonies to speak of, and yet strength enough to defy the world. Germany thought it could conquer the world. And how? Because of it having learned the lessons of chemistry. The Germans had the greatest chemical industry in the world, on which we in the United States depended, as did all other civilized countries. In addition they had a great technology.

The Germans never, in my opinion, were the scientists that the French or the British were, for example; but they were technologists. They were technologists supreme, and they have taught the world a great deal. Out of their technology and the science which they absorbed and generated within themselves, they became that little nation able to threaten the world. And do not think it was because of Kaiser Wilhelm, who was a sick man even when he was born, and who had a megalomaniac view. It was because of the strength of the sinews of its science and technology in Germany that it could take that posture.

We shall now discuss Japan. Japan, a little bit of an island kingdom, with very limited arable territory, the people mostly living on its shorelines, with a lot rugged, untillable land, and not rich in natural resources became the power of the East. Japan became highly industrialized. The busy little Japanese went all over Europe and the United States looking, photographing, writing down and asborbing western technology. Japan built a system of universities and technology that was not inferior to any other country. Some of the greatest developments in atomic science, such as the discovery and prediction of mesons, the subatomic particles, have come out of Japan, through Hideki Kagawa. So Japan became one of the great powers, powerful enough to threaten the United States but not to defeat it.

You may also remember that the principle of parity, which is one of the very great advances in science, was illustrated first by two Chinese scientists in the United States.

Well, here are examples of the history of science and technology and their role in national power. Many more can be cited. And now let us turn to Russia.

The Russians have a materialistic philosophy. This they have said over and over again. They were quick to recognize the role of science and technology. And this is our danger. Now, we take science and technology for granted. We inherited one of the richest, most fertile territories in the world. It was unpopulated except for a few hundred thousand Indians here and there, whom we pretty well decimated. And out of this rich land, and with some of the best brains of Europe coming to our shores, all, of course, with the hope of enriching their own lives through gains, we developed a technology superior to any other country in the world.

And now reference is made to the American adaptation which is believed to have been the French development of mass production. We like to think that this was our brain child. In a way we are its foster parents, and we certainly brought it up. But it is believed that the French gave birth to it. They built rifles by mass production methods long before Eli Whitney, who gets the credit for it here in the United States. Mass production, with the American drive and zeal, became our contribution in the field of technology.

This, like the hen and the egg system, required mass distribution. Madison Avenue does not like--this is a presumption--to think that it is

production which makes distribution and not distribution which makes production. You can try to distribute to your heart's content, but if you have not made something to distribute, you do not distribute very much. It is the American zeal, then, for doing something, for being busy little engineers, if you like, that has produced this rich civilization, the like of which the world has never yet seen. It is this which gives us our national power. It is not the wealth of our political ideas or their richness or their farseeing principles. It is not the American character, because we are nothing but the fusion of a lot of older lands with older cultures. The melting pot does not account for it. It is not our climate. Actually Russia today has far more natural strength in the sense of minerals, waterpower, energy, forests, and the like, than we have. And yet it was a land of serfs. Russia was not a land of serfs because it liked serfs; but it had inherited the Greek idea and the Oriental idea. Somebody had to do the work. Well, serfs were a very convinent way to do it.

When the Bolsheviks came to power, they knew that they could not continue to exist in the world. They did not have the facilities, the strength, the posture, the capabilities. It was in 1932--believe date is accurate--that, in taking stock of themselves, they were convinced they must have a spread of technology and science on a scale that the world had never seen. So their educational system, as we now see it in its later stages, was born. And this was designed to produce an enormous outpouring of scientists and technologists.

This was a prior period which many of you do not possibly remember too well, but some are old enough to do so, when the average American said:

"Oh, we never have to worry about Russia in war. They don't have automobiles that their children grow up with. They don't have all of the little gadgetry that we have in the United States that makes sort of second-grade mechanics out of our children and even our housewives. They don't know how to use screwdrivers and wrenches. These are serfs, working with wooden plows out in the steppes. We have nothing to fear from people like that. And if we do give them tanks and machine tools, they'll only wreck them."

This was a common view here in the United States.

The only difference was that the Russians did something about it. They said, "We must educate. If we're going to catch up with the powerful nations, we must use the scientific, technological weapons

which form the strength of a country's posture." And so their educational system was born. With that, the great universities were spread far and wide in Russia, from the boundary of the farthest Asiatic provinces or countries right through the old developed White Russian western frontier.

The universities are good educational institutions. Our National Academy of Sciences has reviewed their curricula, and their reports indicate that they are equivalent to our own higher educational institutions. This is not my opinion, gentlemen. This is a statement by educators.

Let us look at the volume. An attempt will be made to show you in the latter part of this lecture the basis for these opinions, so that you will not merely accept opinions because they are stated from a rostrum. In fact, it is an element of human nature that when you are being told something that you did not first believe, you first attack it. This is a protective device that is built into human minds. Anything that is new, you must disagree with initially, because if it had been good, you would have thought of it first. Think it over and see if much of your own posture in arguments does not stem from that human emotion. So if you are hearing something which you are inclined to resist, this is all right with me. An effort will be made to show you by exhibits the process of arrival at some of these conclusions.

These exhibits by their nature have to be statistical; and statistics can be a booby trap. Beware of it, because a set of figures have a finality, a conclusiveness to them, that is very, very appealing. But when you find out who gathered those statistics and what assumptions they made in putting them together, you begin to realize that you have to treat them with respect and you had better know what some of the assumptions are.

An old definition of a statistician is a man who draws a straight line from an unwarranted assumption to a foregone conclusion. Think this over for a minute. We all do it--feel sure you, too, have done it. It has been done in something in which one believes, and perhaps has tried to make the facts show that the beliefs were right; this has been done without consciously trying to be unethical about it. It is believed that perhaps a little further thought, if some other assumptions were made, would show that the trend would change to the desired direction.

And so, look at these statistical exhibits critically. For example, yesterday, the gentleman on this podium told you that in his opinion the gross national product had some grievous errors built into it as it is

now being interpreted. And he is right; the statisticians, in an effort to find out what the gross product of the United States really is, have conjured up a figure for the contribution of a housewife. It is not known how many cakes your wife bakes--whether she mixes the dough or buys it as a ready mix. But if one housewife starts with raw flour, eggs, and milk and bakes a cake, she does a lot more work than the gal who goes to the supermarket and gets some Pillsbury's cake mix. And the Pillsbury's cake mix already has a gross national product factor through the statistics of the Pillsbury organization that feed into this great statistical machine. But for the purposes of these statistics the two housewives, with their different methods, are alike.

There are many other gross assumptions in these statistics. So you are being warned in advance. But they are the best that exist and they do show trends. It is to your peril if you disregard these statistics just because you know there are some errors in them. Until you can find something better, you have to try to see if they are telling you something. With this thought in mind, the exhibits will be presented to you later.

The United States has been left pretty much till the last. This thesis is, that we are so powerful if, as again Leo Cherne told you yesterday, we are willing to discard the softness of many of the things we have come to think of as our natural right, and we are willing to take the hard-bitten, practical, survival posture that the Russians try to spread in their land, there is nothing on earth that could stop us. What we did in World War II is too recent a lesson to the whole world to have been forgotten. We had vast expansion ourselves; supplied Russia, our huge ally, and our other allies with so much of the sinews of war and still carried on a plus civilization the people at home grumbled because they were limited in their number of beefsteaks and gallons of gasoline. Today there are 60 million automobiles in the United States; a slide will show what they will use in the way of fuel and what could be done with that fuel in the event of war.

These things are mentioned because actually we are the strongest nation in the world. Nothing can upset us if we have the will and the realization, because our Nation is founded on science and technology. Repetitious, but it is not our Congress, or our Executive; it is all of us. And if all of us take the inherited strength that has been passed on to us and add to it the promising possibility of many new breakthroughs, we really have nothing to fear. Leo Cherne's

statement that we are not going to be challenged if we make our position clear is convincing. If we apologize for our position, yes, we are probably in trouble. The fundamental thesis that our position must be made positive and clear is in full agreement with many.

Khrushchev seems to adhere to his statement that words are not going to convince him. All of recent history has shown this to be true. But when we actually landed troops in Persia, he pulled out of Azerbaijan, even though he had been ready for a takeover. And when we shot down those MIGs over Quemoy, the Chinese merely had to construct a saving face device. We do not hear anything about that now. And one can go on and name other incidents to prove to one's satisfaction that we have the strength and that a lot of Mr. Khrushchev's boasting is really just that. Those individuals who have smuggled themselves in Russia, not as Americans but as native Russians born there, and who have contacted the Russian underground and brought the stories out, tell us of some of the built-in inherent weaknesses. There are 100 million subjected people who do not like him, and it is going to take one very large policing effort in the event of a war to keep behind-the-lines sabotage in control.

There is the vast shortage of transportation in Russia. Its railway system has only one-third the mileage of ours and its distances are vastly greater. As to inefficiency--the Russians have twice the number of railway employees we have for one-third of the U.S. mileage. They have half of all the workers in Russia tilling the land and people are starving in many areas. We have 8 percent of the American laboring force working on the farms and we produce so much food that it is our national headache.

This is technology. And remember, technology is not just extended to implements of war. It is as much a contributor to agriculture as it is toward the production of any other commodity.

These therefore are merely some of the things for you to keep in mind when Russia talks of her strength. She has only one thing that we do not have--the ability of the Kremlin to divert large portions of her economic strength into any given channel she desires, that is, within reason.

Russia has much unrest among her people and cannot overdo in her economic changes. But nevertheless, just as you saw on her moon shot, which was undoubtedly one of the finest technological achievements of our age, Russia can accomplish anything if it will

put the necessary resources to work. Some of her resources will be shown later.

The allotted time, and perhaps more, has been used on the subject of the role of technology and science in world power. Judging by the clock, this is an appropriate time to break.

Gentlemen, we will have some charts at this point to see if we can discover some of the forces here that we have been talking about.

Chart 1, page 18.--First of all, you will recognize that research and development are the tools for scientific progress. The figures in the United States are startling, as they also are in the rest of the world, but particularly so here in the United States.

On the left-hand side of Chart 1 is the sum total of Government funds for research. You will see the astronomic climb in the relatively short period since 1954. We cannot show it on this curve but you can see the total research in the United States statistically was supposed to be $300 million per year. Now, compare $300 million which was your preparation for World War II with what you have today. And there is at the moment no leveling off or plateau of this fantastic economic indicator.

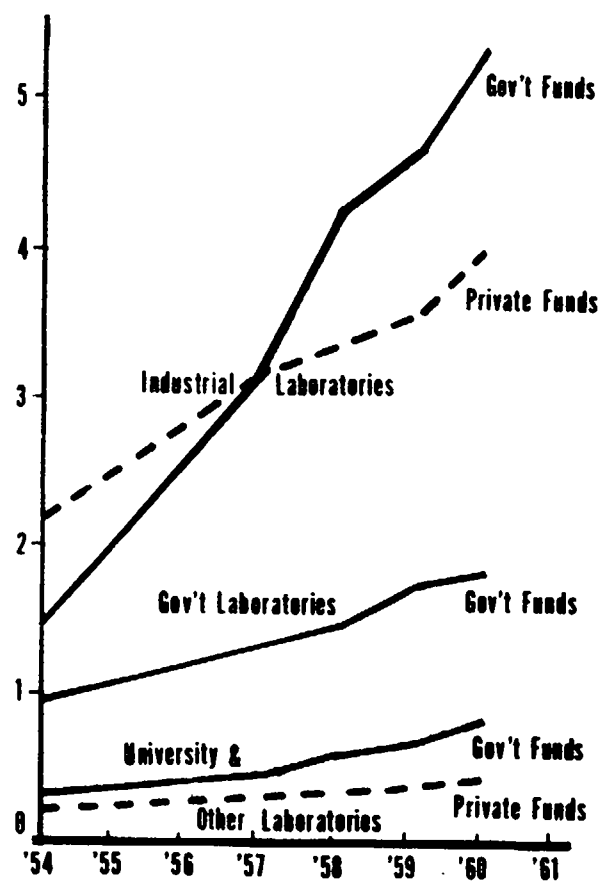
Also notice that private funds loom here rather large. Government funds show the same tendency in this curve. They would not if we took you back to the Korean War and back to World War II. You would see the difference between private funds and Government funds. Here you see again the contribution of universities and other laboratories. These are very vital, and we will come to this again in a later chart.

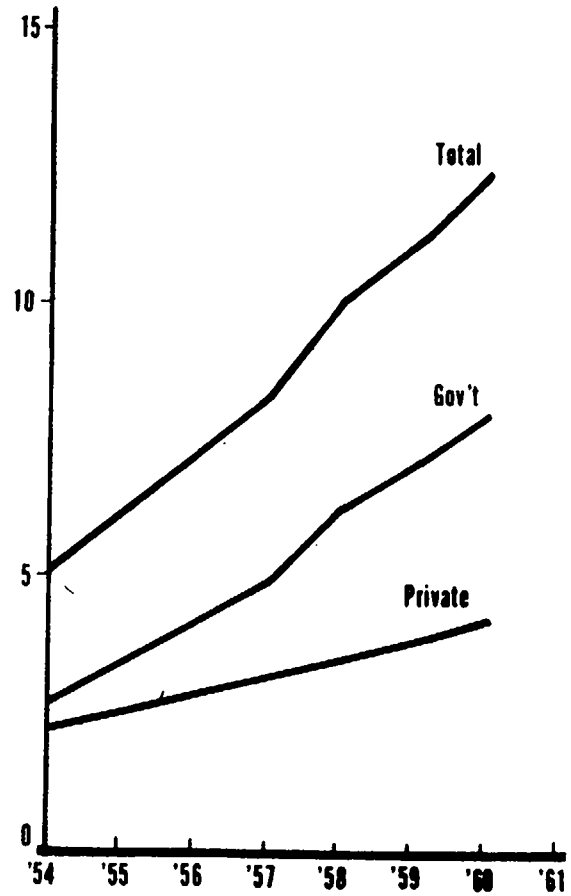
On the right-hand side is total Government and total private expenditures. Actually, more money comes out of the Government directly and indirectly than comes out of the private. Even though the work is done in the private, the money comes directly or indirectly from the Government, with a fairly consistent curve. Some statistician really took a trowel and smoothed this curve out. It is not that smooth.

Chart 1

UNITED STATES RESEARCH EXPENDITURES

(IN BILLIONS OF DOLLARS)





SOURCE: National Science Foundation

Chart 2, page 20.--This gives you a little light on the distribution of the Federal dollar. You see the national security element and what is left is all other, the lower broken line. The fellow was honest. He estimated these last figures. But you will see how national security looms in these expenditures.

This will be interesting to you. The distribution of the Federal dollar is divided into four parts: "profit organizations," which means business; "educational institutions," the Federal Government; and others. With all the vast laboratories of Agriculture, the Atomic Energy Commission, Defense Establishment, Weather Bureau, and so forth, Department of the Interior, Bureau of Mines, you can see that you have to depend upon the American system of free enterprise even though creeping socialism is invading many of these areas at a fairly erosive rate.

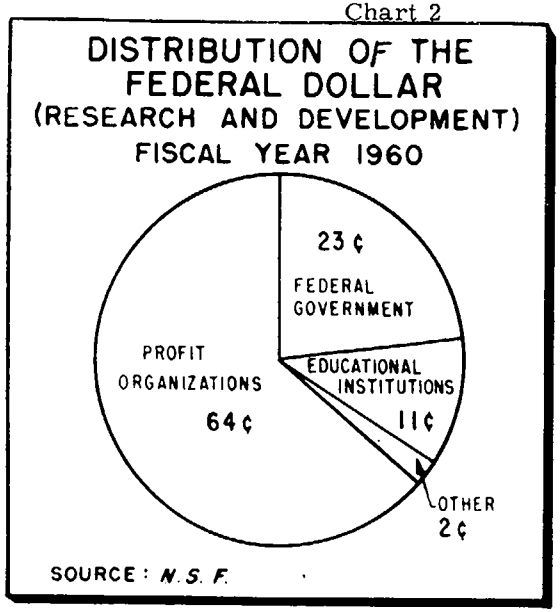
Chart 3, page 21.--This is an interesting thing, because this is a reflection of political sources. Remember now, you have to decide yourselves whether the hen or the egg comes first. Does the politician respond to public needs, or do public needs follow the politicians dictates?

This break (indicating) is caused by one of those rather interesting things which the statisticians always point to as a new method of gathering statistics. In science this would be called a nonlinear equation and it would have a very different context.

Now, up in here they have tried to put in by definition what you would call a prototype in the military. In other words, the first B-70, the first Valkyrie, would be called an experiment, not normal production. So it would fall into this. In these lower curves they did not strain as much to get so-called prototypes of activity in it.

Now, remember this is a booby trap. When you go to an industry like General Electric and ask its people to tell you how much they spent on prototypes, you are asking for something you are not going to get--not because maybe they do not want to give it to you, but it just does not fall that way in their accounting. They will scrape around and make some estimates and furnish them. A lot of these firms that furnish the statistics to these people--used to be one myself--get these terrific questionnaires, which cost a fortune to have filled out if it is done rigorously. And so what many firms do is try to get it off their desk; and if a piece of statistical data is very difficult to get, "We'll estimate it," you know. You have to remember now that human beings are doing it. But even if human beings made some colossal mistakes, this is still a fantastic picture.

Chart 2


DISTRIBUTION OF THE
FEDERAL DOLLAR
(RESEARCH AND DEVELOPMENT)
FISCAL YEAR 1960
23 ¢
FEDERAL GOVERNMENT
PROFIT ORGANIZATIONS
64 ¢
EDUCATIONAL INSTITUTIONS
11 ¢
OTHER
2 ¢
SOURCE: N.S.F.

