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SCIENCE AND TECHNOLOGY AS ELEMENTS OF NATIONAL POWER

13 October 1958

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NOTICE

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. John Carlton Ward, Jr., President, Vitro Corporation, was born in Brooklyn, N. Y., 1 January 1893. He attended Cornell University, receiving the M. E. degree in 1914. He was appointed to the position of development engineer, International Paper Company, 1914; became assistant to the works manager, Niles Tool Works Division, Niles-Bement-Pond Company in 1915. In 1918 he was appointed production engineer, United States Ordnance Department, Watervliet Arsenal. In 1919 Mr. Ward became works manager, Pratt and Whitney Division, Niles-Bement-Pond Company. In 1926 he was appointed vice president and general manager of the Hartford Machine Screw Company. During the period 1929-34, he was general works manager of the General Cable Corporation; was named vice president of the Rome Company, Inc., in 1934; served as vice president, general manager, and director of the Pratt and Whitney Aircraft Division, United Aircraft Corporation from 1935 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 Ltd., 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.

SCIENCE AND TECHNOLOGY AS ELEMENTS OF NATIONAL POWER

13 October 1958

GENERAL MUNDY: General Harrold, Gentlemen of the National War College and the Industrial College: Our subject this morning is "Science and Technology as Elements of National Power."

As citizens we cannot help but be daily impressed with the impact of science and technology on our daily lives. As members of the Armed Forces we are even more impressed with their impact on our weapon systems. Science and technology bear much the same relationship to each other as do the chicken and the egg; but, whichever comes first, both are essential in the development of an industrial society. In fact, the scientific stature of a nation today is almost a direct measurement of that nation's influence in international affairs.

It is the purpose of the lecture this morning to explore these areas and to assess the scientific and technological status of our Nation.

Now, our speaker today is no stranger to these two colleges. To the contrary, he has proved himself a very good friend of these two colleges and also of the services as well. He is in demand each year as a speaker at the service war colleges in addition to these two colleges. Also he's been a member of the Board of Advisers of the Industrial College since 1945, and this year he is our Chairman of the Board.

From his biography I'm sure that you are aware of his background and his knowledge that he is bringing to us today.

It's an honor and a privilege to introduce to this audience Mr. J. Carlton Ward, Jr., the president of Vitro Corporation of America.

MR. WARD: General Mundy, General Harrold, Gentlemen:

The general has defined my purpose very well. Of course I get a very well-defined scope as a bit of instruction before coming before you; and if this isn't enough to frighten a man out of his wits, I don't know what would. Also, I've been reviewing the work you are supposed to have had up to now in each college. It seems to me it converges very naturally at this point on the problem we have to explore today.

Thus we're trying to appraise for ourselves today the consideratio of one of our most fundamental problems. In our present day conflict with communism, the scientific competition has certainly been emphasized and is apparent to everyone. In a group yesterday I was grilled by five women on the significance of the launching of the new "Pioneer' and I was amazed at their depth of interest and at their questions. Tha may probably be typical of the general interest by the public in such questions at this time.

In assessing our problems in a more factual way for us here, I wo like to present a series of exhibits, and from them have you form som conclusions of your own. I hope at the conclusion of this address that will have some specific quantitative background from which to form yo own conclusions and to compare our situation in this country with our allies and with our enemies.

Perhaps we ought to start by defining what we mean by science. I think it was Lord Kelvin who said, "If you can't measure it, it isn't scientific." This is much more fundamental than it seems, because w have, for educational reasons and administrative purposes in the colleges, added the so-called social sciences and many other so-called sciences. These however, are not real sciences. They're quasi-sciences. And the reason they're not real sciences is because of the substance of that profound remark of Lord Kelvin's. Such quasi-scien deal with matter which cannot be precisely measured.

I hope you will think of this when you are dealing with scientists, because it is this peculiar quality of precise measurement that sets th apart from others.

The way in which science operates is peculiar only to science. It first draws upon all of the record of experience available to man to for late a principle. Having formulated a principle, it sets out to prove it experimentation. It's in the role of experimentation that science is unique, because the experiments can either prove or disprove such pr jected theories. At this stage they are really hypotheses, as you know, until the body of experimental proof allows them then to be accepted as laws--laws that define the behavior of the materials and the forces of universe.

So, for our purposes we now have our definition of science. Scier is the knowledge of the behavior of the materials and the forces of the universe as deduced by man's reasoning and proved by his experiment tion.

Here is where the poor so-called social scientists have a rough time.

For years they deduced and accepted the law of supply and demand. It's like the case of the politician. Caught in an argument, challenged with his view, he said: "I don't have to prove that. I admit it."

The law of supply and demand was admitted by most economists until during a recent administration of our governmental affairs, when for some political reasons it was considered no longer to be true. We promulgated many regulations and laws which ran contrary to the so-called law of supply and demand. It became unfashionable. Now it has sort of been sneaking in the back door again. It's again been taken up by many social scientists rather gingerly. Accordingly, you will hear it mentioned now in polite society. For instance, in the field of science this could not occur, say, to the law of gravitation. There has been a term recently introduced into our scientific literature called "antigravity." I'm sure you have all observed it. There are scientists working in the field of antigravity. But it hasn't disposed of gravity at all; and Newton's law of gravitation, as amended under the Einstein relativity theory, is still a very respected and respectable law.

Such an example serves to separate then our thinking and approach to the sciences and the quasi-sciences and, of course, the nonsciences or humanities. It's very tempting to get far afield on this subject. Philosophically it has great depth and great meaning for you, because in your work you often refer to military science. Like the social sciences it is not a science. You don't experiment and prove laws in the military sense. It's an art. Its field is that of an art based upon a great deal of scientific and nonscientific material. Similarly a social scientist can tell you that he uses many of the techniques of science. And he does.

The main tool of the social sciences is obviously statistics, and you're going to see many statistics here today. So I might as well prepare the ground. They say a statistician is a man who draws a straight line from an unwarranted assumption to a foregone conclusion. A very distinguished social scientist wrote a book, a serious book. It's title is "How to Lie With Statistics."

You are thus being conditioned to see these statistics, because I want you to tear them all apart. You should recognize that in them there are flaws, and assumptions. Nevertheless, in many instances they're the best facts we have.

In this field of statistics, for instance, you can take labor versus management in a so-called labor argument. Labor will prove that it has not been rewarded in proportion to the improvement in the econom or the standard of living. The manufacturers, on the other side, will prove that labor has exacted exorbitant demands by its pressures in bargaining. And they will both use both sets of statistics. And both sets of statistics will be arithmetically accurate; yet they lead to opposite conclusions.

Well, what is wrong? For example a typical little statistical devi is this: one can make an assumption, let us say, that the year so-and- is "one," or unity. Then subsequently we are at say "one plus 15." Well, that's an often used device where there is no such thing as a tru base. But the difficulty with it is that if a manufacturer picks a year i a depression period, such as the one in the 1930's, and calls the labor rate unity for say, 1933, and the manufacturer is bargaining with a uni he can show that labor has profited enormously percentagewise far beyond the growth of our economy, far beyond its proportionate share. the other hand, the labor leader will take the peak year of war wages a call that year "one" or unity and thereby prove that labor hasn't done well at all for the same comparison. Both of those sets of statistics a correct, however, in the arithmetical sense. They lead, however, to ferent conclusions. Many other statistical booby traps could be cited.

So much for statistics. What about technology?

Technology, while often so described, is not a science. Technolo is an art, just like the art of war is an art. It's the application of sci but it's the use of science in a field that is in itself nonscientific. By that I mean this: Let us assume an engineer is asked to build a bridge He will use mathematics, stress and strain relationships, physical la of materials, forces of nature, gravity, live loads, dead loads, and s forth; and out of a very complex series of formulae which have been deduced from decades of experimentation he will produce the design of the bridge, and you will say, "This is scientific." Well, here's why i is not so. In the first place, he has to assume that someone is going t use the bridge. Then he has to estimate how many people will use it a the same time, what kind of loads they will have. Then he says: "I'm building this bridge for quite a period of time. The people that are going to use this aren't here now. They will have loads that I don't kn anything about. Since the bridge may be here for 30, 40, or 50 years,

I must assume the growth of population in this area and the degree and characteristics of the traffic. I must assume the number and kind of vehicles. Will it be a 2-lane bridge, a 4-lane bridge, a double-deck bridge, or a single-level bridge?" And he must look into his crystal ball and come up with an answer. This is not science but rather "social" science.

So for the final result, like any algebraic formula, the result is no more accurate than the error of any one of the factors entering into it. If you have a single indeterminate function in a complex algebraic formula even though it is a correct logical formula, nevertheless your answer must be similarly indeterminate. And so it is with the bridge.

Now that we've defined, then, the difference between what we mean by science and technology and established the so-called military science of war as an art, let us look at some charts and statistical exhibits in a sophisticated way.

Chart 1, page 6.--The tool of science is research. If you want to see a very dynamic and dramatic statistical exhibit, here it is. As recently as 1941, which was the beginning of World War II, the total amount of research in the United States, according to the black or "total" curve on the chart, was about $300 million a year. You will see that today this same curve is heading past $11.5 billion per year, almost a 40-fold expansion in 2 decades.

How many of you really realize how recent this tool of research is insofar as your field of interest presently lies, meaning that of our national economic power for military defense? This is a relatively new phenomenon.