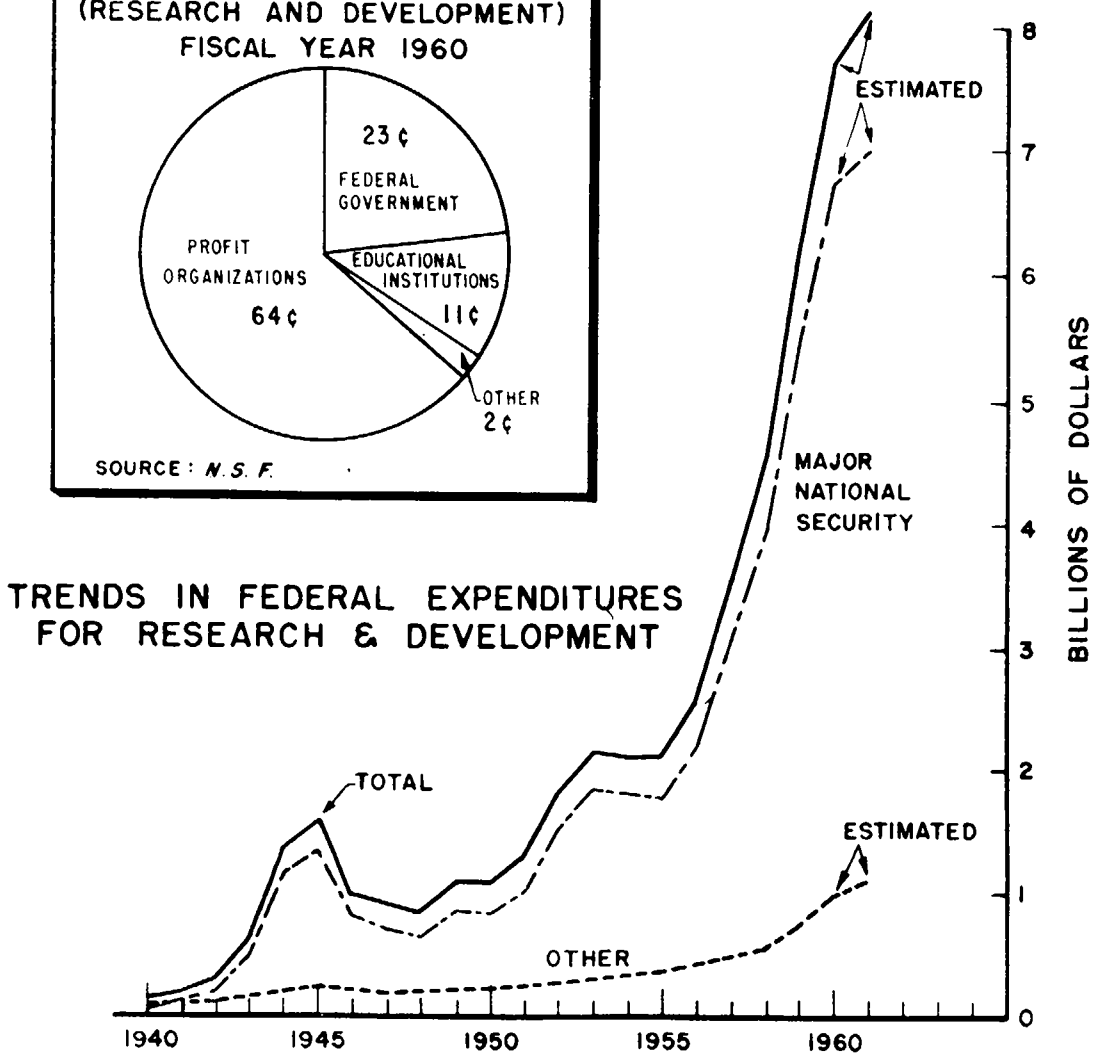
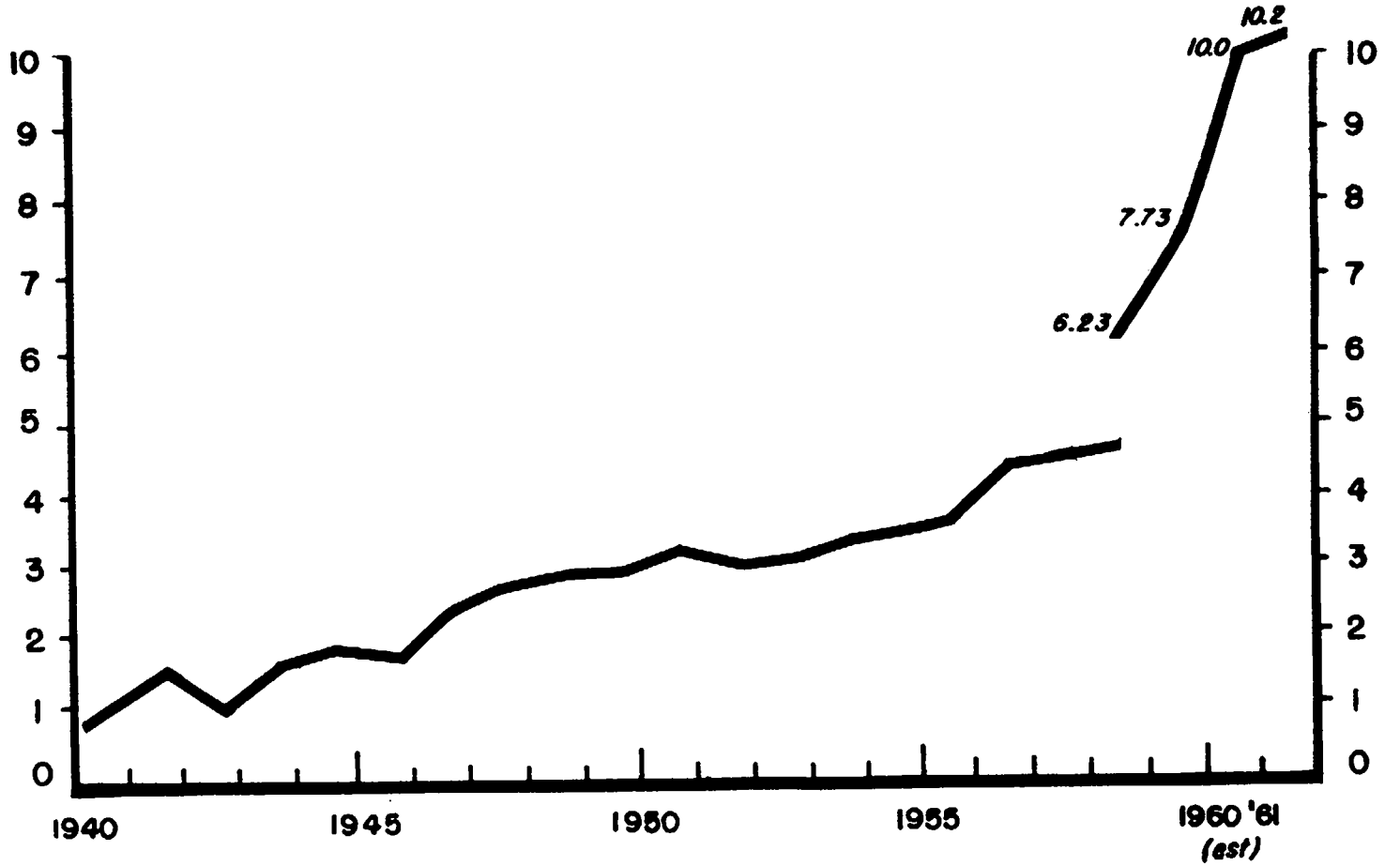

TRENDS IN FEDERAL EXPENDITURES
FOR RESEARCH & DEVELOPMENT
ESTIMATED
MAJOR NATIONAL SECURITY
TOTAL
ESTIMATED
OTHER
1940
1945
1950
1955
1960
0
1
2
3
4
5
6
7
8
BILLIONS OF DOLLARS

Chart 3

AS PERCENT OF TOTAL FEDERAL BUDGET EXPENDITURES



SOURCE: Nat'l Sci. Foundation

Chart 4, page 24.--Here is the total research for 1959, 1960, and estimated for 1961. The chart shows the amount that is going into: life sciences, in hundreds of millions; physical sciences; social sciences; psychological sciences; and all other sciences. The physical sciences obviously take the largest share. You are going to see some vast changes in relationships between the social sciences and the physical sciences in the years that lie ahead.

This (indicating) is a trend that you want to watch, because as military men the lessons that will come out of this research here are going to be as revolutionary as the new weapon systems that you think of now. This subject cannot be discussed now because it alone would consume our time. The research in genetics, or what is called our microbiology or molecular biology, is showing a method of breeding new characteristics by genetic transmission from parents to children. It is in the realm of some of these gentlemen's minds that they are going to design new human beings.

Chart 5, page 25.--Now here is the Federal obligations for conduct of research by scientific fields. The Department of Defense, as you would expect, is large. The Atomic Energy Commission shows a poor little insignificant $840 million a year. And NASA--in space science--with $790 million, is now competing with them for number two place.

The selected other agencies are all the way down the scale. It is a different scale. The largest one is in Health, Education, and Welfare, and this has grown. This is a response to alleged political and social pressures. You can see that this has now taken over from Agriculture; Interior--Bureau of Mines; National Science Foundation; Department of Commerce--Weather Bureau, Bureau of Standards; and the like.

Chart 6, page 26.--Here is the character of work. This is by fiscal years. The thing to point out above all on this chart is what is considered the most significant.

If you talk about the hen and the egg in science, you are really talking about the relationship between basic research, applied research, and development. There are three phases. Development is the engineering field. Applied research is done by a group of scientists who like to work with practical items. Basic research, by and large--these are generalizations now--is done by a group of scientists who like to work like the ancient Greeks. This is the way in which one could say Dr. Hans Baeder, of Cornell, worked out the

nuclear process of the sun, the so-called carbon cycle. It occurs every 5 million years and provides all the heat and energy that keep us alive.

Basic research was America's weakness in years past. Development was her strength. And if we had not had the work of the European scientists, you would not be sitting in the environment you're sitting in today. Atomic science by and large started back with old Dr. Hirsch in 1895; and Dr. Becquerel, and the Polish Curies of France, 1896; Dr. Thompson in England, 1897 and 1898; Max Planck of Germany, 1900; and Einstein, 1905--notice there are no Americans here--and this chain carried you through right smack up to Dr. Franz Strassman discovering fission; and there is not an American in that chain. You owe atomic science to Europe, not America.

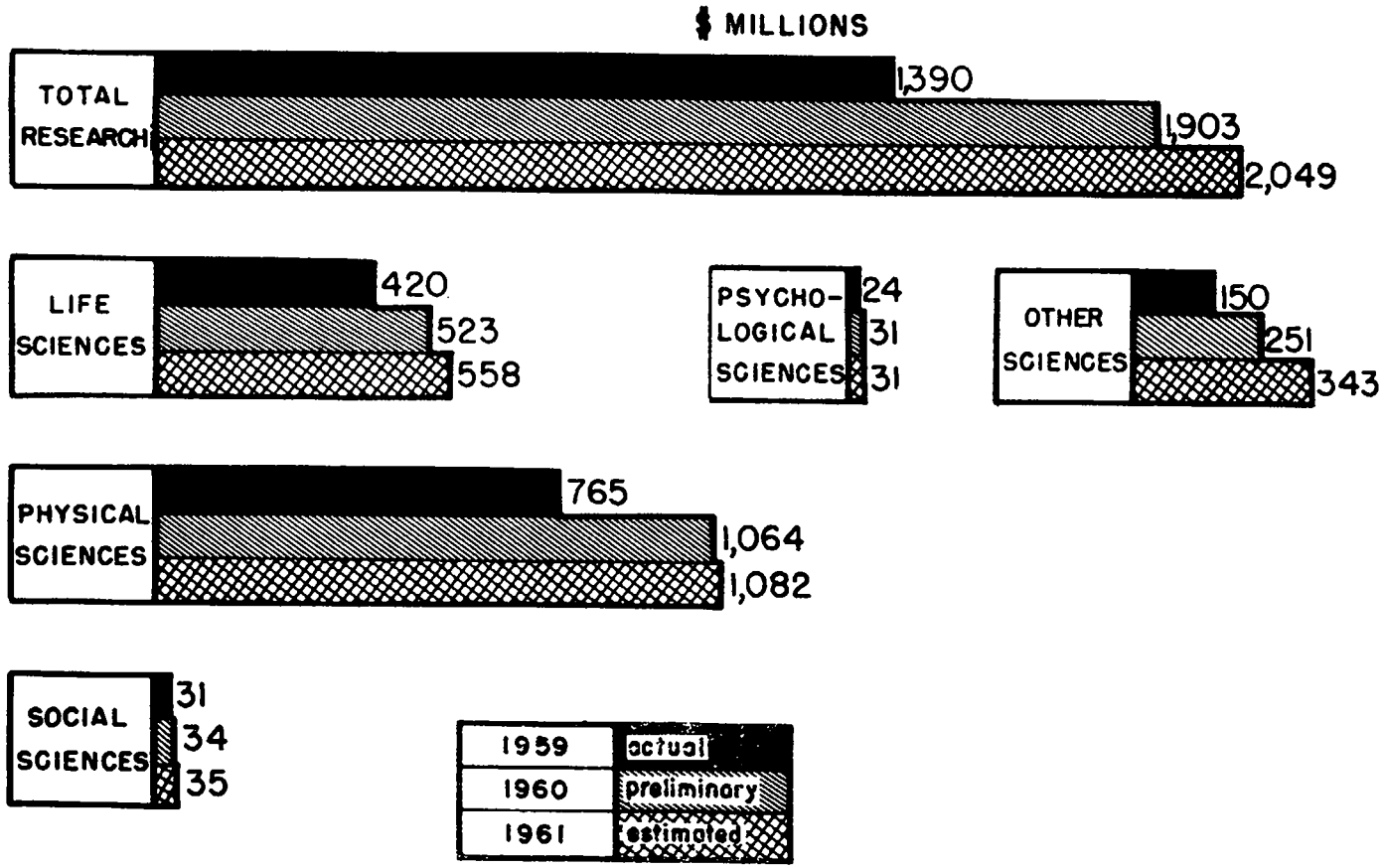
We spent $2.2 billion making the first bomb, because this is our role. We are the boys who can do this, the engineering side. We have never been the boys that were willing to do the basic research. University professors could get money for hardware, but they never could get money to sit at their desks and think. And this is still largely true in American universities. We are trying to break it down. Only last year the Federal Government responded by appropriating nearly double as much for solid state physics research. This was not for research, mind you, but to train Ph.D.'s who can do research because the egg is not here in the United States. And Russia has surpassed us in this area, in the opinion of many--of course all these opinions are the opinions of somebody--and likewise in Europe.

But now notice that basic research is growing percentagewise faster than total research. That is the most encouraging thing that can be shown to you.

Chart 7, page 27.--This is a very interesting chart. As you see, the left-hand circle is the money. Three percent of the money comes from university funds; 59 percent, Government; and 38 percent, industry. But the universities do 9 percent of the work. Thank God for that, because this is the area where basic research largely originates--the kind we are talking about--the man behind the desk. These are the things which really bring about the breakthroughs in science, not the big sums of money that flow into programs. Here is where the whole program starts. You see that industry--private enterprise--is responsible for the bulk of the work. And if you include universities, except the State universities, with the private system, you find that the bulk of the work is still done in this system that we call American free enterprise.

Chart 4

FEDERAL OBLIGATIONS FOR RESEARCH
BY SCIENTIFIC FIELDS

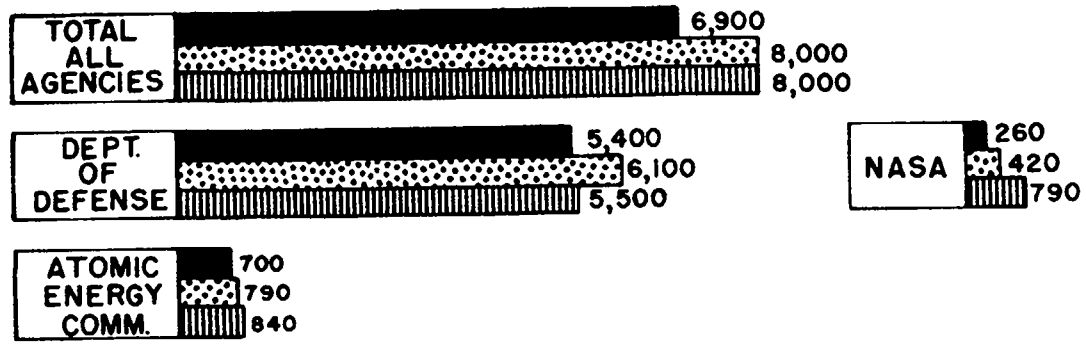


SOURCE: National Science Foundation

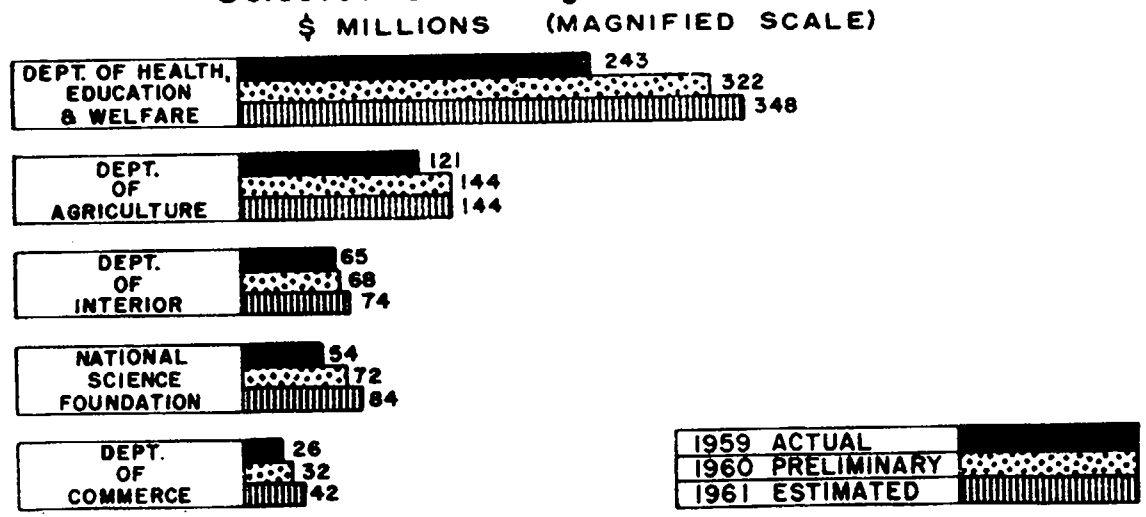
Chart 5

FEDERAL OBLIGATIONS FOR CONDUCT OF RESEARCH & DEVELOPMENT (SCIENTIFIC)

BY AGENCY *(Includes Pay for Military Personnel)*



Selected Other Agencies

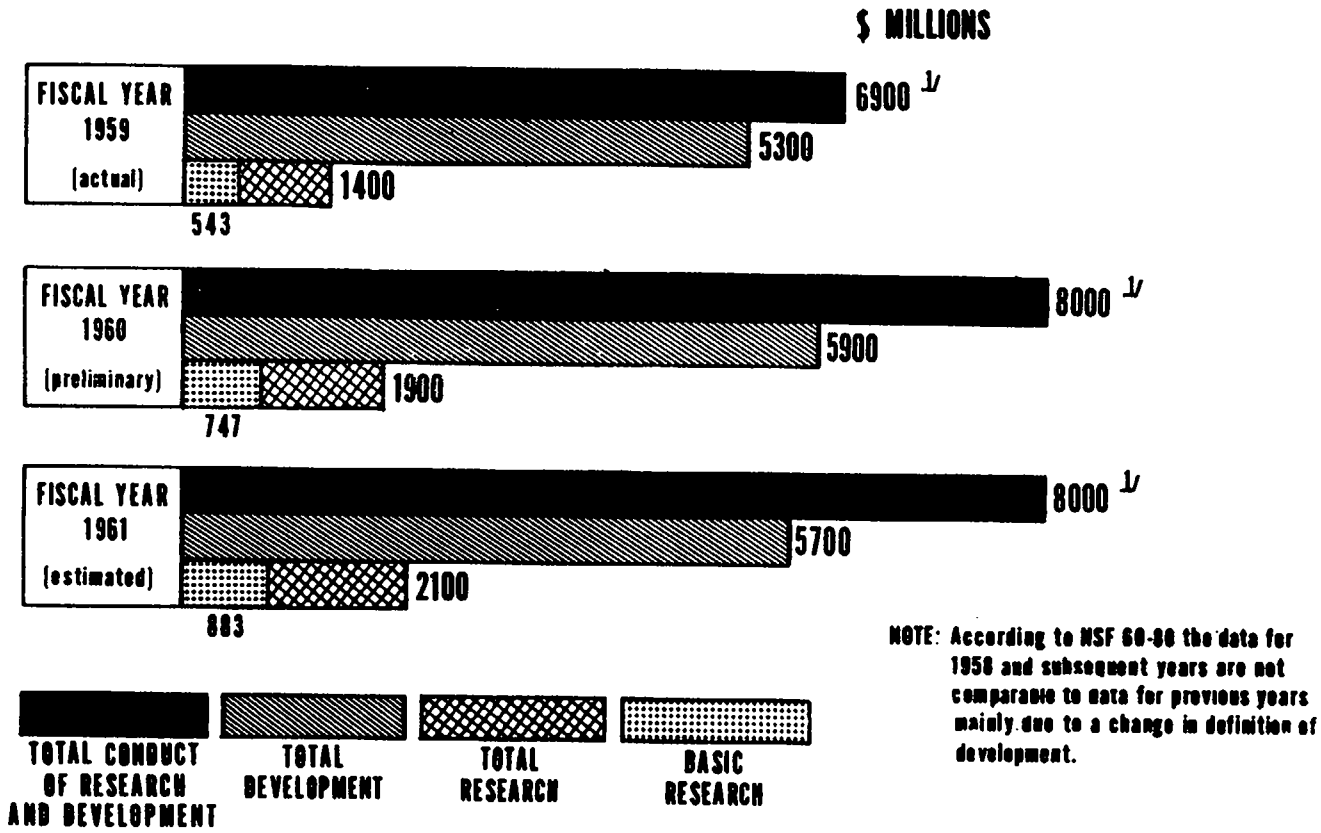


SOURCE: *National Science Foundation*

Chart 6

FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT

by CHARACTER OF WORK



NOTE: According to NSF 60-80 the data for 1958 and subsequent years are not comparable to data for previous years mainly due to a change in definition of development.

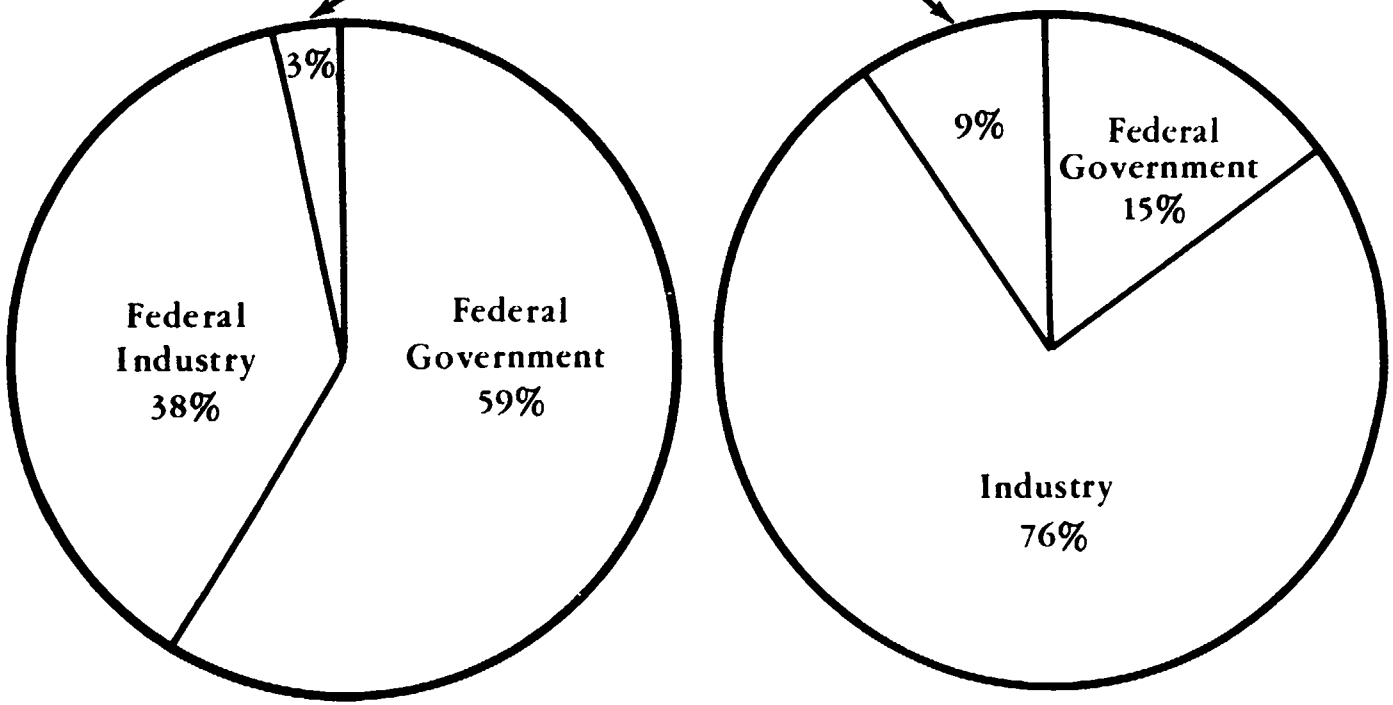
SOURCE: National Science Foundation, NSF 60-80 "FEDERAL FUNDS FOR SCIENCE"

1/ Contains $200 million for pay and allowances of Military R&D Personnel who have not been allocated to Research or Development.

Chart 7

SPENDING FOR RESEARCH & DEVELOPMENT
1956-1957

UNIVERSITIES AND RESEARCH INSTITUTES



WHERE THE MONEY COMES FROM

WHERE IT IS SPENT

SOURCE: National Science Foundation, Dec 1959

Chart 8, page 29.--This shows the spending for basic research only, as statisticians have fixed it. They say industry does 30 percent of basic research. That is questionable; but there is no proof to this contention except personal knowledge of certain industries and their claims. Now, all of them are subject to Madison Avenue writers; and just like General Motors won the war in World War II according to the double-page color spreads in the "Saturday Evening Post," this is not nearly true. Industry likes to take credit for an awful lot of basic work. It is a sort of a kudos that sheds off on it, makes it a little better than the other fellow. There is basic work in industry, sure there is; but it tends to be in the hardware phases and not in the man-behind-the-desk phase. It seems impossible that a statistician can really cut this pie into those segments. You will notice that the Federal Government is given a very large share of money; the chart shows that colleges and universities are, as pointed out before, even under this statistical approach, doing the bulk of the work.

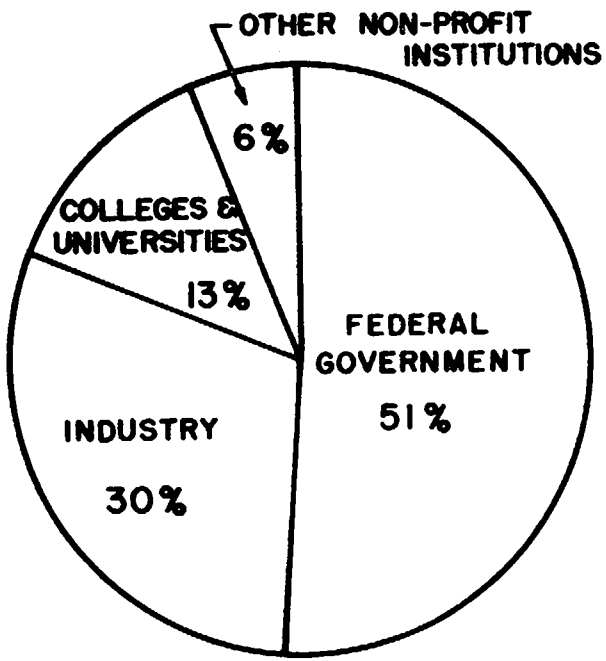
Chart 9, page 30.--This is a good example of Parkinson's law at work. This is the Atomic Energy budget of the United States. It started off in 1950 with what everyone thought was a huge sum. This was an annual expense of almost half a billion dollars. Getting used to this question of a billion dollars has not been done as yet. Do you all know how to visualize a billion? One will have trouble with the darn thing until one realizes that there have been only about a billion minutes since the birth of Christianity. And so when a fellow speaks of "a billion dollars," just think of the billion minutes since the birth of Christianity. This used to mean a long time back in my days before it was discovered that the universe is 3 to 5 billion years old. Now there will have to be a whole new set of findings. But, however this may be, this is a large sum of money--but this is an annual cost. Now look where we are. With Parkinson's help we are up here to almost $2.5 billion per year.

Where it goes, how, and why will not discussed, but there is a terrific political question buried in here. There are several of them. One of them is public versus private power, which is one of the hot political subjects on the Hill. The other one is a concomitant of it, and Dr. Gren Seaborg's statement the other day as chairman was that now their laboratory is so big they ought to tackle all kinds of problems. Well, this would mean that all of a sudden you have a brand-new agency in Government that wants to span all the science fields and really go to work. So you can see, Mr. Parkinson was very successful.

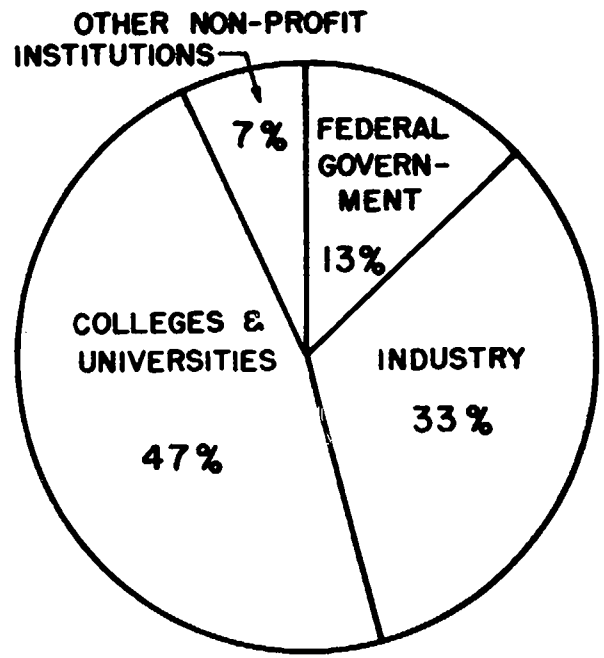
Chart 8

SPENDING FOR BASIC RESEARCH

1957-58



WHERE THE MONEY COMES FROM

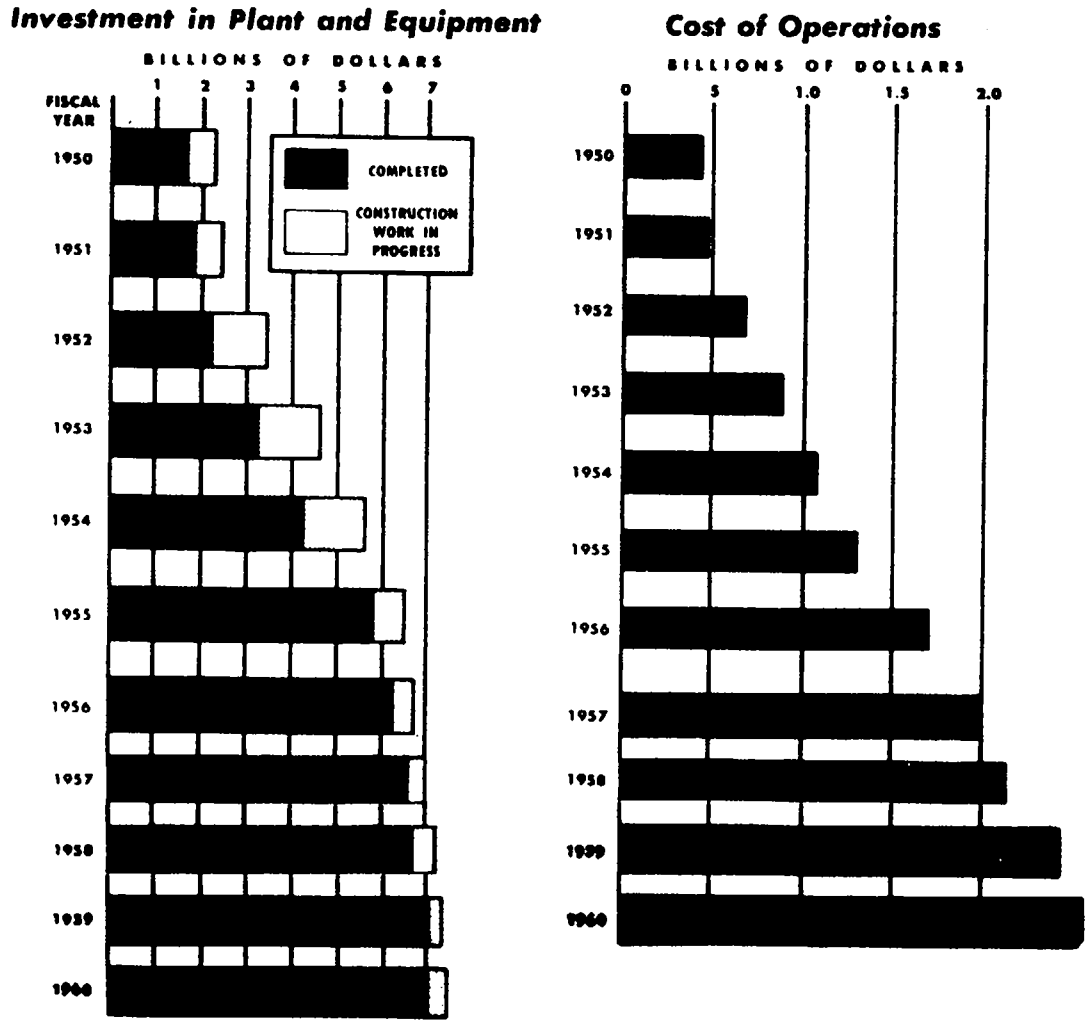


WHERE IT IS SPENT

SOURCE: *National Science Foundation*

Chart 9

U. S. GOVERNMENT INVESTMENT IN ATOMIC ENERGY PROGRAM



SOURCE: *AEC Financial Report for FY 1960*

Chart 9 shows the money spent for the plant and equipment, and also the amount for construction. Congress is trying to hold that down a bit; it is a key to the bill of a few days ago for some 25, 85, or $95 million--I have forgotten which--at Hanford, Washington, to build an atomic plant instead of dumping the heat into the Columbia River. That was a selloff of the worst kind. It is not known who got in from Madison Avenue to present that problem to the American public, but wish we had time to show you the fallacies in the political arguments that were used. It is an example really of how politics can take science and bend it.

This was put on not alone to show you these trends which were pointed out, but to show you how, out of pure theoretical science by Dr. Hirsch, et al., a huge new development is born which will revolutionize life. Later a slide will show you why. This thing came out of pure science. No politician, military leader, nor businessman hatched it. Science hatched it.

When you hear that science and technology determine natural science, you will see how many reasons for this argument have escaped the professional historian--it is always amazing. Sometimes it is the obvious that we do not see.

Chart 10, page 32.--Here is a method of measuring our position in science. It is not too good, but it is the best available. There are only two that anyone has suggested. One is the Nobel Prizes accorded and the other is for the number of papers published in the leading scientific magazines. The latter is far too complicated and no one has really done a good job on it--very complicated indeed. But we will take the Nobel Prize winners.

Here you see 11 Nobel Prizes to the United States in physics in the period in question, against 3 for the Soviet and 12 for others. This means that our allies--this is largely France, England, and Germany, some for Italy--are as strong as we. Actually they were ahead of us. We are coming in now, and this is a reflection of what you saw on the other chart--the growth of basic science. Look where the Soviets are--this in spite of the largest scientific body in the world, with 30,000 scientists under the Soviet Academy of Sciences.

Chart 10

NOBEL PRIZES FOR SCIENCE

Since World War II

	PHYSICS	CHEMISTRY	MEDICINE & PHYSIOLOGY	LITERATURE	PEACE
U. S. A.	11	9	18	3	6
SOVIET	3	1	0	1	0
OTHERS	12	11	14	12	8
	26	21	32	16	14

SOURCE: THE WORLD ALMANAC AND BOOK OF FACTS-1961

Look at chemistry--9, 1, 11.

Look at medicine and physiology. The Soviets made a great to-do about eye banks, liver banks, and all kinds of gadgetry in medicine, But let us see who got the Nobel Prizes. It is somewhat different than the press would lead you to believe.

Let us look over in the nonscientific fields. You see, Americans still are closer to the pioneer stage than are academicans, literati, intellectuals, or humanitarians. Chart 10 reflects it; all you do is look across the chart.

Peace is something that was put in here in addition to medicine.

Chart 11, page 34. --This chart shows our weaknesses. In 1932 the Soviets analyzed their situation and said: "Only by scientific technological education will we be able to have the power that we need in world affairs." So their educational system went into being. They put in the brainiest men in Russia as teachers, and paid them higher salaries than the top politicos and the top industrialists. You perhaps know that a senior professor chairman of a department, at the University of Moscow, will get a higher salary than the White Russian head of industry. The Russians deliberately said, "We must take the very best brains, pay them the most, give them the best possible summer houses, give them free transportation on the Russian transportation system, unlimited sabbaticals, and vacations." They made it so attractive that they put their best people to work on education at the universities. This vast system of Russian universities spread from Kazahkstan and Vladivostok all the way to Moscow. The result: they specialized on science and engineering because of their materialistic philosophy and their recognition of what is being discussed here today. So out of Russia's 245,846 degrees, there were 90,830 in science and engineering. Out of our 287,401 degrees, there were 53,480 in science and engineering.

Now, let us look at percentages for all these leading countries. Russia, 37 percent in science and engineering; 19 percent in the United States--one-half. It was 44 percent in Great Britain, 29 percent in France, 34 percent in Germany, and 26 percent in Italy. We are the low man on the totem pole. And for next year the colleges report that the engineering enrollment is declining further. This is ominous--very ominous indeed. Sorry that later figures are not available, but there are some trends which can be shown today.

Chart 11

SCIENCE AND ENGINEERING GRADUATES

from Universities and Comparable Educational Institutions in 1954-55 Year

	Science & Engineering Degrees Awarded	Total Degrees Awarded	Perc. Sci. & Eng. to Total Degrees	Sci. & Eng. Degrees per Million pop.
U.S.S.R.	90,830	245,846	37 %	445
UNITED STATES	53,480	287,401	19 %	313
UNITED KINGDOM	8,332	18,796	44%	161
FRANCE	6,681	19,233	29%	152
GERMANY	6,005	17,851	34%	117
ITALY	5,483	20,600	26%	112

SOURCE: OEEC, 1957

Chart 12, page 37.--Here is one of them. This is productive engineers only. Please note the characteristics of the Russian curve. About 15 percent of the 106,000 graduates in 1959 were from correspondence extension courses. Similar proportions have prevailed in recent years.

Russia has an enormous correspondence system for education. She has another system which we cannot take time to go into, but will tell you some in passing. These are called technicums. A technicum is a 2-year university. And, amusingly enough, Russia a so-called allegedly socialist country, does not adopt the American system that everyone is entitled to an education. She says that only those who can intellectually use an education are entitled to it.

And how does Russia decide? She decides in the secondary school system, to which everyone must go. She has a lower percentage of illiteracy than we in the United States. Down in Arizona and our Southern States there are Mexicans who do not go to school. Nobody enforces school attendance. In Russia one must attend school. So in the secondary Russian school system the State Bureau of Education rates every student; and anyone proficient in mathematics, physics, chemistry, and the like, above a certain line is personally approached and offered a university of their own choice and a course of their own choice--provided it be in science and engineering. And for this students will get all tuition paid and a salary. Then, if they graduate from that university above a certain level of intellectual attainment, they are given twice the salary of the other graduates, preferred jobs, and security. This is called the incentive system; in Russia it is not based on the fact that everyone is entitled to this, but is based on performance.

There are certain people--we have a great many of them in this country, as does every civilization--who have a three-dimensional imagination as the educator calls it, but who are not geared to higher mathematics, physics, chemistry, and the sciences. But they have an inherent, intuitive understanding in these fields. Russia takes this class of people and feeds them into what are called technicums. In these technicums in Russia--there are over 3,000 of them--there are as many people as there are in institutions of higher learning. So if the technicum 2-year universities are put on chart 12, this disparity between Russia and the United States becomes even more alarming.

These 2-year graduates, if they are exceptional--and the Russian educational system has made a mistake or the children have developed late in life, as many children do--are automatically offered a transfer into a 4-year university, but only on excellence. The result is that the

American students who have gone over there find the Russian students serious. Well, why not? This is their future. A student has time off for certain work. In this country a student can take a job in the old man's factory or do something else, but in Russia they have only the state to employ them. Students either succeed or fail. They are serious. Our higher education problem is deadly serious. At the moment it is going down, not up. The things that have saved us up to date are the bank of older people, educated before the Russian educational system really got going, and the fact that during the war Russia lost a great deal.

Chart 13, page 38.--This is a very odd curve. As to who first drew it is not known. It was presented at a logistics conference at Ohio State University and there came into my possession. This is your old friend gross national product per unit of population, or standard of living if you like.

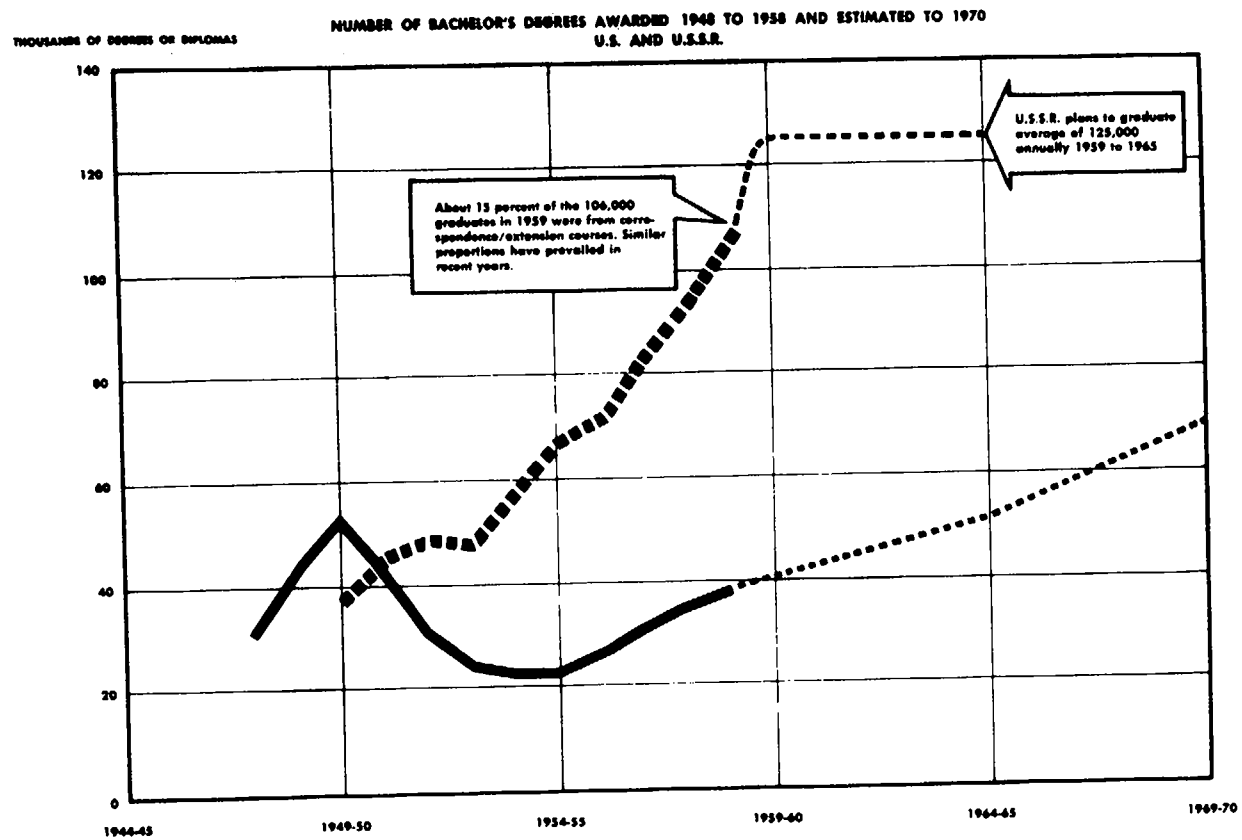
This merely says to you gentlemen that production in the United States follows absolutely the number of practicing engineers. This is another way of saying that you cannot create with your own hands, no matter how industrious you are. You must have tools, trucks, and automation. You must have highly technical equipment in the form of machine tools and the like. And this means engineers.

So if you want to see again a totally independent exhibit--and remember, these were not gathered from the same source--these were not taken from a volume trying to prove my thesis. These were selected across the board in the United States from various sources, and not picked just because they prove my argument. But it must be stressed that it is seriously believed that our strength is our science and technology; this is not belittling our political leadership, our military leadership, and so on. Without them science and technology would be useless. This statement means that a good science and technology breeds good politics and good military leadership.