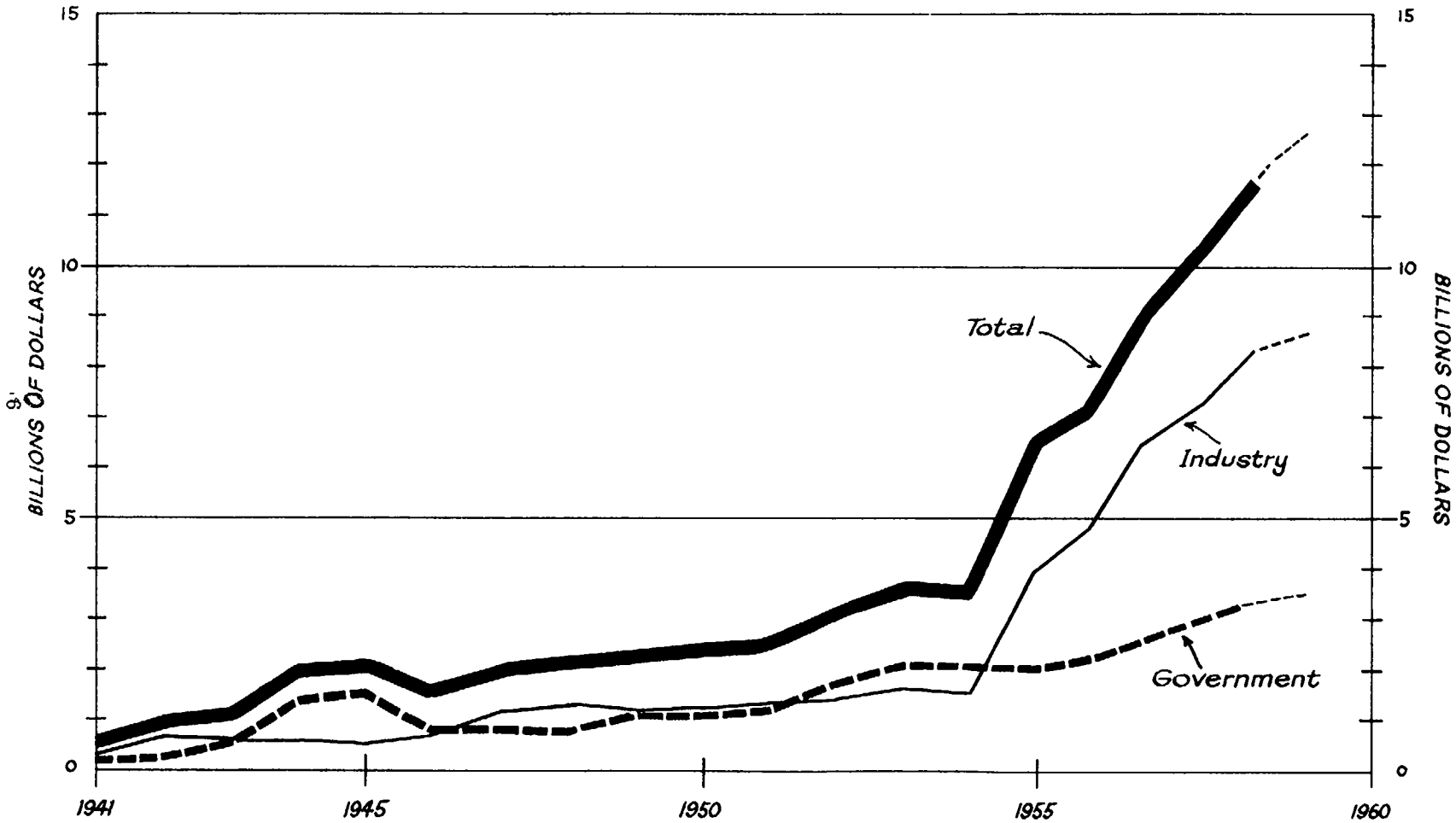
Now, if you go back before World War I, you will be amazed to know that the first research laboratory in the United States was formed in the year 1900, by the General Electric Company in Schenectady, New York, and had not over seven scientists in it for several years.

Prior to that there was what might be described as the age of invention. Invention is largely the product of the ingenuity and persistence of one man pursuing an idea. He may have laboratory assistance, but it is essentially the work of a man like Thomas Edison.

CHART 1

GROWTH OF RESEARCH IN THE UNITED STATES

Based on Research and Development Board and McGraw-Hill estimates



SOURCE: Industrial College of the Armed Forces

Vitro CHART

On the other hand research is the work of a team; and as science has proliferated, the team concept becomes more and more vital. And this concerns you, because the modern weapon systems are the end products of a great many different sciences and technologies. And it is the putting together of the team and creating the environment for the team that give you the successful weapon system or the unsuccessful weapon system.

So this concept that you are looking at is not only historically new, but it really began to flower after Korea, because of the impetus of the so-called cold war and the threat it poses for our security.

This is the basic tool you're working with in fashioning your new art of war and its various modern weapon systems. And, obviously, many of you can remember when there were serious discussions in the Defense Establishment as to how you could integrate a scientist into the defense organization. This frequently occurred after World War II, and in fact I was present at some of these typical discussions. They were philosophically very complex problems, because there existed the thought that scientists were unlike other people. This is in some respects quite true for they certainly aren't readily amenable to the normal discipline required in a military establishment. How do you join such forces? It's in the skill of adding these disparate forces of scientific work and military command together that the final desired result can be obtained. And there is much waste in the process.

In this next chart let's note that in 1945 that hump that you see is the reflection of World War II in promoting additional research and development. And it was a numerically enormous development. It climbed over $1 billion a year from a base line, as was said, just before the war, of $300 million. That's a growth factor of three and a third. It doesn't look like much on this curve, because of the enormous growth since.