How would your leadership be if you were forced to go into battle with ships as ancient as the Spanish Armada, or the Spanish fleet that Dewey encountered? They could not hit the side of a barn with their guns. You would not like it. You are a good military leader because you have confidence in your weapon systems. Even though you criticize the daylights out of them, you still have confidence that they are as good as you need to accomplish the task and good enough--let's put it this way--because you will never have your ideal.

Chart 12

HIGHER EDUCATION GRADUATES IN ENGINEERING



SOURCES: Office of Education and Soviet Sources

Chart 13

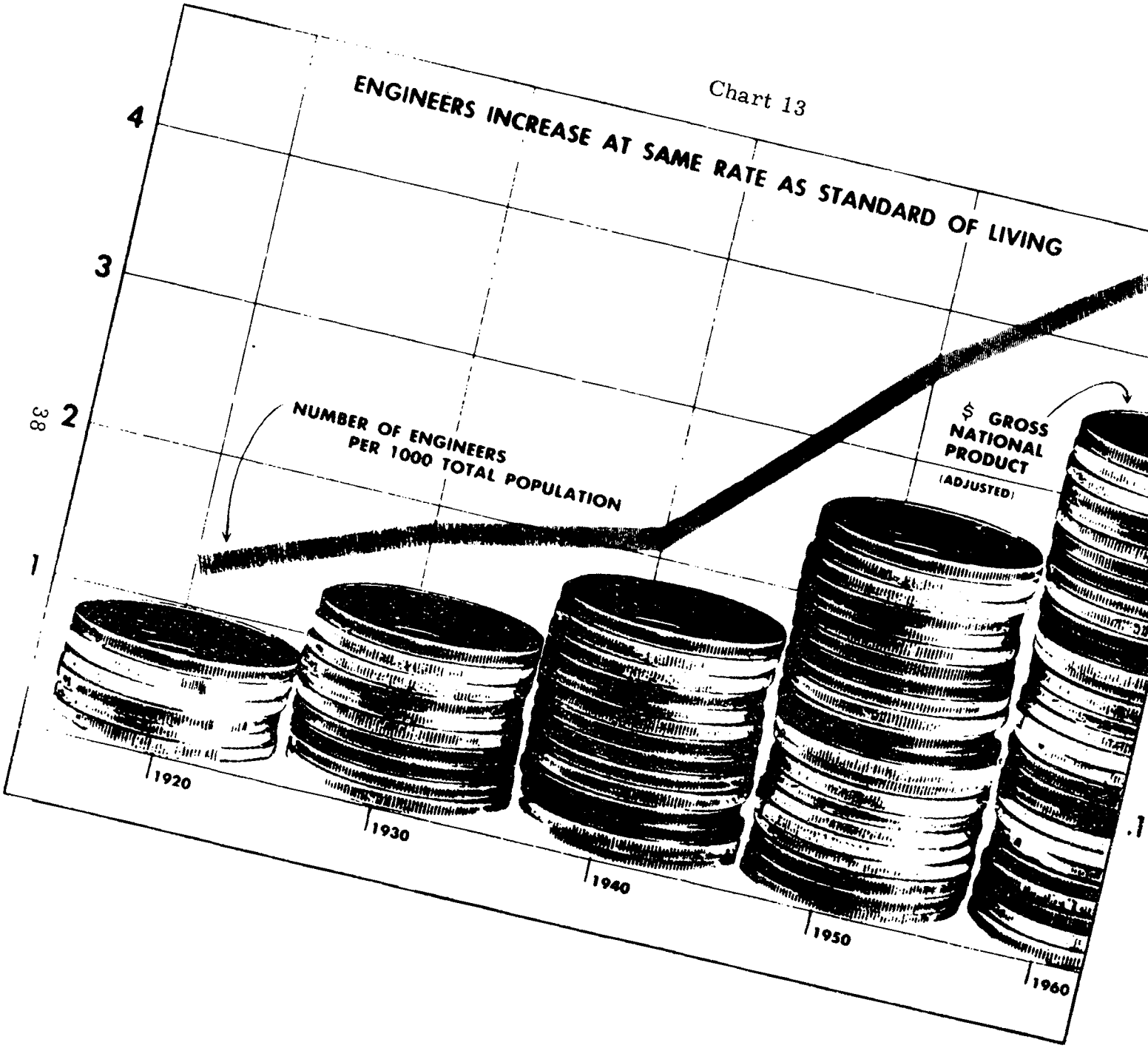

ENGINEERS INCREASE AT SAME RATE AS STANDARD OF LIVING
4
3
2
1
NUMBER OF ENGINEERS
PER 1000 TOTAL POPULATION
$ GROSS
NATIONAL
PRODUCT
(ADJUSTED)
1920
1930
1940
1950
1960

Chart 14, page 40.--This is a very interesting exhibit. It is not sheer coincidence that over all those years--taking you back 100 years--it was like that. This figure represents the amount of energy per unit of population contributed. Man plowed the field, cut the wood, pumped the water, hauled loads. He chopped. He dug. Now, this fellow worked and his other source of energy was predominantly an animal--the horse. There was a little New England waterpower factory, which was relatively small, but made a contribution. It took him according to the clock 13 hours a day, on this statistical average now, to produce a standard of living equivalent to this symbol.

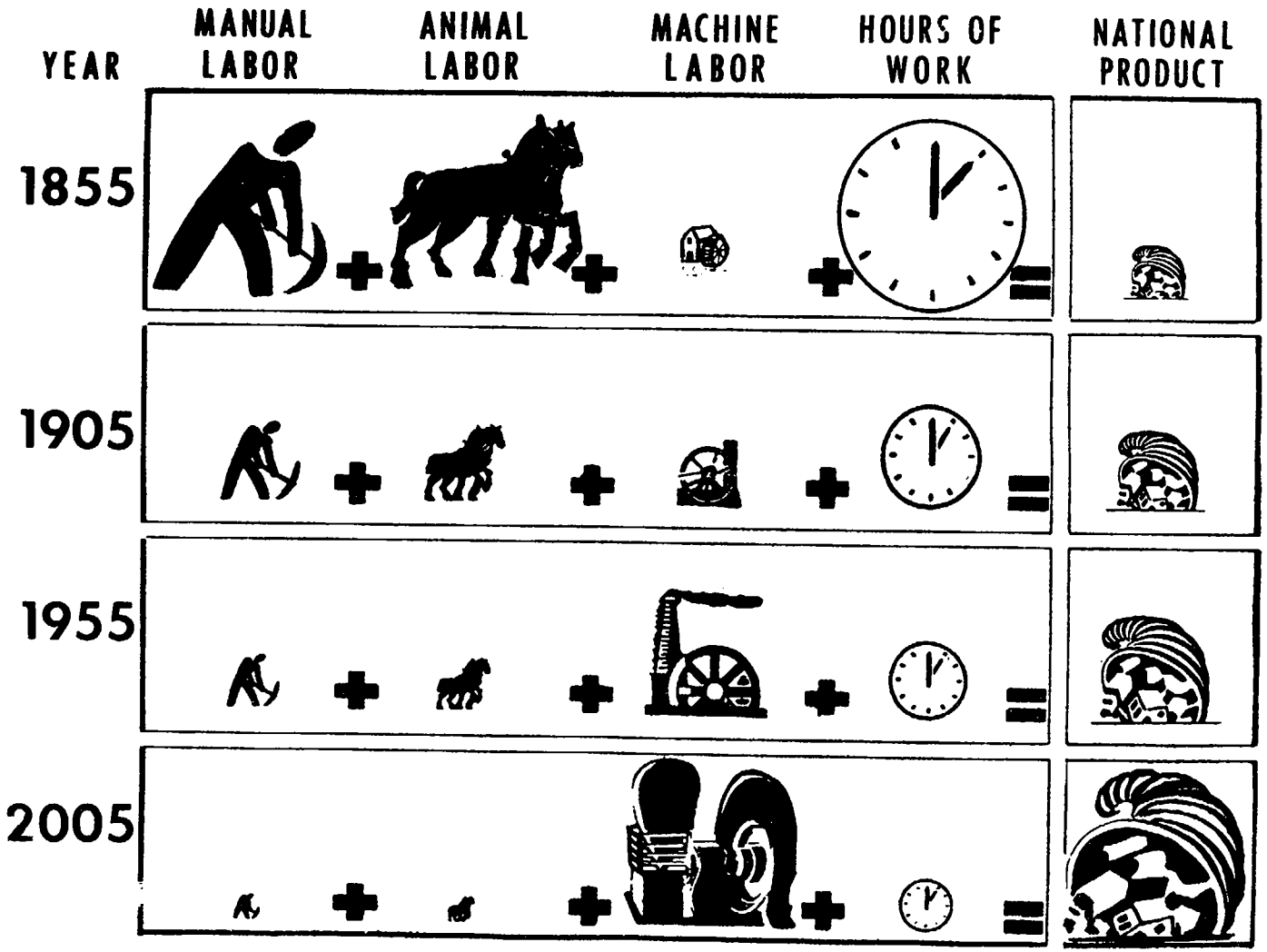
In 1905, 50 years later, steam engines had come into being. Sheldon had tried to invent the automobile. It was not much of a factor. The horse was still around in quite large numbers. The steam engine had come in in place of the waterpower. We got it from England. The clock had shrunk actually a little, but not very materially. People still worked very long hours. In fact laborers in the steel mills all worked a 13-hour chain shift, 7 days a week. Here was the standard of living--quite a remarkable change. In spite of the fact that man did less and horses did less, machines did more. Look what happened.

And now, in 1955 a man has two automobiles in the garage. He has a power elevator to carry him up to his office. He has an automatic coffeemaker to cheer him in the morning. He is pretty well gadgetized. The horse is beginning to disappear. The steam engine had become so ominous that many social writers were saying, "Man has created the machine to destroy himself." How many of you remember reading a plethora of those articles? Perfect folderol and nonsense. But it was popular at one time for the humanitarians to point to the fact that we were so mechanizing ourselves that we were becoming inhuman and the machine was going to be a Frankenstein which would be our master and not we be the master of the machine. This was a popular theory. But look what it did to the standard of living, which was called the soft life.

It is not known what this guy does now. Someone has been trying to think of something for him to invent; it seems that a motorized zipper is the only thing he has not yet invented. He has invented nearly everything else. The horse is a museum piece, the machine is unbelievable, but the clock has been shrinking. Whereas workweeks here are averaging around 40 hours statistically for the United States, the labor unions are pressing, as you know, for a 32-hour workweek. In spite of the few hours worked and the small amount of contribution of energy by our friend, the standard of living has still risen.

Chart 14

THE MACHINE vs. MEN AND ANIMALS



Being an engineer and having studied or been exposed to economics, let us say, an attempt has been made to understand it. This was a sincere effort, accompanied with a great deal of toil and sweat, but no particularly satisfying results; primarily because, if you read Professor Samuelson at Harvard and MIT, you will find that socialism is the source of all poverty. If you look at history, you will find that every socialist country has gone down the drain. Somebody must be wrong, so some prefer to use history, which is the scientific method, rather than the Samuelson method, which is the intellectual egghead method. His books are in over two-thirds of all the universities in the United States, and this is what your children and mine can read. Fortunately they are natural skeptics. Youth never likes to believe what its parents believe. So there is a rise in conservative clubs on the campus of the United States today. They are all through with the liberalism that espoused pseudo-Communist ideas, but there is quite a revulsion, because they think that the parents have succumbed to this pseudo-socialism and now they are against it. And this is good. This is why as a race we survive.

Chart 15, page 42.--Here is an attempt at sort of a reconciliation or marriage between an understanding in engineering and what sometimes is not understanding in economics. The amount of electrical energy produced in the United States and distributed over the utility lines--factories, farms, houses, and the like--per unit of population was plotted as far back as the records exist. You do not have to worry about the growth of the country now. It does not come into this. Neither do you worry about so-called variation or inflation of the dollar, which has been stupendous in the same period because we use the economist's gadget, the constant dollar, which some of us have never had.

Now, eliminating population growth and fluctuations in the buying power of currency, and calculating the gross national product to those standards per unit of population, we lay down this curve or dotted line. With the help of the College and a very clever individual, we plotted over the actual power per person in the United States in kilowatt-hours. And what do we find? What to an engineer makes sense. It will not to an economist, maybe, but it does to us; that is, the more energy you use, the more you produce in goods and services, whether it is transportation or manufactured products--this is your standard of living. And all of a sudden economics is understood. We will get rid of that chart before someone begins to question it.

I had another very interesting occasion when lecturing at Rutgers University--the United Nations representative from Norway was a victim of my lecture. I showed that curve to espouse my theory of the gross

national product and its relationship to the use of energy. Well, he came to me afterward and said:

"I've never heard that argument before. While you were giving that lecture and I saw this curve and divided Norway's total electrical production by her population; and I'll be darned if I didn't come out with the same thing that you got through economic research, as the standard of living."

Well this set me on fire. At home the same thing was done for England and the same thing was found to be true for England. And now it can be said that those countries that have been tested here--not all were tested--fall in this pattern--that the amount of energy a country has determines its standard of living, which in my book determines its war posture, its ability to sustain the devastating drain, economic drain, of a war.

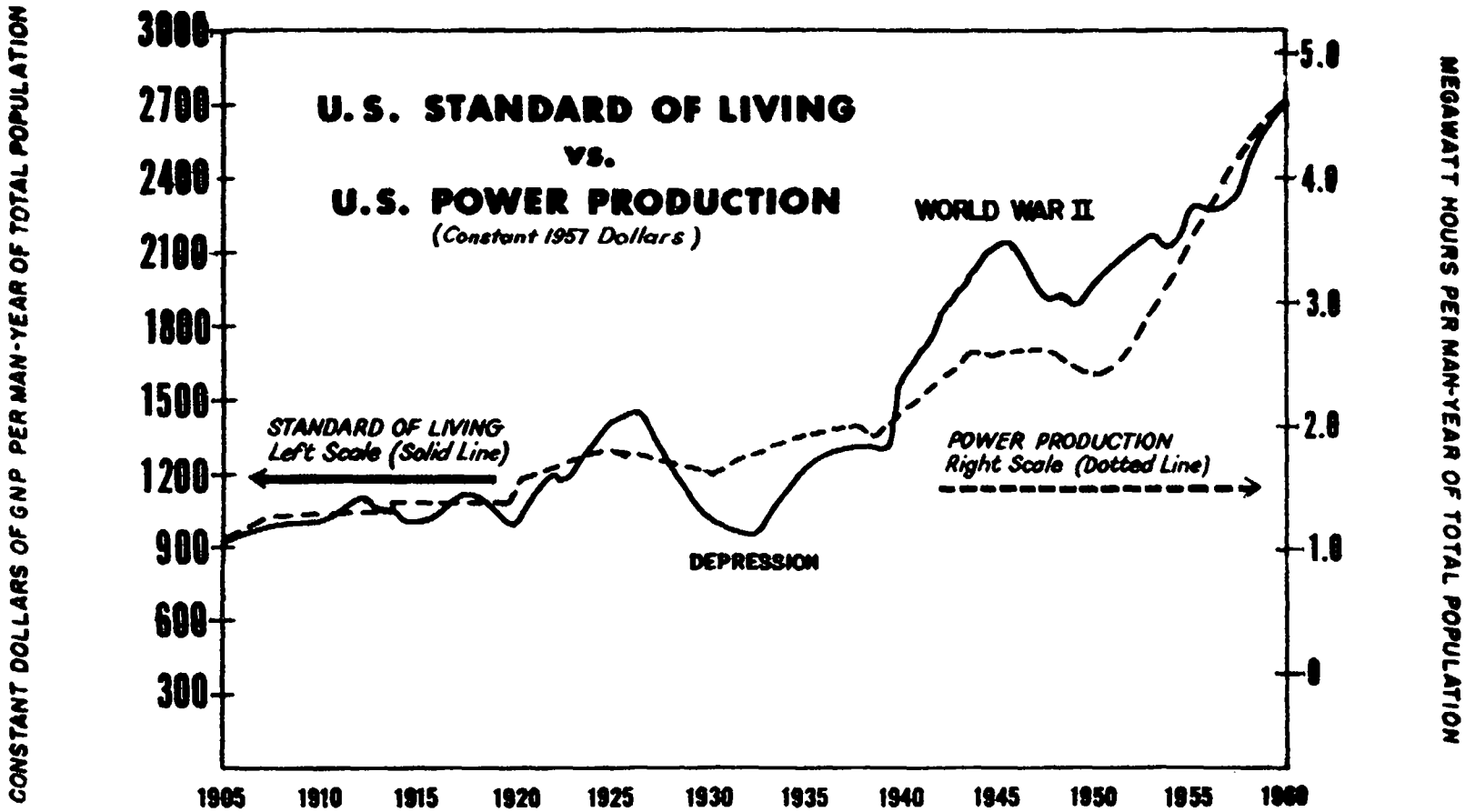
Chart 16, page 44.--Now, to dramatize it, this is the total population of the United States in terms of the world, and this is the amount of power we produce in terms of the total utility power in the world. It does not take into consideration the Chinese coolie pulling up rice and so on. There are some obvious errors. But you cannot laugh off the lesson shown. These are the actual figures that go with it.

Chart 17, page 45.--Now let me show you our strength. We are so strong that one can agree with Leo Cherne. We have been our own worst enemy. We have not followed Theodore Roosevelt's "Speak softly and carry a big stick."

In electric power production it is interesting to note that Canada's 18 million people consume about as much power as the 100 million people of Russia's European satellites. Communist China, whose statistics are very doubtful, has very low production but, compared with that of a few years ago, has really enjoyed a terrific increase. Compare the total capability of the West with the Soviet bloc--about three to one.

Chart 18, page 46.--There is our gross national product per man-hour. This shows technology at work. If you ever stop graduating engineers and employing them, putting them to work, this curve will start going down. This curve says to you that with one man-hour today, instead of producing 0.9, we produce 2.6 dollars. This is submitted to you, as one of the most fantastic developments in all economic history. This is our strength.