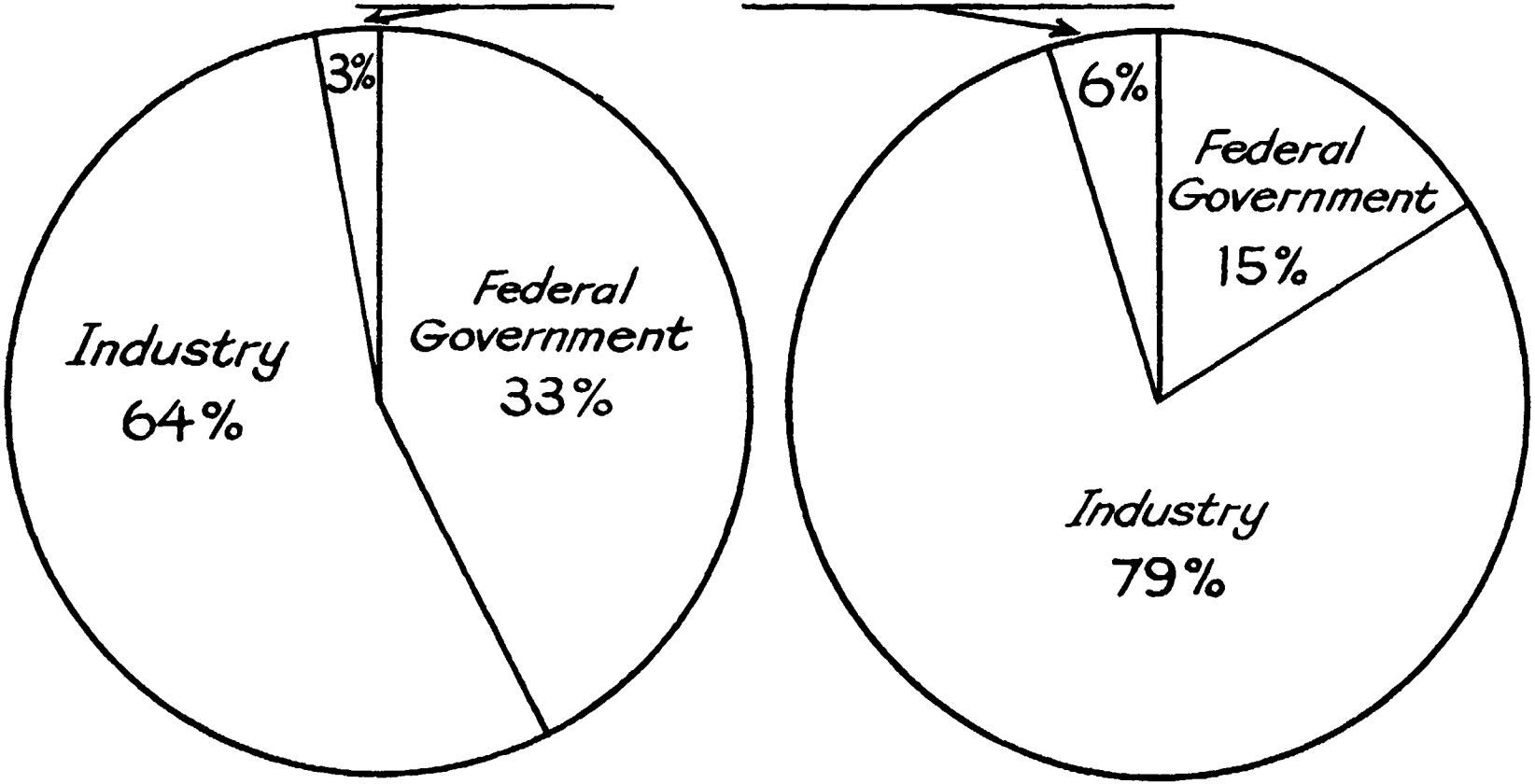
Chart 2, page 8.--Here, please note the difference between industrial research and governmental research. You will note that industry has passed Government in effort expended. And here you will see that the Federal Government furnishes 33 percent of the money and industry 64 percent, but industry does 79 percent of the performance, with Government doing only 15 percent.

CHART 2

SPENDING FOR RESEARCH & DEVELOPMENT

FOR THE YEAR 1957

UNIVERSITIES AND RESEARCH INSTITUTES



WHERE THE THE MONEY COMES FROM

WHERE IT IS SPENT

SOURCE: Industrial College of the Armed Forces

Vitro CHART

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That tiny little sector at the top of the "pie" is the most significant. Research is divided into fundamental research, applied research, and lastly, of course, development. The borderline between these definitions and concepts is not clear. Therefore the statistics are not clear. It depends on how one chooses to grade the work being done as to which pocket it falls into. Of course a computing machine will accurately sort and tabulate the punch cards--after they have been punched.

So, that little 3 percent at the top, which is the work done by universities, is largely basic research. And Vannevar Bush said in his book after World War II, "We've used 50 years of basic research in 5 years of war."

That was a very significant statement, and is still true today that we have emphasized applied research and development at the expense of basic research. If we have in this country a deficiency, it is that we have not properly weighted the function of basic research in terms of total research effort. In the past and even today we have drawn essentially on the older cultures of Europe. And so you notice the number of imported scientists that we have in the United States, both in the educational institutions and in our laboratories. That 6 percent spent by the universities is probably more significant than the other 94. Certainly for the future!

Chart 3, page 10.--This chart shows the Federal obligations for research. It comes from the National Science Foundation and is a fairly recent report. You will notice the total research at the top for the years 1956, 1957, and 1958.

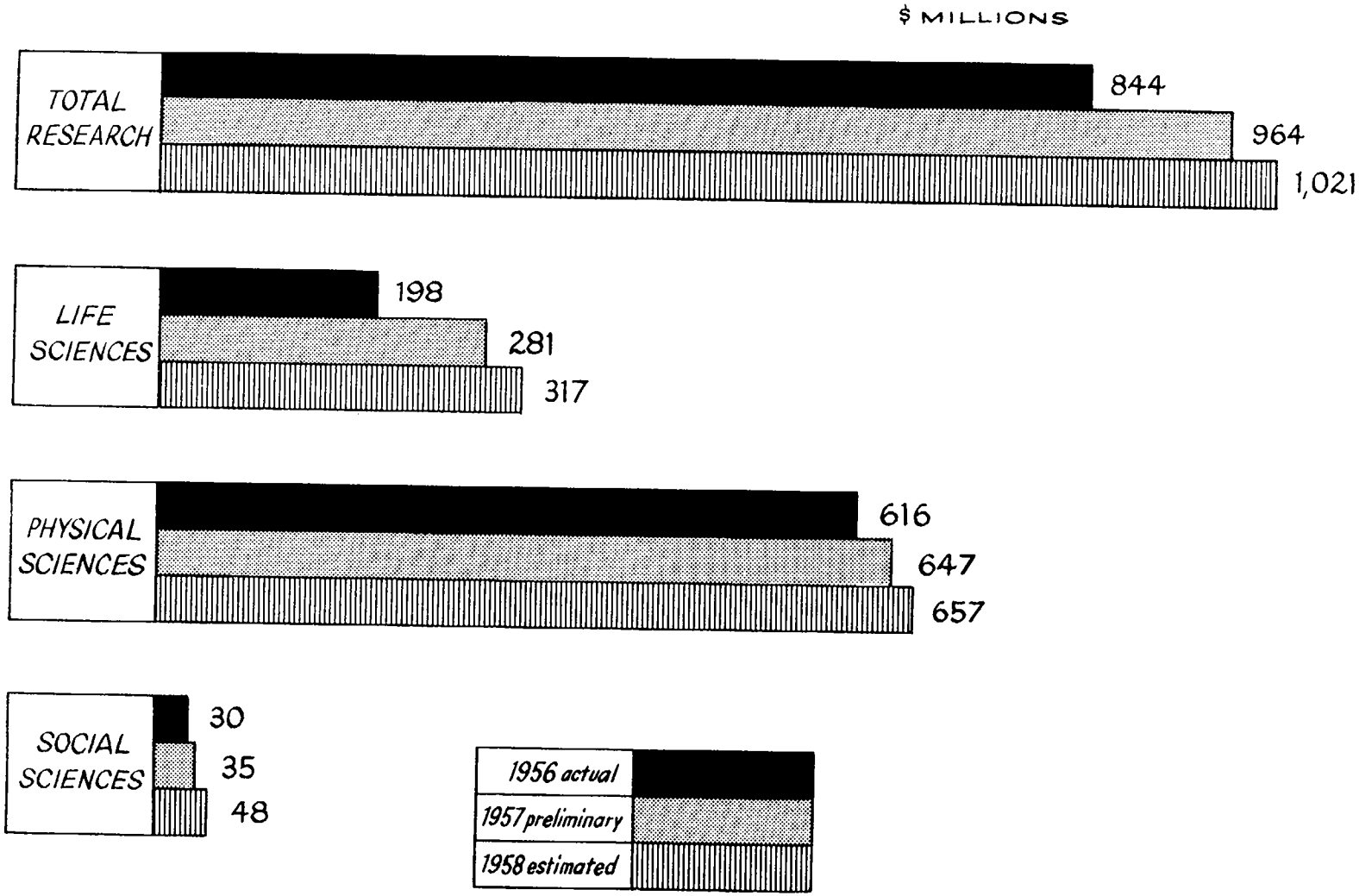
These bars represent 1956, 1957, and 1958, but for our purposes today just think of the last one. You will see that the total research was a little over a billion dollars. The so-called life sciences, which are medicine, agriculture, and biology, are 317 million, and the physical sciences 657. And lastly are the quasi-sciences, the social sciences, 48 million.

The social scientists, of course, work mostly with IBM machines and pencils and paper, whereas the men working in the physical sciences have great enormous instruments and laboratories. So that the money values can be quite different. This is why some categories are weighted over others.

CHART 3

FEDERAL OBLIGATIONS FOR RESEARCH

BY SCIENTIFIC FIELDS



SOURCE: National Science Foundation

Vitro CHART

Chart 4, page 12.--This chart shows the character of work in research and development. Again you have the total conduct of research and development, the black portion showing total development. Again, it must be noted that it's a very difficult thing to separate total research and basic research.

Notice here the growth of basic research. In some ways it is the most significant thing on the chart. It represents the growth of sophistication in the United States. The percentage growth, while it may look