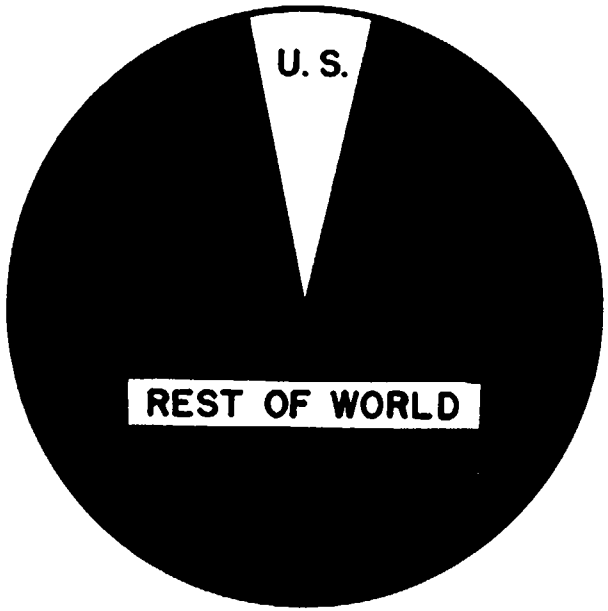
Chart 15

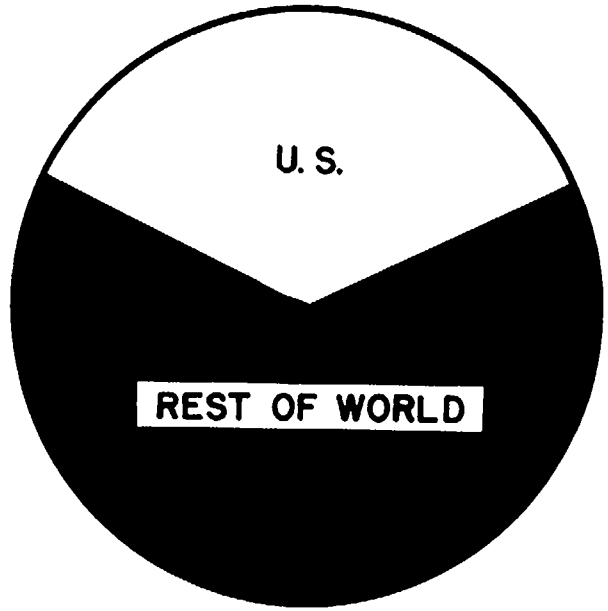


SOURCE: *Monthly Bulletin of Statistics, U. N., May 1961*

Chart 16

WITH 1/16 OF THE PEOPLE U.S. HAS OVER 1/3 OF THE POWER





POPULATION

United States	180,000,000 persons
Rest of World	2,720,000,000 persons
World Total	2,900,000,000 persons

ELECTRIC POWER CAPACITY

United States	174,998,000 kilowatts
Rest of World	324,467,000 kilowatts
World Total	499,465,000 kilowatts

SOURCE: *World Almanac, 1961; UN Bulletin of Statistics, May 1961*

Chart 17

ELECTRIC POWER PRODUCTION 1960

	BILLIONS KWH
UNITED STATES	840
WESTERN EUROPE	530
CANADA	114
TOTAL WEST	1,484
USSR	291
EUROPEAN SATELLITES	116
COMMUNIST CHINA	50 est.
ASIAN SATELLITES	12 est.
TOTAL SOVIET BLOC	469

SOURCE: ICAF, Based on U.N. Monthly Bulletin of Statistics, May 1961 and U. S. Dept. of State

Chart 18

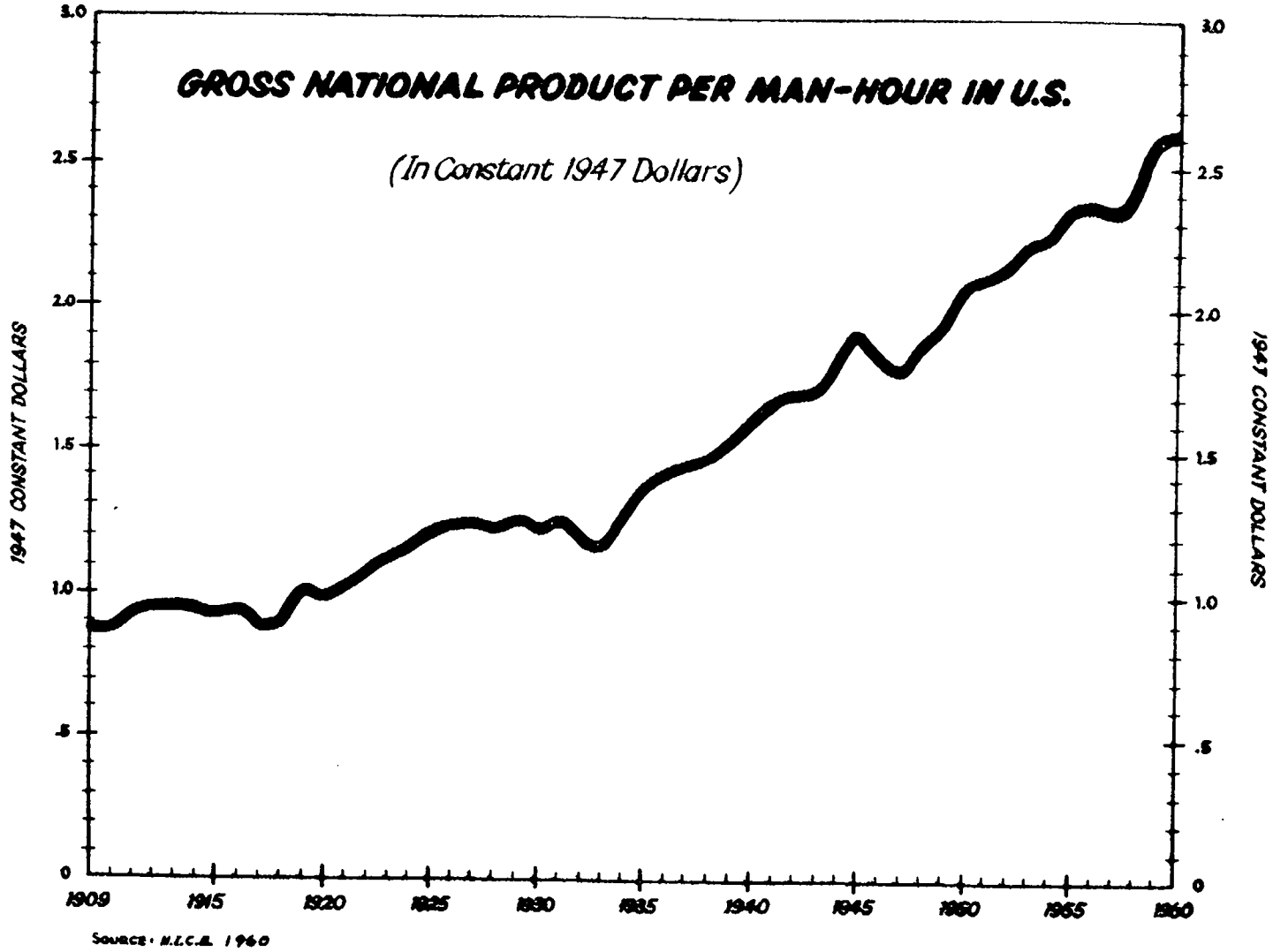

GROSS NATIONAL PRODUCT PER MAN-HOUR IN U.S.
(In Constant 1947 Dollars)
1947 CONSTANT DOLLARS
3.0
2.5
2.0
1.5
1.0
.5
0
1909
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
SOURCE: N.I.C.B. 1960

Chart 19, page 50.--This chart shows per unit of population. You see, it is even more striking. The darn thing is taking off. Where it is going is not known. The curve goes back to 1900 to show how far we have come in the cycle. The depression is shown in that little drop in the curve.

Chart 20, page 51.--This chart gives a few of the vital statistics vis-a-vis Russia, showing international economic comparisons.

People are always talking about the terrific population of China. Statistics show that Communist China and satellites have 25.1 percent of the world population; Russia and satellites, 11.2 percent--a total of 36.3 percent which equals about 1 billion people. The rest of the world (non-Communist), including Africa, has 63.7 percent of the world population--a total of 1.7 billion people.

We talk about agricultural land, but let us make some comparisons of the arable land in China which is 8 percent; Russia, 22 percent; all others, 70 percent.

The percentages in the Crude steel production are: China, 4 percent; Russia, 22 percent; all others, 70 percent. We used to call steel the sinews of war. Russia has done a tremendous job--her production is up over 60 million tons per year. Russians can be as proud of their progress as we are of ours. China, in spite of that "make steel in your backyard" program, is not doing too well. China has a lot of catching up--percentagewise--to do.

Coal production! After all coal is going to be the cheapest energy equivalent for some years to come in comparison to oil and gas--reasons will be given later. With their satellites, China produces 18.7 percent of the world coal supply and Russia, 34.2 percent--both have enormous supplies; Poland has a terrific amount of coal. All others produce 47.1 percent of total supply, so they do not have a great advantage.

As to crude petroleum, China shows zero. Russia produces 18.3 percent of all crude petroleum and is already disrupting world markets in petroleum. Rest of the world produces 81.5 percent. However, no one has been crying crocodile tears for our oil industry, because it has had such a supreme position so long that it has not had any challenge at all. Now that Russia is beginning to challenge the oil industry, and Italy, making contracts for concessions, and so forth, the industry is really making quite a fuss. But if you will look at the figures, Russia's and China's strength is in coal. On the right-hand side you have the

electric power production, which has been shown to you. This repeats the story on the earlier chart.

Gentlemen, there are some of your strengths.

Chart 21, page 52.--The black region--number 1--represents wood in 1850. Wood furnished quite a bit of energy in 1850--about 7 percent of what it took to run the country. Number 2 was anthracite coal. Number 3 was bituminous coal, which was about the same as anthracite. And now you come to wind--number 7--which was quite an element here, because they still had sailing ships, all of the windmills, and the like.

Number 6 is normal waterpower, which is not too unlike today, percentagewise from what it was 100 years ago, largely due to the so-called improvement of navigation.

Now, what do you see? You see a tremendous transformation. Natural gas did not appear back in 1850. Today one-third of all our energy comes from natural gas, one-third from oil, and about a third from coal. If this chart were brought up to date, which it is not, you would find one-third for each natural gas, oil, and coal.

This is significant because this is a very drastic change, as you see by studying the chart. And it took technology to make that change. That did not just occur by somebody whistling. It took some doing.

Chart 22, page 53.--You will now see why that can be done. This is theoretically an oil beaker and out of that you get certain bases--methane, ethylene, propylene, butylenes, hydrogen, and naphthalenes. From them you make--all the intermediates, will be skipped, though they are very interesting--resins, antifreezes, dacron, synthetic fibers (Orlon, Dynel, Acrilan), ethyl fluid, rayon, polyethlene, plasticizers, detergents, paints, explosives--and you know about solid fuels--GR-S and CRN, synthetic rubber, butyl rubber, lacquers, fertilizers, insecticides. What would your civilization be without those?

How much longer can you burn the precious storage of 300 million years ago in the Pennsylvania geological era, not to be repeated, and destroy civilization's basis of carbon chemistry? This is a question for the scientist and the technician. They had better answer it! They most likely have an answer.

Chart 23, page 54.--This chart shows some very interesting estimates. Note that all energy from normal sources, represented by the white section at the foot of the "Estimated Atomic Energy" column,

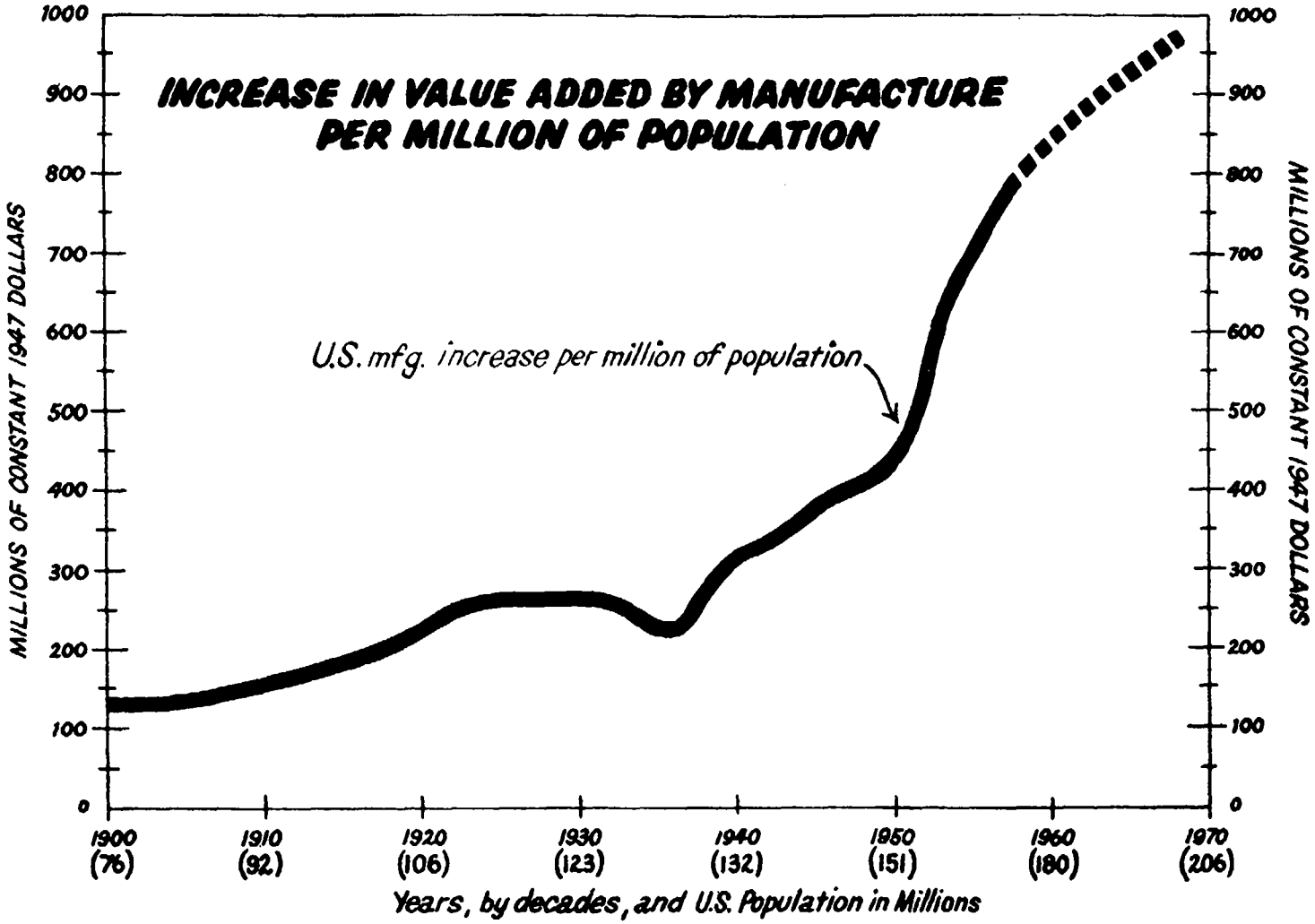
would provide only about one-twelfth of our requirements for the next 100 years. This will be true despite the development of many potential waterpower sites and natural gas. And now you are entitled to ask, What becomes of civilization? You are going to go back 100,000 years to the civilization of your ancestors. You are going to be working.

Enter atomic power! So you can see that this devastating physical development, decried by humanists and many scientists, who were ashamed that they worked on the bomb, may be the preserver of your children's children. Never since the invention of gunpowder has any scientific development failed to bring to humanity its useful as well as its useless contributions. Some old Chinese Mandarin no doubt, pontificated around the family fireside when he heard the first gun go off with powder and said: "We have always been hitting each other with spears and swords. Now, by God, we can stand a safe distance apart and annihilate each other. This is a ghastly thing."

But what happened? The forces of chemical gunpowder and its equivalent, dynamite, have built the road systems, your great earthworks, dams, other structures. They have made modern civilization, transportation, and habitation possible. And so the old mandarin, if he had said it, would have been wrong. And the same applies to atomic energy as a development of the bomb. Any scientist will tell you that the bomb was a more difficult assignment than atomic power for peaceful use. We did if for survival, but the atomic power for peaceful use is where we get our dividends. And without it civilization would be facing a very dark future--not for the 5 billion years that the cosmologist can show climate on earth will support man, but for 100 years.

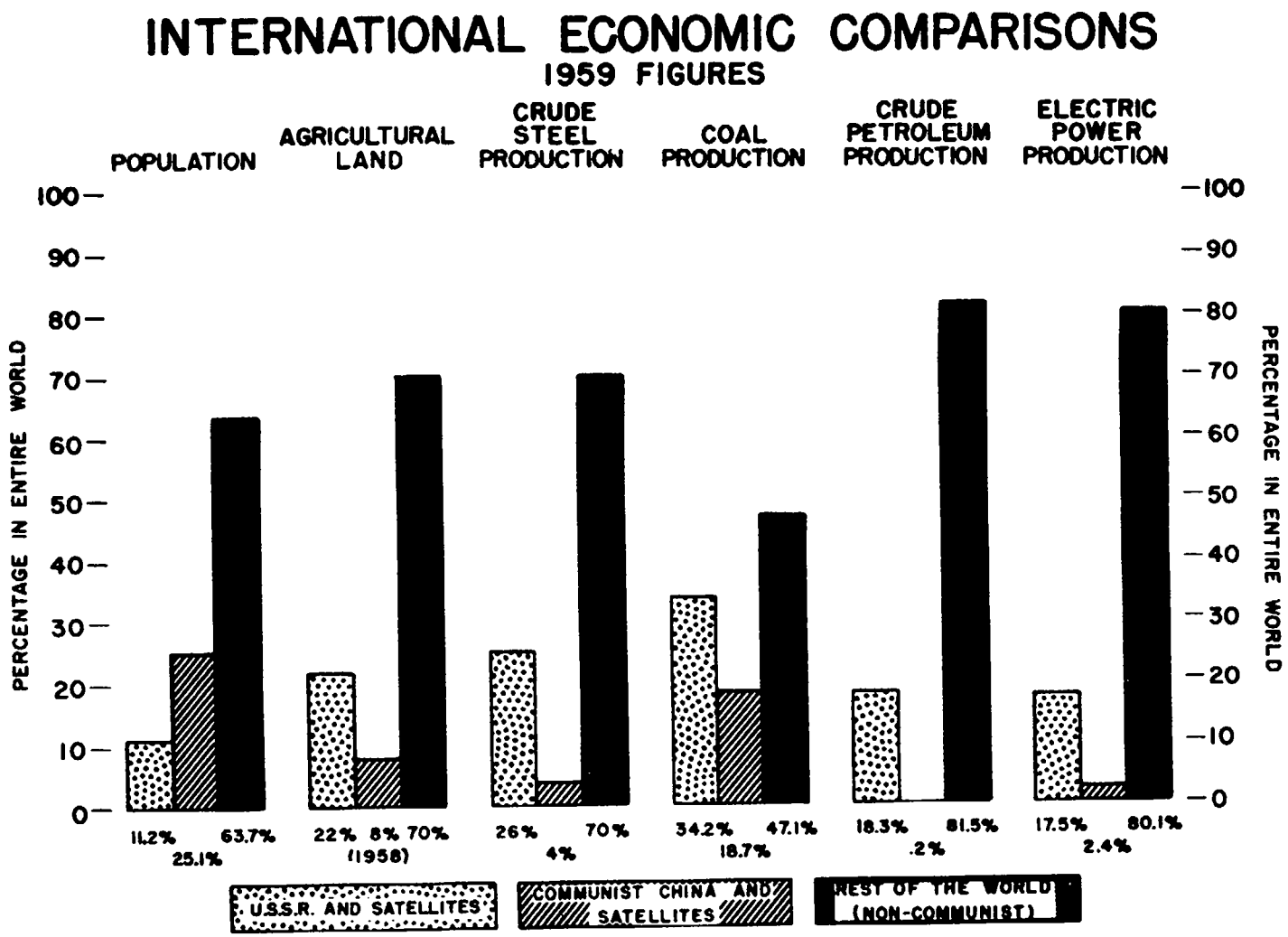
Chart 24, page 55.--This curve gives you a quantitative view of normal technology at work. It goes back to 1905, but could have gone back to 1882 when Thomas Edison built the first steampower electric station. According to the early records--which are not too good, but they are reasonable--he used 19 pounds of coal to make a kilowatt-hour. By 1900, as you see, we had dropped down to six pounds. When I got out of college, I remember going to a meeting of the American Society of Chemical Engineers and hearing a learned paper on the new Public Service of New Jersey power station which showed a kilowatt-hour per four pounds of coal. Everybody said, "Oh, boy, isn't that something." And now look where we are. We are down to actually two-thirds of one pound in the American Gas and Electric's latest station in the Lehigh Valley.

Chart 19



SOURCE: U.S. Census of Manufactures

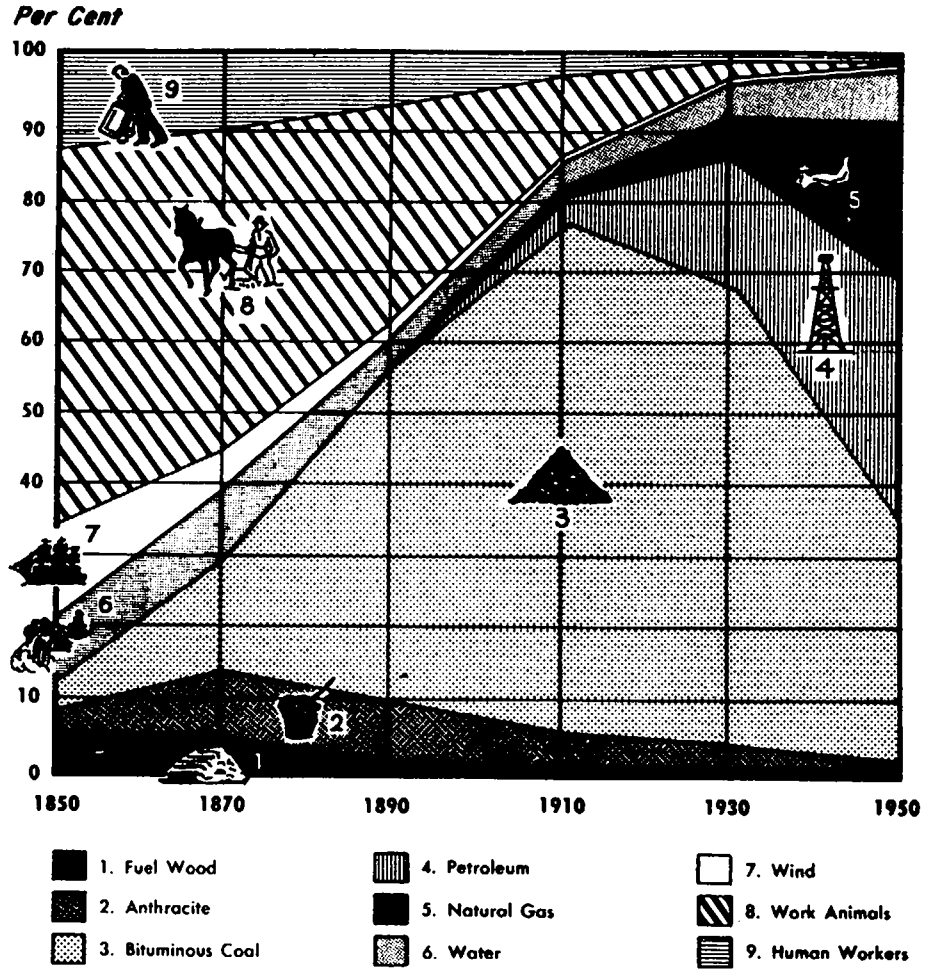
Chart 20



SOURCE: *Economic Indicators, U.S. Dept. of State, 1960*
ICAF - NAT. SEC. SEM.