small to you on the chart, is very large percentagewise. It is in that factor that we can look to the future; to such things, for instance, as the successful launching of the "Pioneer," and space technology.

Of course there are errors in all these statistics. Take the aircraft industry as an example. Much development work is done on production orders, and just how you would sift some of that out of total figures is rather difficult to say. And having been an aircraft manufacturer, I'll tell you now, one doesn't do so. So that the conclusion is that these figures are to be taken with a certain grain of salt. But they do teach broad issues which are fundamental to the military establishment.

Chart 5, page 13.--In this chart are the Federal scientific obligations for research and development by agency. You will notice the total of all agencies of the Government at the top, of $3.4 billion with Defense $2.1 billion and the Atomic Energy Commission $672 million. The lower box of the chart is on a different scale; so don't get confused by the length of the bars.

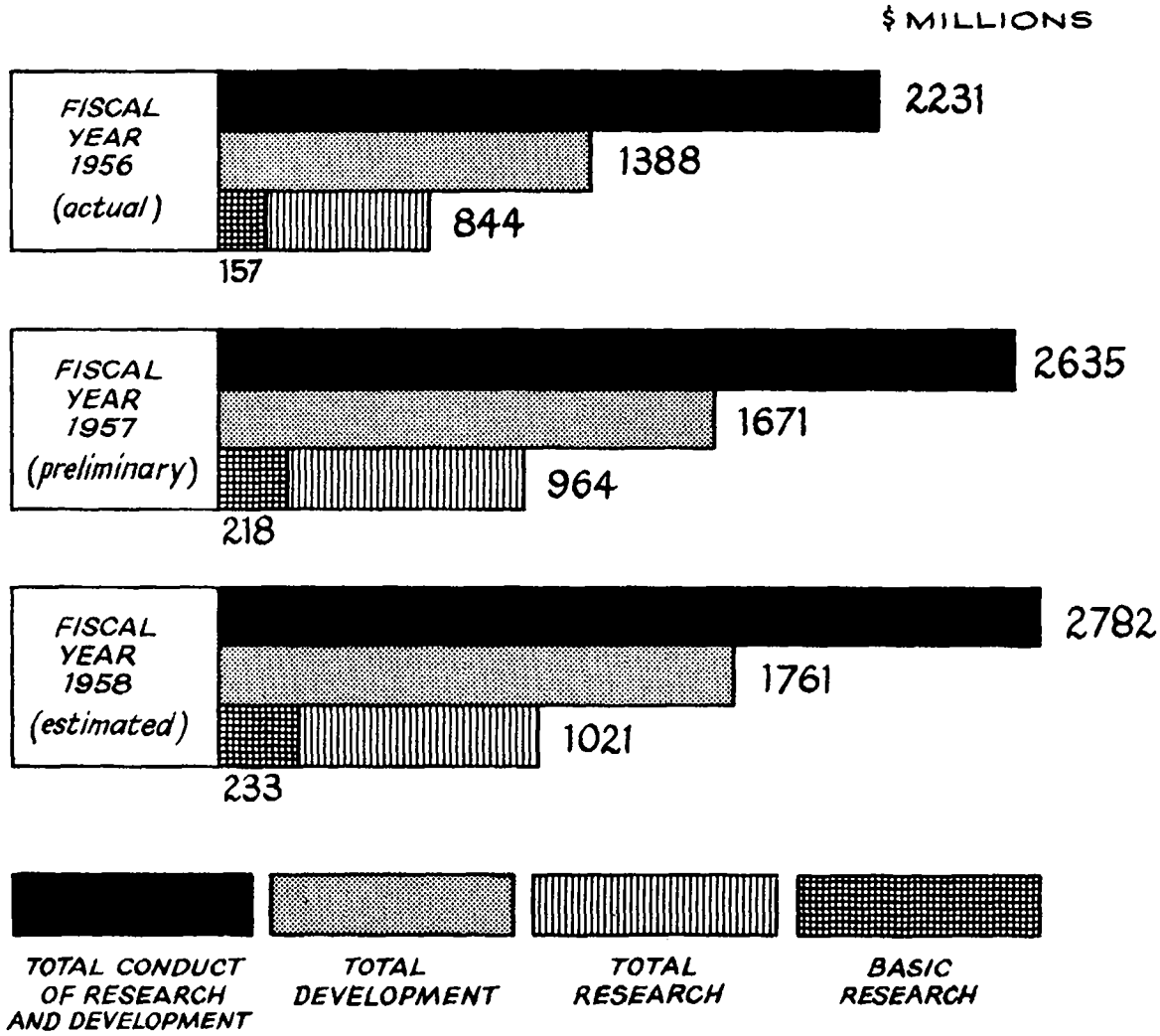
You will note that the next largest budget is for the Department of Health, Education, and Welfare, which represents the life sciences for $200 million. That is less than a third of the AEC's portion alone.

The Department of Agriculture, which you normally think of as a pretty expensive bureau, takes only $132 million. Then comes the National Advisory Committee for Aeronautics, which really belongs up in the Department of Defense category because it's concerned largely with weaponry. Then come the other departments and agencies which are apparent. That provides a breakdown of the main divisions of research in the Federal Government.

CHART 4

FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT

by CHARACTER OF WORK



SOURCE: National Science Foundation

Vitro CHART No. 4

CHART 5

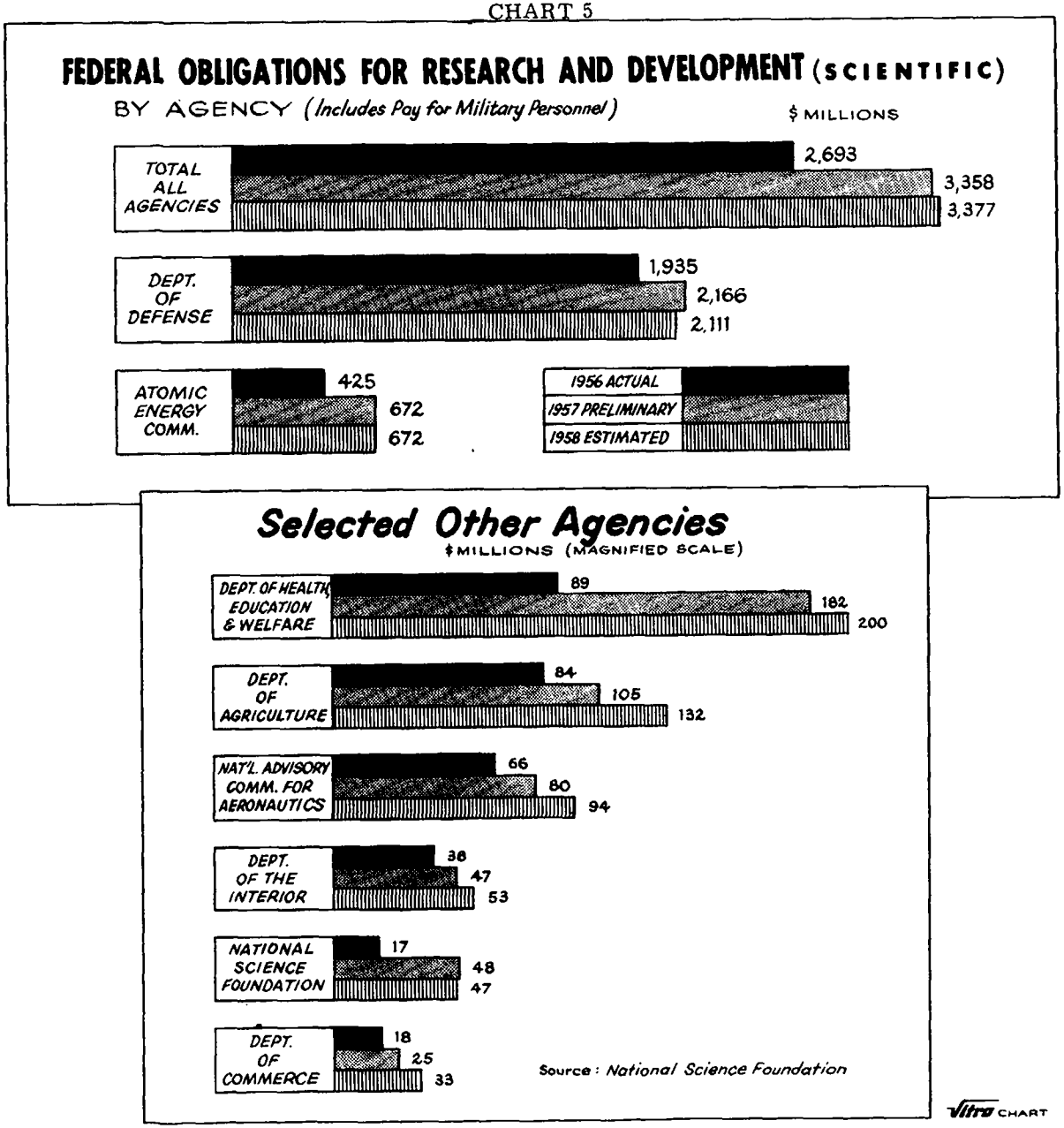

FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT (SCIENTIFIC)
BY AGENCY (Includes Pay for Military Personnel)
$ MILLIONS
TOTAL ALL AGENCIES
2,693
3,358
3,377
DEPT. OF DEFENSE
1,935
2,166
2,111
ATOMIC ENERGY COMM.
425
672
672
1956 ACTUAL
1957 PRELIMINARY
1958 ESTIMATED
Selected Other Agencies
$ MILLIONS (MAGNIFIED SCALE)
DEPT. OF HEALTH, EDUCATION & WELFARE
89
182
200
DEPT. OF AGRICULTURE
84
105
132
NAT'L. ADVISORY COMM. FOR AERONAUTICS
66
80
94
DEPT. OF THE INTERIOR
38
47
53
NATIONAL SCIENCE FOUNDATION
17
48
47
DEPT. OF COMMERCE
18
25
33
Source: National Science Foundation
Vitro CHART

Chart 6, page 15.--This chart shows the trend of scientific research and development in expenditures in the Federal budget only. In 1945, of course, you see that bump which we mentioned earlier in World War II. As is obvious, it represents over a billion dollars.

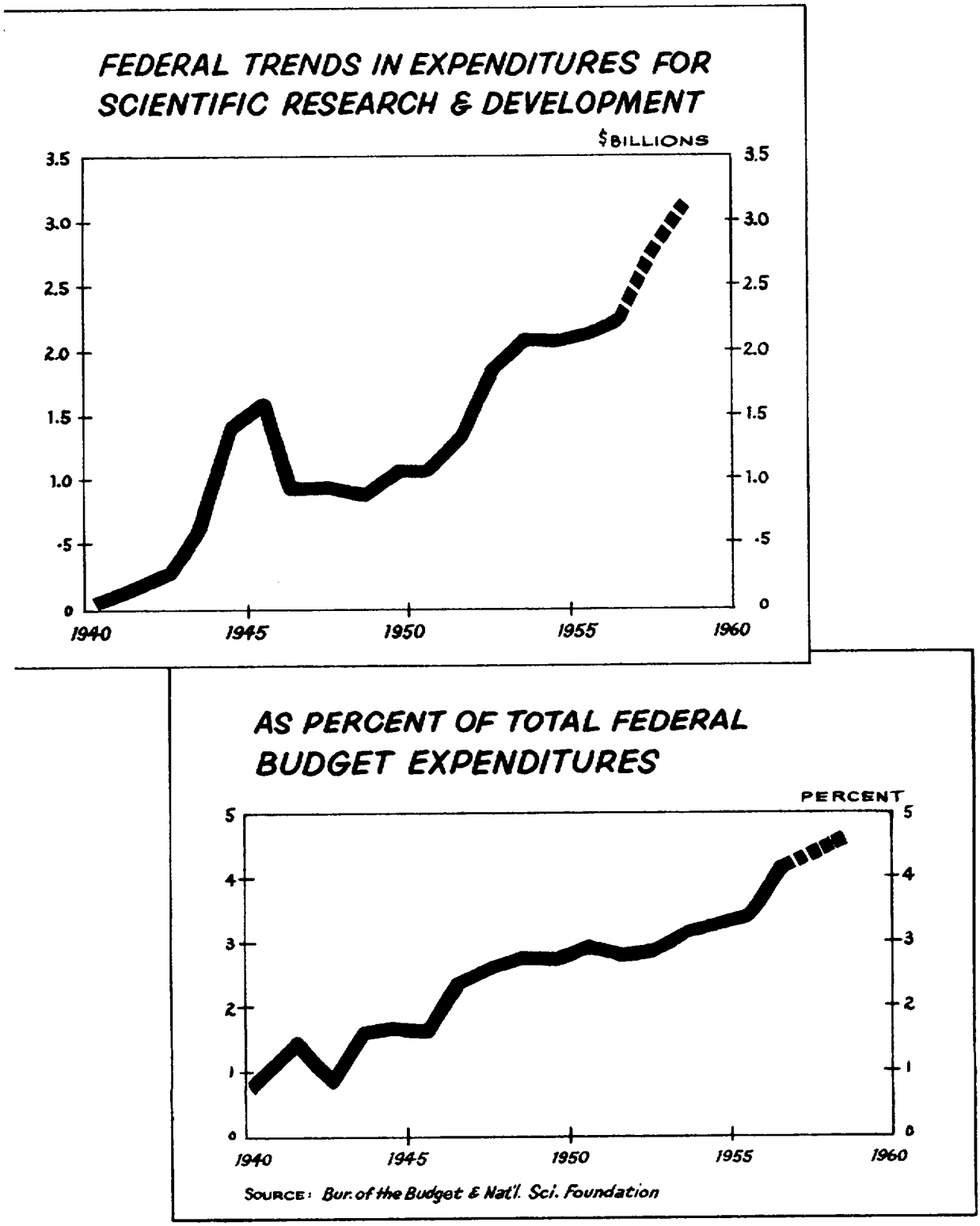
This is a National Science Foundation and Bureau of the Budget chart. An interesting thing is to look at the change in the percentage of the Federal budget as shown in the lower box. Back in 1940 1 percent of the Federal budget went for research. You will observe how that curve is steadily climbing, and today 4.5 percent of the total Federal budget is used for research and development. That is a very significant curve indeed!