Chart 21

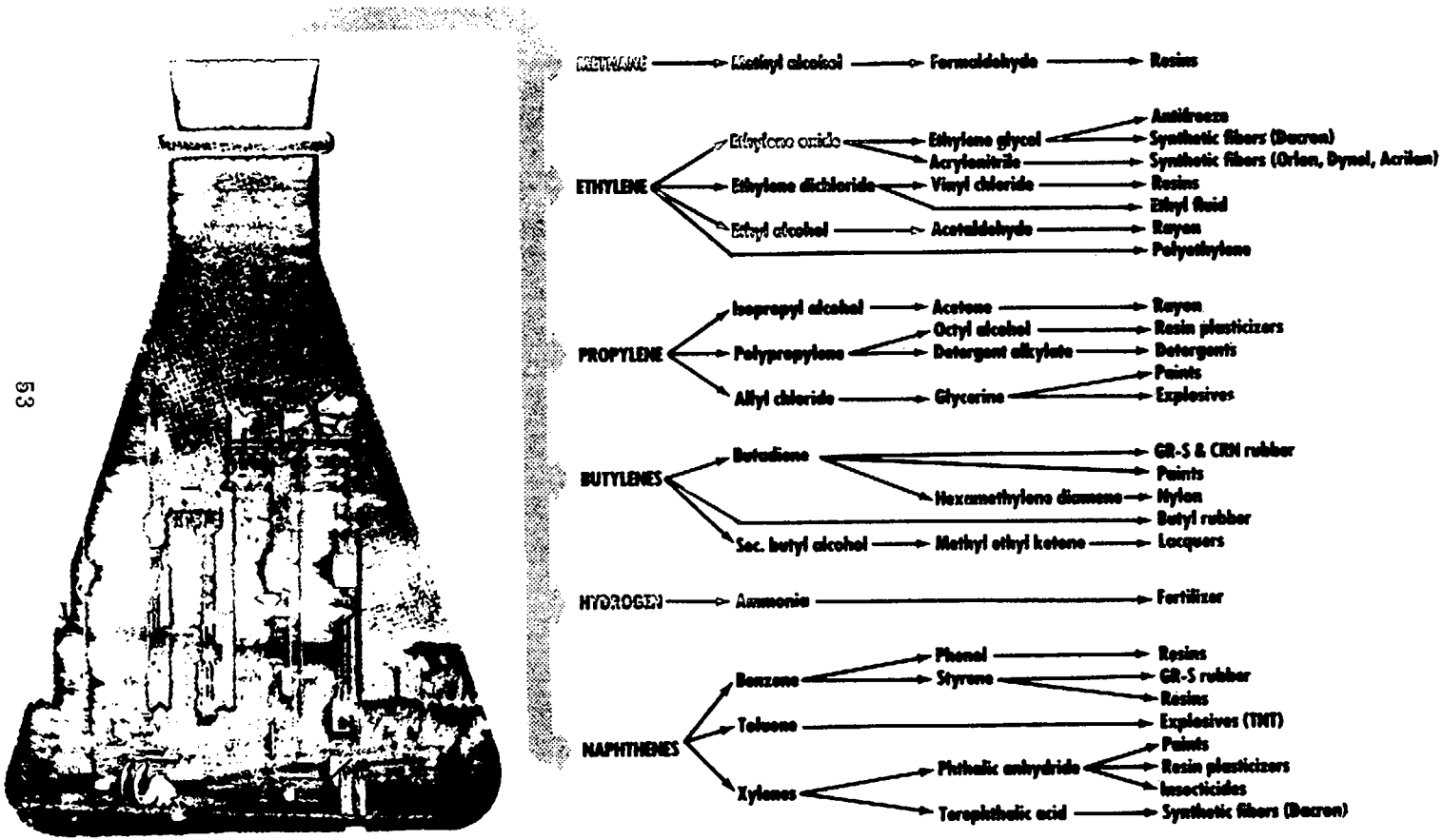
ENERGY OUTPUT BY SOURCES IN THE UNITED STATES (1850-1950)



SOURCE: Twentieth Century Fund

Chart 22

CHEMICALS FROM OIL



SOURCE: *"The Lamp", Standard Oil Company (New Jersey)*

Chart 23

ENERGY REQUIREMENTS AND FUEL SOURCES TO 2050 AD

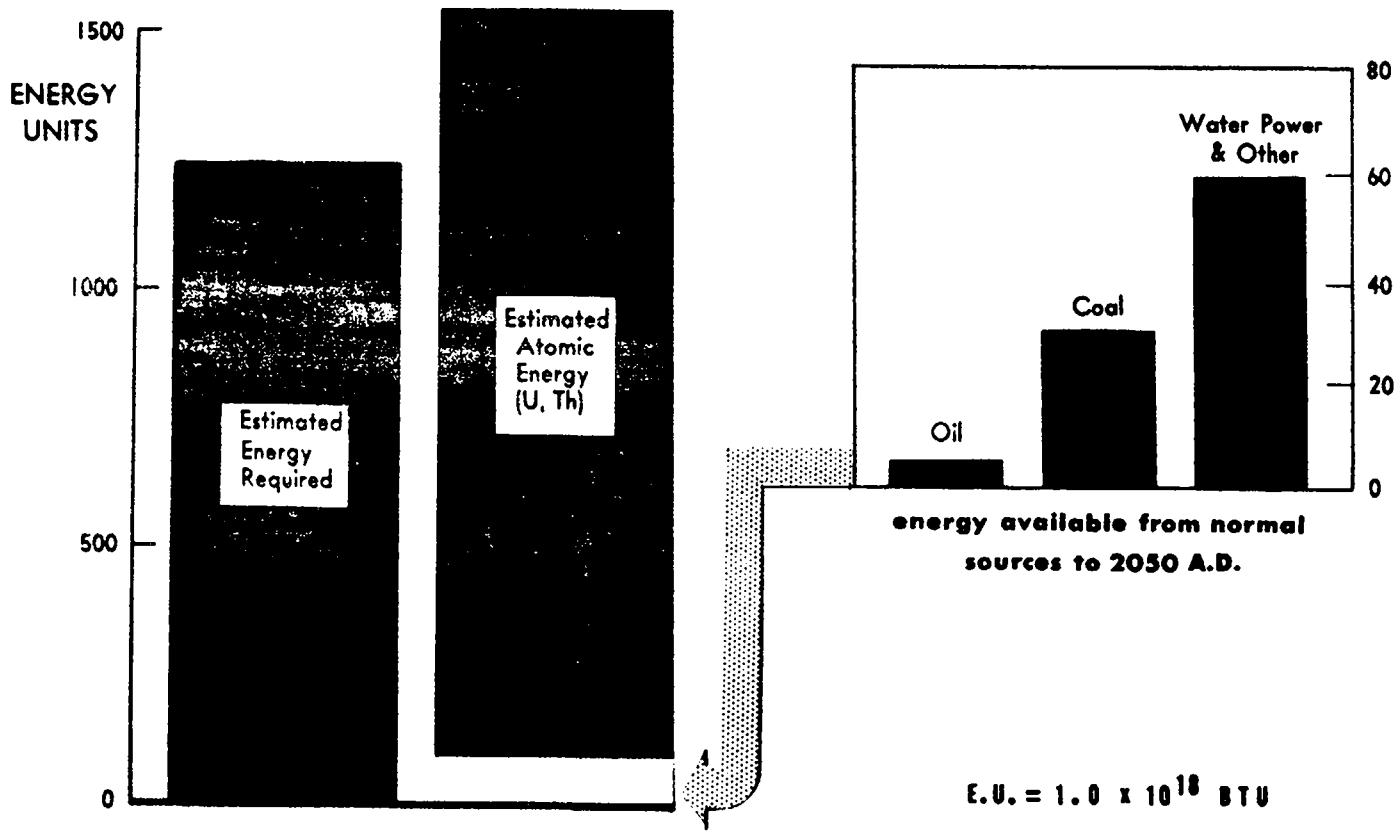
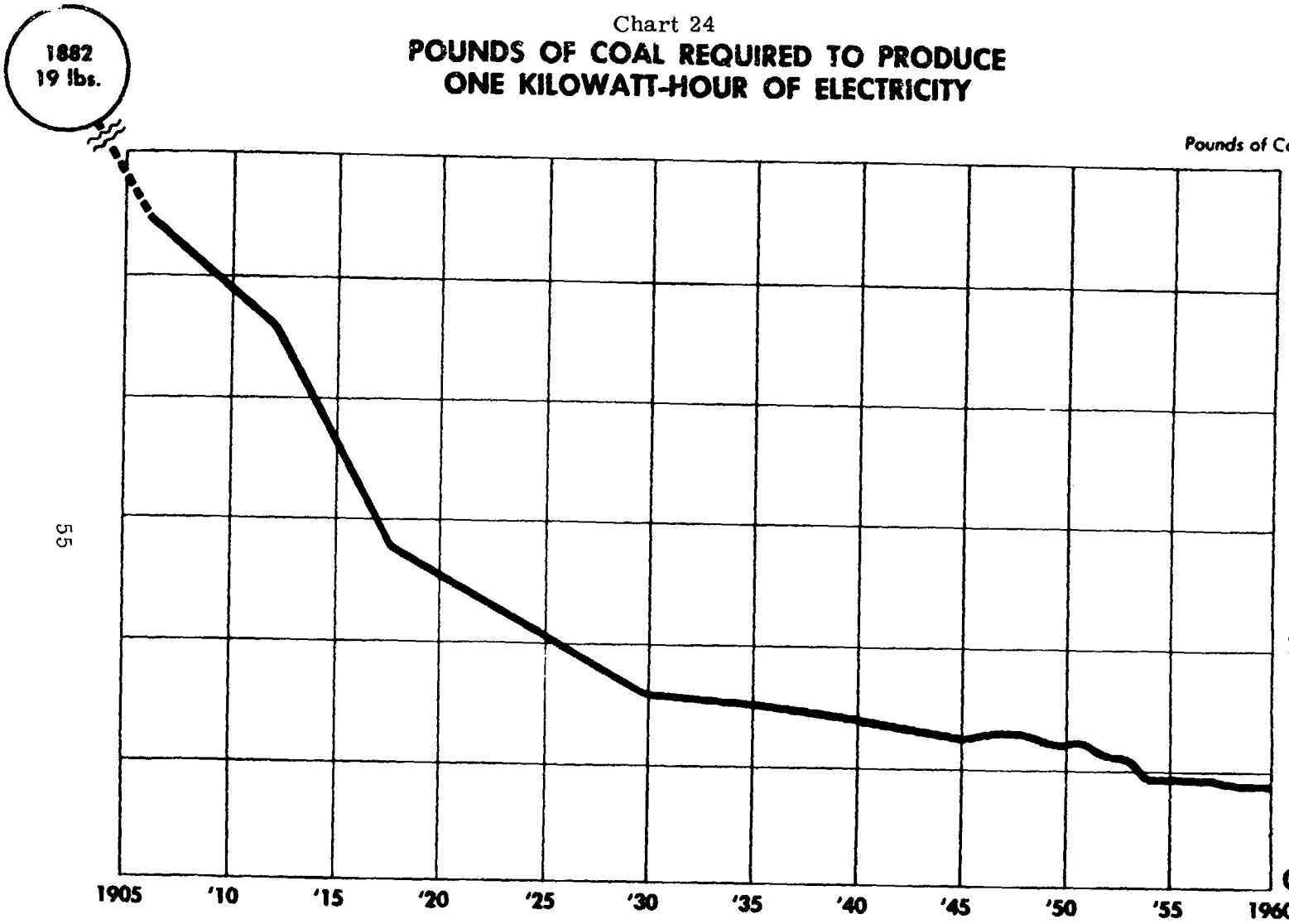


Chart 24

POUNDS OF COAL REQUIRED TO PRODUCE ONE KILOWATT-HOUR OF ELECTRICITY



SOURCE: Federal Power Commission, 1961

Why is this shown to you? Because you and your counterparts sometimes underestimate this profit. It was underestimated in the atomic-propulsion-of-airplanes project, in which seven years of my lifetime were spent, and which has been canceled. It was misunderstood, because the people who condemned it did so largely on the basis that the first airplane would not be supersonic.

Well, my goodness sakes alive, the first Edison station was not supersonic in a coal sense. And an engineer learns by doing. He is not a scientist. He is always hitting a whole lot of new technological breakthroughs that he never saw done before. The only way he can solve them is to intuitively barge right in and try solving them. Half of them will be solved wrong, and then he does it over again, and this is how he learns.

That is how we got where we are! There is no new science in this thing in the true sense. It is technology. This is a curve of technology at work, not science at work. And what you view on this chart is a fundamental of technology. And never forget, when somebody brings to you as a procurement officer, a proposal to do something, and you look it coldly in the eye and say, "I want better than that." Maybe you do, but it may be the best that the art can do. If you turn that fellow away from your door, you may be turning away a development two or three machs subsequent that will be one of the most precious weapon needs that you have.

You have to recollect that this is the method engineers use. We said to many of our scientific betters who condemned the airplane project--they were scientists who do not understand engineering and we could not get it across to them--that the first airplane we were going to fly then was a B-36, and we would have flown that airplane in 1952. And what would it have done? It would have been a demonstration airplane. But the next one would have been something quite different. Now, if you wait for the hen and egg theory to get the supersonic airplane in your first go-through, you are going to be twiddling your thumbs for a good, long time.

Chart 25, page 58.--Let us look at the same thing applied to heat from the use of atomic energy. Gentlemen, Mr. Rickover has gone to some pains, it seems; to frighten the public with the impracticability of atomic power for electric purposes. He uses as his example a station in which he had a responsibility--Shippingport, Pennsylvania. He has said from many platforms--know the gentlemen well--that it costs over 50 mills to make a kilowatt of electricity from atomic power. How did

he get it? It is a Thomas Edison station. It is a very poor station from the point of view of what is known today and is being done today. And in it he put all the developmental costs. That is why the statisticians cannot get him out of that other curve. And so he has this fantastic cost. Chart 25 shows where conventional power is. So, obviously, he could conclude that atomic power is no economic counterpart for conventional power.

However, the nuclear costs curve was done by two of the top men in the Atomic Energy Commission, who were not committed to any theory, and they built this curve as a forecast. This was 1960. What do you see? These stations are known by me, because my firm designed one of them; you see that its economy in 1960 was 13 mills. That is a long way down from 50. And now that same company is looking at its next atomic station with a cost of 8 mills, which can be built in 1966. And where is 8 mills? Competitive with their own best engineering estimates of their coal, gas, oil-fired stations.

Gentlemen, this is again the same proof to you that engineers learn by doing. Otherwise they could not have built that powerplant when Mr. Rickover built his. You have to go through these intermediate steps, like a child has to learn to crawl before it walks, and walk before it runs. This is the process of engineering and not the process of science.

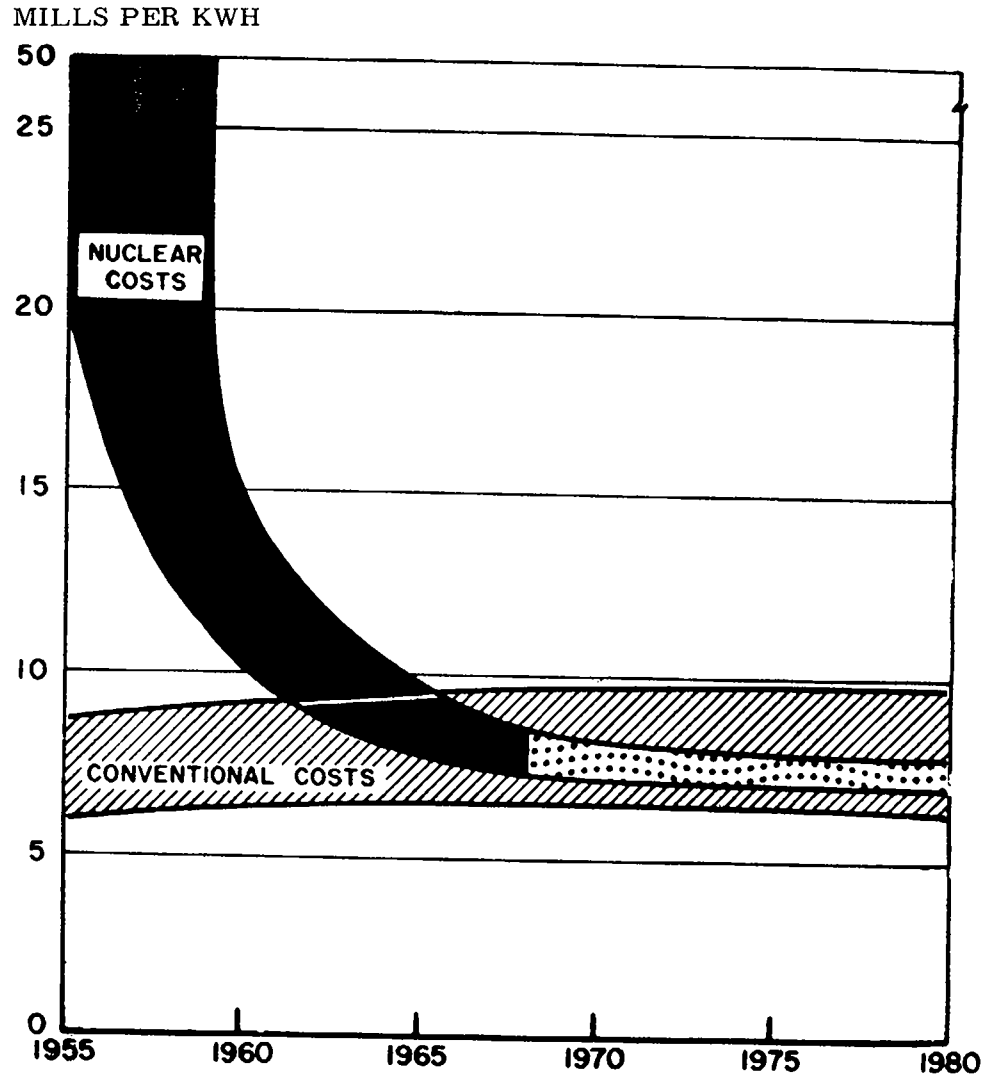
Chart 26, page 59.--Here is one out of your book. The Nautilus' first core steamed 60,000 and a few hundred miles. If it had burned oil, it would have taken 57,000 barrels, right out of the chemical resources of the Nation. The second core, which has been taken out, steamed 95,000 miles, 96,000 to be exact; and it would have used 88,000 barrels of oil. The third core--again remembering this is a curve, like the two you have seen--is calculated to steam 135,000 miles. It is far enough already in flight history to feel that it is going to do slightly better; and it will use 121,000 barrels of oil. But the fourth core on the Nautilus--not on the chart--designed by the bureau, is designed for 200,000 miles of steaming. This again is the proof of this curve in engineering. These are engineering breakthroughs. This is the process of engineering at work, which we need so badly to understand better than we do.

Chart 27, page 60.--Here are the kinds of industries that spring out of engineering and technological development. The Wright brothers flew in 1903, and except for World War II, the industry subsided to a point shown on this chart, in spite of the airmail problems of the twenties and so on.

Chart 25

ESTIMATED COSTS OF POWER FROM LARGE NUCLEAR AND CONVENTIONAL PLANTS GOING INTO SERVICE EACH YEAR

(Assumed Load Factors, 70-80%)



DATA NOT FIRM

SOURCE: TID-8516

Chart 26

IMPROVEMENT IN NUCLEAR PROPULSION

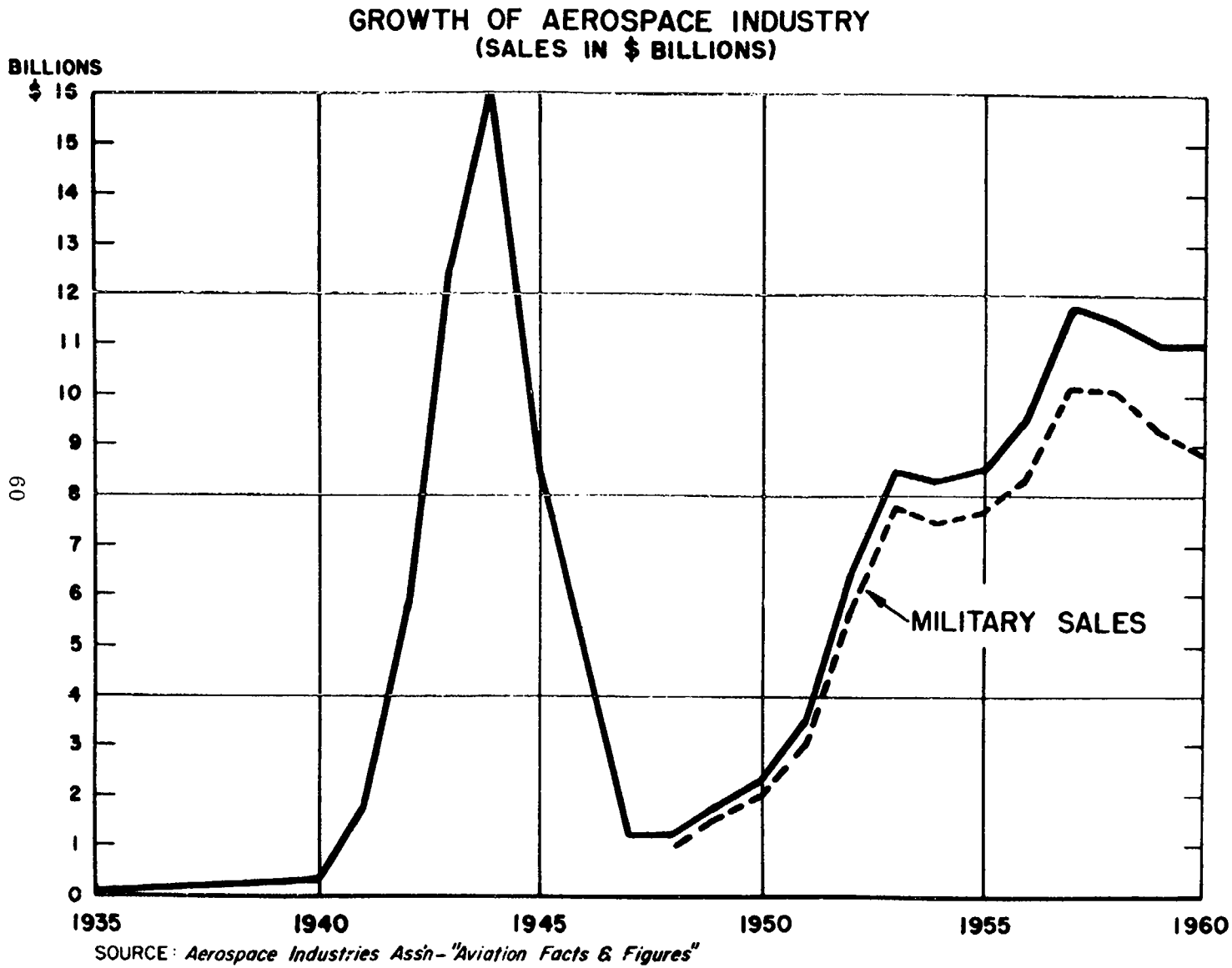
U.S.S. NAUTILUS

	1st Core	2nd Core	3rd Core
NAUTICAL MILES STEAMED (APPROX.)	60,000	95,000	135,000*
BARRELS FUEL OIL EQUIVALENT	57,000	88,000	121,000

*PREDICTED

SOURCE: A.E.C. and Congressional Record

Chart 27


GROWTH OF AEROSPACE INDUSTRY
(SALES IN $ BILLIONS)
BILLIONS
$ 16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1935
1940
1945
1950
1955
1960
MILITARY SALES
SOURCE: Aerospace Industries Assn-"Aviation Facts & Figures"

The highest point on the cure is the production in World War II. And obviously the "Bring the boys back home by Christmas" deal pulled them back to the lower point. And many of us in the industry at that time were wondering how we would survive.

Well, since then this is the curve, speeded on by the Korean War, and this includes today a major national effort. You see in terms of billions of dollars that this is not inconsiderable. It is just under $12 billion.

This entire effort grew out of the technology of aerodynamics, started by old Dr. Eiffel in France, who built the Eiffel Tower and who first enunciated the first basic principles of economic forces. Very few people knew--he did that in the latter part of the previous century--that he was founding one of the great industries of all time, and something that was not only a great industry but would revolutionize the pattern of civil life. You could not have the United Nations function without airplanes, carrying their emissaries back and forth to say their piece, bringing them face to face. If you did this by the old diplomatic interchange of striped pants and cutaway coats, you would never be able to function in the United Nations. It would be a stilted policy, long trailing the crises in the news. The airplane has changed the commercial, the military, and the national power. Dr. Eiffel even helped the country that does not have capability in this new technology. And no one can say that that was a product of political thinking, political leadership, industrial thinking, industrial leadership, or the social sciences. None of them even foresaw the tremendous effect, the revolution, that would occur in all of those fields--political, social, economic--by the use of the airplane as an instrument of civilization. There is no question about whether the hen or the egg was first there.

Chart 28, page 62.--Here is another one that the hen hatched out. See what it is.

Just before World War II there was the so-called radio industry of communications, which it largely was--elemental TV, experimentation mostly. When Sir Watson and his associates in England defeated the Germans by the use of radar information, thank heaven you gentlemen quickly clambered aboard. England helped us on our way. The Radiation Laboratory was formed. A new industry born, fully as spectacular as aeronautics, atomic energy, or any of these products of the science-technology team. You will see that the military sales do not dominate the total electronics history. It is a life-giving element, but it does not dominate, fortunately for you.

Chart 28

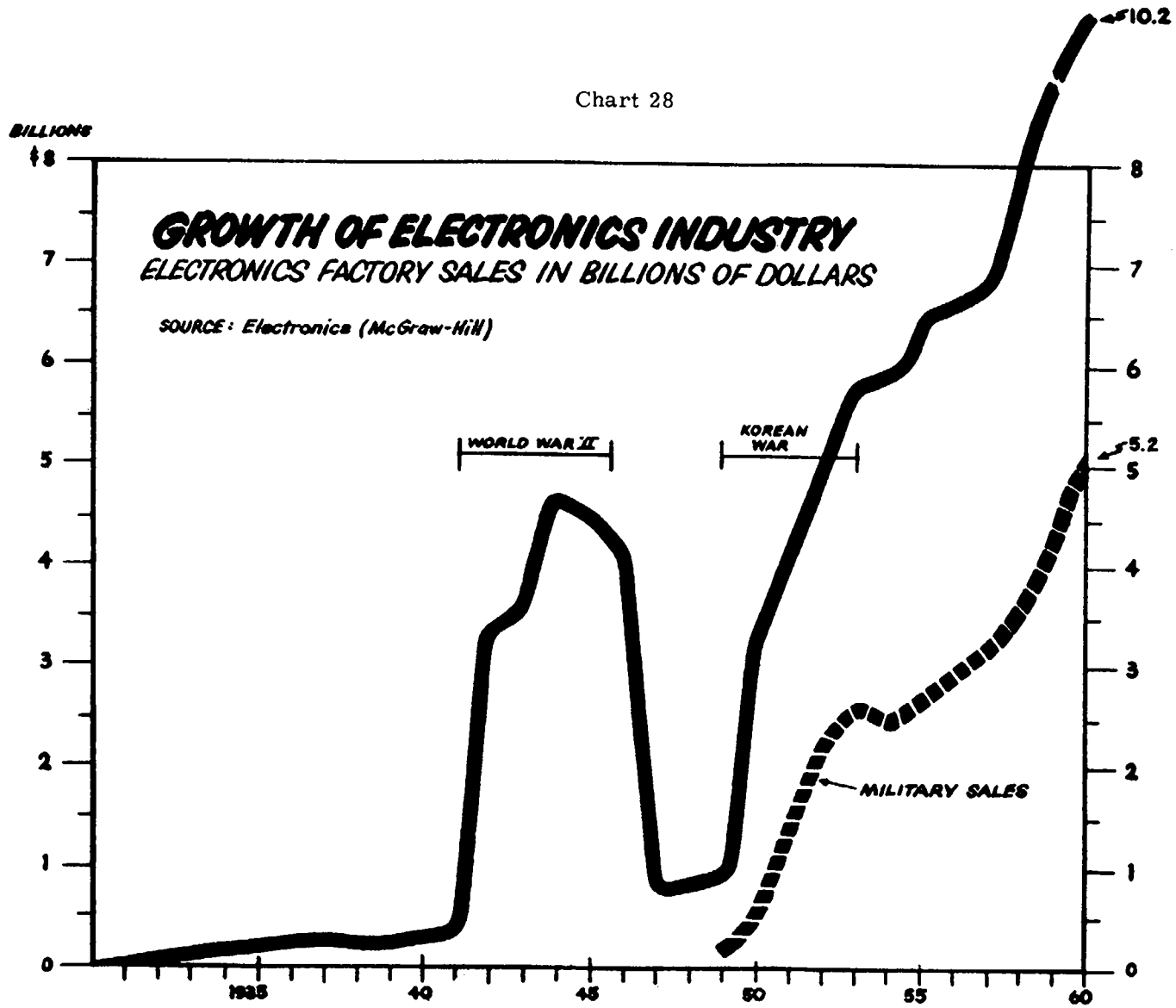

GROWTH OF ELECTRONICS INDUSTRY
ELECTRONICS FACTORY SALES IN BILLIONS OF DOLLARS
SOURCE: Electronics (McGraw-Hill)
BILLIONS
WORLD WAR II
KOREAN WAR
MILITARY SALES
10.2
5.2
0
1
2
3
4
5
6
7
8
1935
40
45
50
55
60

Chart 29, page 64.--Here is your competitor's work. Picture yourselves in the Soviet Union, you and your family. At the time this was built, you and your family had 86 square feet of living space. That included your bathroom, your bedroom, and a living room if you had one. If you did not have children, you did not have a living room. Regardless of the size of your family, you still got 86 feet of family space, and so your large family was sleeping four and five abreast.

Now, mind you, here is a country in which you have already started your educational program, and you are telling its people about the better way of life. A lot of them get over the boundary and see how other countries live. And in the face of all that the government has political strength enough to do what no democracy could do--take its kopecks and its rubles and build a momument like the one shown on the chart to house that scientific instrument, which is for pure basic research. That was the largest instrument in the world by a factor of 600 percent when it was built. The reason for showing it is not because this is a wonderful instrument and this is a lovely building and this is a pretty girl at the control. But to show you by a fact, not a statement of principle, that Russia regards its science-technological future as even more important than satisfying the political needs of its populace.

Chart 30, page 65.--Now, as for the challenge of the future, a request was made to talk briefly on it, and it is going to be very brief. No watches have been seen at your ears, but a few yawns have been detected. Hope you see something that is very obvious to me--the fact that we have not scratched the surface in science; the boundaries that science looks forward to now are proliferating and are greater than those which it has already passed and of which you now are conscious.

This is the periodic table. You all have it in your chemistry books. Most of even the humanitarians are familiar with it as a document.

On chart 30 note the following elements: cerium, praseodymium, neodymium, promethean, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutecium. How many of you know what any one of those is? Only a few chemists sitting in this audience perhaps might know. What significance do they have for you? Well, if there are any Air Force officers here, the answer is "a lot." If you are interested in the B-70, the answer is "Yes." The B-70 is perhaps practical in part because of praseodymium and neodymium which, when alloyed at about 5 percent, will give you a resistance to the heat that the B-70 airplane structure will have to suffer in flying at a mach number of 2 to 3 in the upper atmosphere.

Chart 29

Chart 30

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES
1 H 1.008														1 H 1.008	2 He 4.003
3 Li 6.940	4 Be 9.013									5 B 10.82	6 C 12.010	7 N 14.008	8 O 16.000	9 F 19.00	10 Ne 20.183
11 Na 22.997	12 Mg 24.32									13 Al 26.98	14 Si 28.09	15 P 30.975	16 S 32.066	17 Cl 35.457	18 A 39.944
19 K 39.100	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.95	24 Cr 52.01	25 Mn 54.93	26 Fe 55.85	27 Co 58.94	28 Ni 58.71	29 Cu 63.54	30 Zn 65.38	31 Ga 69.72	32 Ge 72.60	33 As 74.91	34 Se 78.96	35 Br 79.916	36 Kr 83.80
37 Rb 85.48	38 Sr 87.63	39 Y 88.92	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (99)	44 Ru 101.7	45 Rh 102.91	46 Pd 106.4	47 Ag 107.880	48 Cd 112.41	49 In 114.82	50 Sn 118.70	51 Sb 121.76	52 Te 127.61	53 I 126.91	54 Xe 131.30
55 Cs 132.91	56 Ba 137.36	57 *La 138.92	72 Hf 178.50	73 Ta 180.88	74 W 183.86	75 Re 186.31	76 Os 190.2	77 Ir 193.1	78 Pt 195.09	79 Au 197.2	80 Hg 200.61	81 Tl 204.39	82 Pb 207.21	83 Bi 209.00	84 Po 210.	85 At (210)	86 Rn 222.
87 Fr (223)	88 Ra 226.05	89 †Ac 227.0															

58 Ce 140.13	59 Pr 140.92	60 Nd 144.27	61 Pm (145)	62 Sm 150.35	63 Eu 152.0	64 Gd 157.26	65 Tb 159.2	66 Dy 162.51	67 Ho 164.94	68 Er 167.27	69 Tm 169.4	70 Yb 173.04	71 Lu 174.99
90 Th 232.12	91 Pa 231.	92 U 238.07	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (243)	97 Bk (249)	98 Cf (249)	99 E (253)	100 Fm (254)	101 Mv (256)	102 Nm (254)	

*LANTHANUM SERIES

†ACTINIUM SERIES

Well, are these very exotic and rare materials? No. They are neglected materials. They are not rare. They are labeled "rare" in the chemical book.

Now, gentlemen, this whole thing is a horizon, a horizon in materials that can perhaps contribute to the solution of some of your very critical weapon systems, but which requires a tremendous amount of work, work in research and development, of a kind we were not doing sufficiently in the United States. We were trying to find out how to make steel cheaper. We were not trying to find out what such things do metallurgically.

Now, all scattered through here are some other forgotten elements. The Air Force has been buying scandium at $5,000 a pound until recently. The price had dropped way down to $2,500 when it was last heard of. Well, nobody knew what scandium would do, but some very theoretical investigations indicated it might have some very useful properties.

Gallium is very peculiar material. It melts very easily. It becomes like mercury.

So you are now looking at a challenge for the future of materials. And remember, it says nothing about the organic materials. This is the carbon group. This is the sulphur group. And this is expanding with a proliferation that is utterly beyond the comprehension of anyone not working in the field.

This is given to you merely as a document of challenge for the future. And here accompanying it is one to which you are only becoming sensitive and alert and which is the basis for many of your new weapon systems.

Chart 31, page 69.--This chart shows the radiation spectrum. Here are radio waves to which you are accustomed. Simply to go from radio waves frequencies, which are stated in cycles per second, up to ultraviolet, which you are all acquainted with in one form or another, is a ratio of a million to one. And in between there are a whole array of signaling capabilities not at present explored.

In the higher frequencies we are using radio telescopes for new knowledge of the cosmos. And what do they show? They show structures in outer space that we never envisaged. They are bringing us brand new information on outer space. The Air Force in Puerto Rico

is building a $6 million station that will use electron frequencies in the upper range for measuring the physics of outer space 100,000 miles out. It is so powerful that it has to be enclosed in a ring of hills and all entrances to the valley guarded, because anyone going near it would be killed by the radiation energy of the waves. It has to be run from underground like Cape Canaveral.

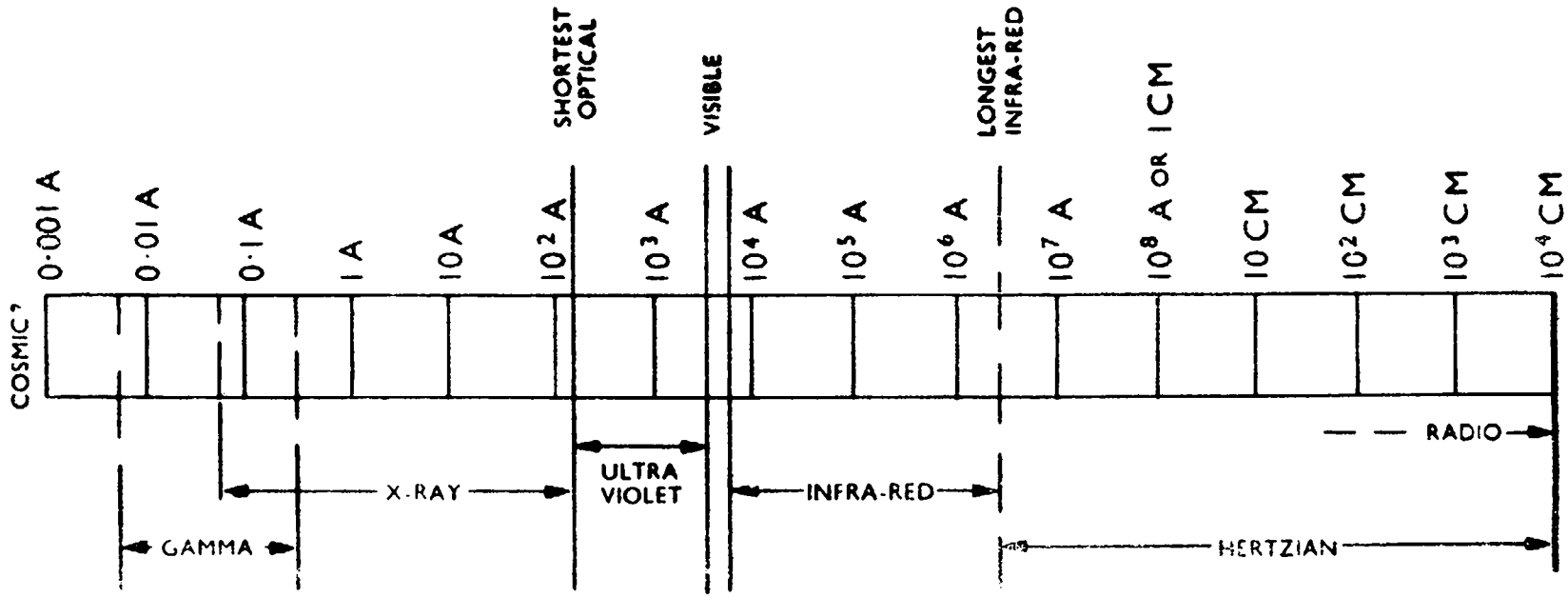
This is in its infancy. This idea was proposed by two university professors. One came to us from Cambridge, England. Such a vast array of intelligence signals, power signals, and science too, as yet has been only scantily harnessed. In infrared is the area of your new heat seeking missile systems. It has been only recently developed by proper detecting mechanisms.

The human mind gets all of its visual information from a very small increment. If you are philosophically inclined let me suggest something. The bee finds its food by frequencies we do not even know. Animals get much of their knowledge of their surroundings from signals that we cannot sense. Our signal system was developed by evolution. Hence colorblind people really have the eyes of their ancestors before the eyes developed to the extent they are today. So all of us depend on that tiny bit of radiation information from the outer world. What would a sunset look like if we could see all those other colors instead of merely the six limiting colors in the visible spectrum?

This is only a personal reaction. Science is not personal. It is not subjective. It is objective. In other words your practical knowledge of the world you were brought up in and live in comes to you very recently only through that tiny gateway to this vast outpouring of possible intelligence from the outer world. We have shown by charts two of the basic challenges--materials and electronagnetic energy. There are many more. These are simple invitations to scientific and technological breakthroughs. They cannot be accomplished by politicians or by direction.

Today the Kremlin has shaken up the Russian Academy of Science in a very fundamental way. This is the largest body of technical scientists in the world, put together into a massive mechanism. The head has just been relieved after eight years as head, and the man put in has been stripped of his budget-making power, which, as you know, is the hand that rocks the throne, and a committee of five has been substituted. And who are the committee of five? It is headed by a Russian general from the army, who, unfortunately, died right after his appointment. I do not know whether from fright or what. And now they must find a new head, but it will be an army head. And on the committee of five only one scientist resides.

Chart 31



THE RADIATION SPECTRUM

This, gentlemen, is significant. The Kremlin is not pleased with its technological advances. And what do we get out of the reports? We get the fact that they are not pleased, because the scientists, left to their own budget-making and program-making functions, were devoting too much time to theoretical and basic science. I hope to heaven this news is right, because nothing could be better news in the long run. The short-run effect might be a stimulation of development of Russian weapons systems, but in the long run that is not good for them. So all is not well with our competitor in the field of science in spite of what have been spectacular, highly propagandized breakthroughs.

You will now be told a few of the areas that perhaps hold scientific technological breakthroughs for the civilized world.

The radiation spectrum you have just seen. However, beginning with 1895 and ending with 1939, there is the development of atomic energy--that is a very short time for something that revolutionizes the world's source of energy. Thus one pound of atomic energy equivalent under $E = Mc^2$ is 11.4 billion kilowatt-hours. One pound of coal is one and a third kilowatt-hours. So the force which was discovered as atomic energy is not an evolution. It is a revolution! Never before has there been such a breakthrough of the knowledge of the outer world, or the resources for man.

In reading the scientific literature today, one finds a new breakthrough which might be far more significant to us and to the world. This lies in the field of basic biology. It is being called by the term "molecular biology." Through the use of electron telescopes and evermore refined techniques, the genetic mechanism that gives us human qualities has been detected and has been chemically analyzed. The variations in the nucleic acids changed from their sister compounds determine what kind of a man you are, what kind of an animal the mouse or the monkey is or an insect, a butterfly, a plant, etc. And by means of energetic processes, such as radiation, man is beginning now to refashion new living organisms not found in nature. In fruit flies there are some strains so valuable that they are kept in highly guarded vaults. There are fruit flies with twice as many wings, with no wings, with queer-colored eyes, with various arrangements of legs, all bred by man's experimentation.

This is merely being dramatized for you, but the underlying knowledge which is flowing out of it is what is of interest--the knowledge of the behavior of molecules in life; not in materials to make weapons out of or fuels to propel them, but in life. And one very perceptive scientist put in better words than I could, that in his opinion the decades that lie not far ahead represent a far greater breakthrough in science, more

meaningful to men, perhaps to national power, surely to national power, than the atomic developments so recently completed in their present early forms.

All of this involves the life sciences, which you saw pointed out on the chart for research. Thus electronic techniques are used for the analysis of the human brain. Likewise, there has been an operation performed recently in which a magnetic coupler has been inserted in a man's head inside his skull, hooked up to his eighth audile nerve, and by means of an exterior mechanism transmitting to the coupler through his skull, he hears--although he was stone deaf.

So we do not know what medicine will do with some of the new knowledge, even to the working of the brain. We still know that no expert has found out how the memory works in a human. We know the number of neurons and we know their similarity to our so-called computers, and our computers are toys. In one man's head there are over 2 billion neurons, each capable of original impulses, all interconnected by circuits that have limiting thresholds of value in a vast network like electronic displays.

Likewise, we do not know precisely what lies in the horizons--space physics, plasma physics, and magnetohydrodynamics. All are new. All are new since the war. Much is being learned, much that can be applied.

Cosmology was touched on briefly. This is the knowledge of the outer space and the cosmos--how it came, how it operates, where it goes. Mass meteorology may lead to the control of weather by powerful forces intelligently applied. Oceanography--the mechanism of the sea, living and inert. The capabilities of the sea, the minerals of the sea, the riches of the sea. Here we trail Russia by a wide margin. But there is a very pronounced effort to catch up. Molecular chemistry is a new chemistry. It is almost like taking a drawing board, arranging the molecules by means of mechanical drawing, and producing something that did not exist, with properties not known or anticipated. Solid-state physics, which the Government is earnestly supporting with funds for the first time in universities. Direct energy conversion, which was touched on, now by four totally different scientific systems. Much that is coming out of these sciences will also revolutionize agriculture.

Let us close with what was a rather startling development. You all remember the MASER, which made your modern radar possible and your advanced electronic systems. This raised their power so they were not limited by those early limitations of the 100 miles of vision, and so forth. A Columbia professor designed the MASER. It is based on a resonance cavity, with an electromagnetic wave bouncing back and

forth so that every time it bounces it becomes more energetic because of an electrical impulse which is fed into it. When the wave finally escapes, it has a vast power. This was revolutionary. Two years ago another professor discovered the LASER. Now, the LASER does with electrons or light what the MASER did with lower frequencies of the electromagnetic spectrum.

It has been calculated that with the MASER one single watt of energy--call it a seven-hundredth of a horsepower--will broadcast an intelligence signal 50 million miles in space. Incredible! With the LASER it is calculated by experimental evidence to date that an electron beam can be projected from the earth and it can bore holes in the surface of the moon.

Now, one of your faculty, who was in technical intelligence reports something which was given a certain amount of publicity--that in flying over a certain area in Europe two different pilots reported that their engines went temporarily dead. There was plenty of leakage of information from Russia that it was working on a ray which would operate in such a fashion. It was even described as a cosmic ray, which I think was quite inaccurate, although Russia has been the leader in the world science fields in cosmic rays, which are way, way up at the end of the spectrum beyond the gamma rays. You see a simple reference here to cosmic. Whence these originate or come from no one knows. They come from outer space and they are falling through this room as we sit here and going through us, and in many cases going deep into the earth, down into the deepest mines that we have recorded. The LASER projects streams of electrons of such high intensity and power that they will go through an army tank like cheese.

What this will mean in a new weapon system at this stage is not known. It is a laboratory development at this moment and requires a synthetic ruby, shaped like a pencil, maybe two inches long, fashioned with a very accurate surface on each end, some mirrors which will transmit a percentage of the electrons bouncing back and forth, and then feeding energy, by electrical means, into the electrons so that when they escape, they escape with these tremendous energy contents.

If you have any doubt as to my views, this talk has failed. Nothing is seen that will invalidate my assumption that the history of both the rise and fall of nations, our present posture in world affairs, our strength vis-a-vis our potential enemy, our future maintenance of that strength, the very tools that we give you to work with as military leaders--all depend upon our intelligence, comprehension, and the use and development of science and technology.

CAPTAIN HYDE: Gentlemen, Mr. Ward is ready for your questions.

QUESTION: Sir, I would like to have some comments from you regarding our current engineering education program in the United States, with particular reference to knowledge of the humanities and social sciences and whether or not we should go into a 5-year program, which seems to be a very popular basis for comparison in professional schools.

MR. WARD: Being chairman of the Cornell University Engineering College Council, which deals with this question, will point out in advance that my views are obviously a little slanted.

Now, only Cornell has 5-year engineering education. The author of this program conceived it in the late thirties and he did it in response to two facts which in my opinion are becoming very prophetic today. One is that engineers no longer are technicians to be hidden behind the scenes. They are heading businesses. They are in public affairs. A couple of them even wandered into Congress. The theory was that they were ill-prepared for these roles unless they went through a heavy self-education process after coming out of technical school. So the initial idea was to broaden the engineer's viewpoint so that, in his words, or as near as possible to quote him, the engineer knew the consequences of what he was doing. This lecture had to do with the consequences.

In other words, when the engineer invented the automobile, did he know he was destroying city life? Did he know he was peopling the countryside with everything from shopping centers, bowling alleys, a former proliferation of farmland into homelands? Probably he did not. The Wright brothers never knew what they were going to do to civilization. Well, the author's theory then was that an engineer should be motivated, not merely as a technician in his craft, but as an understanding member of the broad community. In order for him to do so, he had to have some knowledge of history, some knowledge of how to speak well and write well, an understanding of economics, and then a free choice, whether it is an appreciation of music, a study in art, a course in philosophy, or in psychology. The dean even required at that time courses in psychology. But he found that the colleges of arts and sciences were not prepared to teach engineers, and this is one of the big problems. The engineer approaches these subjects differently than the liberal arts student.

The result was the engineers took courses such as Philosophy One, and what did they do? They came out utterly disgusted, because Philosophy One was taught by the Arts College faculty--men with no knowledge of natural philosophy, which to the Greeks, mind you, was one of the most important elements of philosophy. And, furthermore, it was set at a pace which was much slower than the engineer had to travel in his own educational procedure. So the engineers became discouraged. They quit in droves. These early experiments showed some of the educated problems in trying to do what your question is directed toward.

Now, for my own conclusions, having presided over this council for some years, on which there are very distinguished educators and men from industry, as well as scientists, and by intent many non-Cornell, so that we did not have an ingrained, you know, "We do it in that fashion"--out of all those deliberations come to me these conclusions:

First, you can no longer afford to teach skills, shopwork, which was always the old mainstay. You cannot even give them much mechanical drawing, which is their language. Second, you are required to give them basic science in far greater depth and width, as illustrated by many examples that have been given here. How would they understand a semiconductor, which is a very subtle principle for the old classic physics or atomic phenomena? So now you see the curriculum changing itself toward a greater content of the sciences, which you would assume, but throwing out the engineering skills as something they could learn better in their natural business environment. Third, narrownig down the engineering sciences and, fourth, including economics.

This is one of the things like the old lady who lived in a shoe. And so the 4-year colleges are sweating. In all their catalogs they tell you they do these things. But they cannot. They are trying to do the best they can in four years. These statements are made from personal knowledge. The engineering curriculum at Cornell requires a minimum of 165 university credit hours for a bachelor's degree and this is more by a wide margin than a master of arts gets in five years. This is work.

If the engineer, then, is to do all the things implied in Colonel Meyers' question, he has to do more than just have an elemental course in business writing and call that English. So he set up free

electives. But, gentlemen if your son is in an engineering school and he is presented with a choice of free electives, he goes to his faculty adviser in many cases or his fellow students and one of them says, "Gee, that course in gas turbines is a dilly. You'd better take that." So instead of taking appreciation of music or something else that he might have, he finds himself sitting down in an advanced course in turbines or something like that. This is just human nature.

There is no answer; except one thing. It is not likely that engineers will be educated in a 4-year course too long. Doctors are not. Lawyers are not. Even architects have a 5-year course today, everywhere in the United States. There is not a 4-year architectural school left. Why? Because they have to know sculpture and art in addition to structures, materials, and design. It is believed that engineering ultimately will be a professional course very much like you find in medicine, with a heavier accent on graduate work.

My second point in answer to your question: A much higher percentage of engineering students is staying for graduate work. This is a way they have of supplementing the 4-year course. So you are hitting this thing in an area of great change. One of the great questions the engineering educator is asking you "Will there any longer be mechanical engineers, civil engineers, chemical engineers, electrical engineers, agricultural engineers, engineering physicists, et cetera? Will there any more be these? Or will there merely be a system like the British have at Oxford and Cambridge, for instance, where you simply get an education in basic sciences and engineering, and you develop your specialty by subsequent work?"

Do not have an answer, sir. A committee that bats it around is presided over by me. It is known that there is a ferment working in the engineering schools; and the old theory that engineers were a kind of sublimated plumbers has gone down the drain.

QUESTION: It has become recently popular for a scientist to be employed in a political decision-making process. We apparently have come to recognize the advantage of science in that process. Have you any comment on that?

MR. WARD: It will never be my policy to generalize on human beings and say that no scientists should be employed in any political position. But what is about to be said is what your question implies--that the very logic of science sometimes leads to some very dangerous political approaches.

When the Defense Establishment was questioning itself on how to use some scientists, it did what all human people do. It went from "keep them at arm's length and don't let them know too much" to "give them insight to all the higher councils." Perhaps the latter is not too wise. It seems that they did a disservice to the scientists and to themselves, because they took the fellow out of an environment in which he was at home and with tools that he knew how to use, and they put him in one to develop military decisions where it requires intuitive judgment in making a decision in an environment where all the variables cannot be known in advance. This is not science. So that is wrong for a man who is so grooved in science that he thinks that way.

If a scientist has learned through the buffeting of life that life is more complicated than that, then he might be very useful in politics. But then he is no longer in his thinking and action a regular scientist.

When in a certain engineering school--which shall be nameless--a dean was selected who had been chairman of the department of physics, his fellow engineering educators said, "My God, they've gone down the drain for good. They're just going to turn out to be a kind of scientific school teacher, with long egghead engineers." But the dean said--and said it to me, so it is known that he meant it--"I debated with my soul and myself for a year before I agreed to take this assignment, because I recognized that educating engineers is more difficult than educating scientists."

Now, what was said? It was that if you want to do what your question implies--get scientists who can give useful, intuitive judgment--you will have an educator and not a scientist.

QUESTION: We have all heard military people talk about trying to maintain a level of about 9- or 10-percent basic research. But how do you measure basic research? Is it ideas other than scientific, Nobel Prize winners, or what?

MR. WARD: If you mean how do you measure a proposal in basic science, the same criterion as the one used by me can be given. If the proposal indicates no reference at all to any committee or administrator, that would probably be basic science. If a proposal comes to you that my desire is to work on megacycles to 10 to the third power or electromagnetic waves because it is believed that there can be concocted a signaling system superior to any now in use, that

is not basic science. I don't give a darn whether there's a background for that existing at the moment or not. You have to do basic science to arrive there, but the scientist is motivated already and the one thing about true basic science is that it is not motivated. It can take twists and turns in its investigations without reference back to committees or administrators or any of these shibboleths that scientists really dislikes. As you know, a scientists always feels that he has been degraded when he is removed from working and made an administrative scientists. He does not consider that to be an advance, even though his wife may, because it gives him more money. He may do it, but in his own heart he feels he has been degraded. And so in my book a proposal for basic science, if it were brought to me, is one for a fellow to work on something where he has not the slightest idea how he is going to do it.

QUESTION: I was thinking more from the angle of, How do you justify it? In other words, you must have good arguments to justify maintaining the level, or in fact raising it. Many people would like to do so. To do this, you have to battle with a hard-headed board of directors in industry or the military, or with some real hard-headed development people in the Pentagon. By what can you measure your basic research output in fact to justify maintaining it or in fact increasing it?

MR. WARD: Your time and mine could be saved by saying you cannot. Now, you can pretend to do it, and you have to do it to protect yourself. You manufacture a lot of background language. But you just cannot do it.

The best program that was ever established in the United States, particularly in view of its time, was the naval research program after World War II, where the Navy went to a university and handed it a sum of money and said, "Put some scientists to work. You don't have to tell us what you're going to do. You don't have to bring in a report. You don't have to show us what you do." This was in the early part of it, before Congress got it. That was the best research and that was the best stimulus to American education that has ever been applied, and it did not cost so darn much money either. It was very modest.

When the educators finally were faced with your question--How do you justify it?--they wrung their hands and said, "Oh, this is impossible." And in many respects it is. Now the work that they are doing falls much closer to applied science than basic. You can label

is that, just like my instance of a man working on a new signal system about an electromagnetic specter for which there is no knowledge. Sure, he is going to do some basic work and you can call it that. But it is not. It is unoriented research.

Let me give you an example. My feeling was so strong on this issue after World War II that a trip was made up to Congress presenting a plea for maintaining experimental research when the "Bring the boys back home by Christmas" was the fashionable thing. All these big fine teams were being demoblized. In my own heart it seemed evident that we were going to fight Russia some day. My belief was very strong. Aside from having a lot of trouble, some things were accomplished by me.

An attempt is being made to show that my keenly felt concern caused me to see a university president and say to him, "Why is it we have nowhere in America men who do things like Professor Shoerder or Heisenberg, in Germany?" Heisenberg's principle, gentlemen, for those of you who do not know, is that you can never see an electron. You cannot make that pay off in the marketplace. The reason is that any way you look at an electron you are looking at it with other electrons and the very act of looking at it knocks it out of place, so it is never where you would think it was. In fact, you are never going to see it anyway because of this uncertainty principle.

This is called the uncertainty principle, and it is one of the great principles of science, without which we would not have attained our present goals in nuclear science. This was Heisenberg, and he was the guy the Russians tried to bribe to go to Russia. We tried to bribe him to come to the United States. Oh, no. He would not go to either. Why? Because only there where he was working could he work without being oriented. And if he had done that in an American university, he would not have been promoted. But if he had come up with a new insecticide--sure, he would have been right there. This is your question.

So upon contacting this president of the university and saying, "Look. Everybody talks about a force and no one in history has ever explained what a force is." How do those keys fall to the floor? What is the mechanism? What reaches up out of the floor and grabs the keys and pulls them down? You can use terms. You can say Mr. Newton got hit in the head with an apple and he figured it out. But he did not. He simply put the mathematics on it. And the

mathematics did not explain it. Now, if you can explain force, you would put the country that could do so in science ahead I do not know how far. Would not even hazard an estimate.

So, my statement to the president of this experimental university was: "I would like to see this university get somewhere in the world. Get one or two scientists of the Heisenberg variety who will come to work here. You set them up in a laboratory but never have them write a report. Do not have them teach a class. They will just have to start finding out if it is possible for a human being to understand this principal secret of the universe--What is a force? How does the earth pull the moon with it through a vacuum? A very simple thing."

Well, he was entranced, although he was a social scientist and he did not know what my talk was about; but he thought it made pretty good sense. So he brought in the professor of physics who said, "Well, now, you know, that's a pretty good idea, but I have been working on surface forces and I have found that there are some molecules that can give birth to molecules and none of them are lost, and this takes force. I'm going to find out what those forces are." You see, he had already developed an interest, thank heaven. He backed me up.

The suggestion fell down because we could find no one in the United States who would put up $15,000 to get the equipment and space. We located one man in Australia and one in the University of London who would have come over here if we would have guaranteed them tenure and a place to work and no interference.

This is basic science, and this is the thing which in the long run will spell the breakthrough. And that is how it has to be done. You cannot do it, because Senator X will be down your throat. At least it seems unlikely that you can do it.

QUESTION: I have a double-barreled question. In view of the increasing need for better-trained engineers, the first half of my question is, What are we going to do about getting more engineer graduates? And is there any importance in the registration for these new-type scientists-engineers in contrast with the old engineering school registers for public safety?

MR. WARD: Your reference to public safety is not understood.

STUDENT: I asked, first, how do you get more engineers? And, second, in this need for this new type of more flexible engineers is

there still a need for public license in the registration of these people, as you have in all 48 States now?

MR. WARD: First, about how we get them. It is standard with any problem that if you are going to solve it, as the Orientals say, you first have to state the problem. Then you have to understand it. It does not seem that by and large the public understands it. Even if they heard it said and believed the statement, they would still probably feel that it is not important. They are still getting new cars out of General Motors, new iceboxes out of Frigidaire, and so forth. This is the way the untutored feel on the subject. The matter is for, unfortunately, the informed minority.

It largely centers around the youth at the high school middle age, in the sophomore and junior levels. The thing that the educators are complaining bitterly about in the United States, and with good reason, is that too much raw youth is coming to them unmotivated. They do not know what they want to study. They do not have a great drive to study. They go to the university because "Pa" and "Ma" want them to. It is a nice four years, meet nice girls, marry better, get social prestige. All these things enter into it. But they are not motivated. They have no burning desire to be the best architect in the world and create the best buildings. They are not motivated.

How do you motivate them, whether they are engineers, doctors, architects, lawyers, or whatever they may be? The answer is, you have to depend on the parents. But, the parents--let's face it--are so darn busy. And it is so difficult to cross that barrier of age from parents to youth, which is worse than the Brandenburg Gate today, trying to get through at times. Nevertheless, there are ways of doing it if they are worked intelligently, one of which is not to talk down to the children, not to talk at them, to talk at the dinner table about other people's children--and other people's children's problems are never yours--and how it works and how it does not work. So something has to be done by parents. You cannot leave it to the public school system.

The public and private school system can also do something. Not so many years ago "Life Magazine" published an article and gave the statistics for the engineer graduates for either the Wayne University or the Detroit University. It showed that only 30-odd percent had a job on graduation. And from this the article concluded that there was a surplus of engineers in the United States.

Before that article was on the presses in final form, a dean of my acquaintance, who had submitted the predraft, wrote to the editors or called them up on the phone and said, "You're completely wrong." "Well," they said, "we got the figures from the Bureau of Labor Statistics." They did; but the Bureau of Labor Statistics had built in the most colossal error.

The figures were true for the university in question, but it was not a top engineering university. It was not even indicative. Furthermore, in no previous year had the graduates of that university all gone out into plush jobs. Even in the best universities the percentage never exceeded about 60-odd, because a lot of them do not want to commit themselves till Papa has sent them to Europe or on a trip or they have taken a last fling or they want to sit back and shuffle things around at their own personal convenience. Therefore the figures as presented by "Life" were just what I have been warning you about in my figures. Do not take them literally. Look behind them. And so the comparison was wrong, the school was badly selected, and the facts were not as presented.

Do you know what happened? The next year, engineering registration in the United States went all to h---. That is what one national magazine can do. And you know in the military what it does to you. And do not think that the civil institutions are free from this thing either. It took several years. The Bureau of Labor Statistics revised its method of gathering statistics and admitted its errors, but nothing could be done. Nor would "Life" stop the presses when the dean told them it was wrong.

Now, the answer to the first part of your question is--you must get the secondary school advisers to appreciate the nature of the problem if there is a shortage; and many of them are humanitarians by education. They are bachelors of arts from some of our very good schools and so on. They are teachers. They went to school at teacher's college and got a bachelor of science in education. They are not engineers. Many of them do not know what an engine actually does except as anyone would by living in an engineering world. So these men are advising the children.

Well, the first thing is that there has to be a recognition of the national need. It has to extend to the advisers in the school system. The parents have to motivate their children--not toward engineering, but toward the selection of something they are willing to do in life.

Remember, children do not know what these engineers, architects, or lawyers do. They have a very dim view. This is not holding myself up, gentlemen, but have had two problem children in this area. The problem was solved by taking them through navy yards, mines, manufacturing plants, courtrooms, universities--all around the country--showed them the difference. So they selected their own university and their own career. But it was a bloody piece of business. They could not be told. There is no ready answer to your question.

As to the second part, the need for certification for professional engineers and so-called engineer-scientists: What do we mean by these terms? This is a semantics problem to me.

There are known engineering schools today turning out men who can go to work tomorrow on the drawing board and produce a very good engineering result, because they were narrowly specially educated as technicians; and a very good job it is. There are other institutions where you would not dare put a graduate on the drawing board until he has been with your organization for a while. But a good wager is that the second man will be bossing the first man in not too long. Statistics have been collected on this in one very big American enterprise over which it was my privilege to preside; it proved this figure. So there are all kinds of engineering schools.

As to professional engineering, for the protection of the public, you have to keep pseudo-engineers from practicing. That is the reason for the certification. It seems unlikely that any engineer resents the certificate, particularly if he is going out into independent practice. This is as necessary as the certificate which a doctor or a dentist hangs up in his office or a lawyer has by being a member of the bar. It is simply a protection to John Q. Public. It is considered to be all right.

CAPTAIN HYDE: Mr. Ward, I am sorry our time has come to the end. It has been a wonderful presentation. We could not ask for better. I certainly thank you very much.

(4 Jan 1962--5,600)S/bn:en:mr