Chart 7, page 16.--Now, let's turn to those who do this research work. This chart shows the scientific and engineering graduates of various nations, and is probably the most recent study that is available. As you see, the source is the Office for European Economic Cooperation and the figures were compiled last year.

The USSR shows 90,830 graduates, the United States, 53,480. And now look at the United Kingdom, 8,332--it was very difficult getting these other figures--but France shows 6,681, and Germany considered a very technically advanced nation, 6,005, and Italy only 5,483. However, these are very superior people.

In the next column are the total degrees of all kinds awarded: Soviet Russia had 245,000, and notice the United States, 287,000. You see that, whereas we give more degrees, we give a little better than half as many as the Russians, percentagewise, in science and engineering. Notice the United Kingdom has the same tendency to have a high percentage of total degrees and a low percentage of engineering. But notice 37 percent for the USSR, only 19 percent for the United States, 44 percent for the United Kingdom, 29 percent for France, 34 percent for Germany and 26 percent for Italy. You will notice that we're the only fellow out of step here. The United Kingdom is doing a real job in assessing its scientific needs within it resources. We, seemingly, are not. These other nations all run somewhat in the same percentage order for scientists and engineers.

CHART 6



Vitro CHART

CHART 7

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

Vitro CHART

Then turn to the scientific and engineering degrees per million population. Notice that Russia has 445 per million to our 313. So on the basis of any base line you desire to take, the Russians are becoming more scientific and engineering minded as a nation than we are. This is very, very serious. This chart has been assembled only within the last several weeks and it is rather a shocker.

Chart 8, page 18.--This chart shows the United States versus the Soviet institutions of higher learning. You can observe that all colleges, universities, and institutes in the United States totaled 1,368, as against 762 in the Soviet. We have 2.6 million students; they have 1.9 million. And also notice that the number of degrees coincides with the figures shown on the other chart.

In technological students you will find that we had only 493,000 to the Soviet's 650,000. And again you see this strange ratio of technical and engineering degrees to the total, which is all in Russia's favor.

Chart 9, page 19.--Let's look at another phase of this same problem. This chart shows how the Russians divide their institutions up into two groups, as you see. There are 204 full engineering and technical institutes, with an enrollment of 650,000 and here again is shown the 90,800 graduates. This chart is put in simply to show you that they also have an extensive correspondence school setup, with an extremely large number of students and a very large number of degrees. The one difference in Russia over our system is that if you undertake to take a correspondence course in Russia, you're very likely to finish it.

The figure for military academies has a question mark on it, because, obviously, it is very difficult to get. Presumably it is felt that there are 18 basic higher institutions in the military establishment, with 20,000 enrollment. Compare that with our West Point, the Air Academy, and the Naval Academy. It is presumed they have about 3,500 graduates a year. That is subject to error, or at least concealment.

Chart 10, page 20.--The Russians have a system in secondary education we do not have to any marked degree. It's called a technicum. A technicum is in reality a two-year university, or college. This chart shows they have 3,753 of them, with an enrollment, as you see, of more than they have in the four-year colleges. Notice the number of graduates.

CHART 8

U.S. vs. SOVIET INSTITUTIONS OF HIGHER LEARNING

	1956 NO. INSTITUTIONS	1956 ENROLLMENT	1955 BACCALAUREATE GRADUATES
All Colleges, Universities & Institutes			
United States	1,368	2,598,702	287,401
Soviet	762	1,867,000	245,846
Technological Students			
United States	–	493,018	53,985
Soviet	–	650,000	90,830

Sources: "Soviet Education for Science and Technology" by Korol, M.I.T., 1957
U.S. Office of Education, 1957

Ultra CHART

CHART 9

SOVIET INSTITUTIONS OF HIGHER EDUCATION

	1956 NO. INSTITUTIONS	1956 ENROLLMENT	1955 GRADUATES
All Institutions	**762**	**1,867,000**	**245,846**
Including:			
Engineering & Technical (VTUZY)	**204**	**650,000**	**90,830**
Other Institutions (VUZY)	**558**	**1,217,000**	**155,016**
Including:			
Correspondence	**22**	**639,100**	**62,014**
Additional:			
Military Academies	**18(?)**	**20,000(?)**	**3,500(?)**

Source: "Soviet Education for Science and Technology" by Korol, M.I.T., 1957
"Soviet Professional Manpower" by De Witt, Nat. Sci. Foundation, 1955

Vitro CHART

CHART 10

SOVIET TECHNICUMS AND OTHER SCHOOLS OF SPECIALIZED SECONDARY EDUCATION

	1956 NO. SCHOOLS	1956 ENROLLMENT	1955 GRADUATES
All Technicums	**3,753**	**1,960,400**	**387,800**
Including:			
Engineering & Technical	**1,717**	**1,331,200**	**222,500**
Including:			
Correspondence Schools	**41**	**286,500**	**26,700**

Sources: "Soviet Education for Science and Technology" by Korol, M.I.T., 1957
"Soviet Professional Manpower" by De Witt, National Science Foundation, 1955

Vitro CHART

Engineering and technical take up 1,717 of that total, and you will note the number of students and graduates. And there are also 41 correspondence schools in the 2-year group.

What that chart really means to us is this: that whereas we take a 4-year engineering graduate student and put him to work on a phase of a weapon system for instance, they often can use a 2-year student for the same purpose. We all agree that there has been much waste in our use of manpower in the technical sense, and I think the weapons groups have wasted more than the nonweapons groups simply because Uncle Sam foots the bill for them; and they therefore can be a little more careless, let us say.

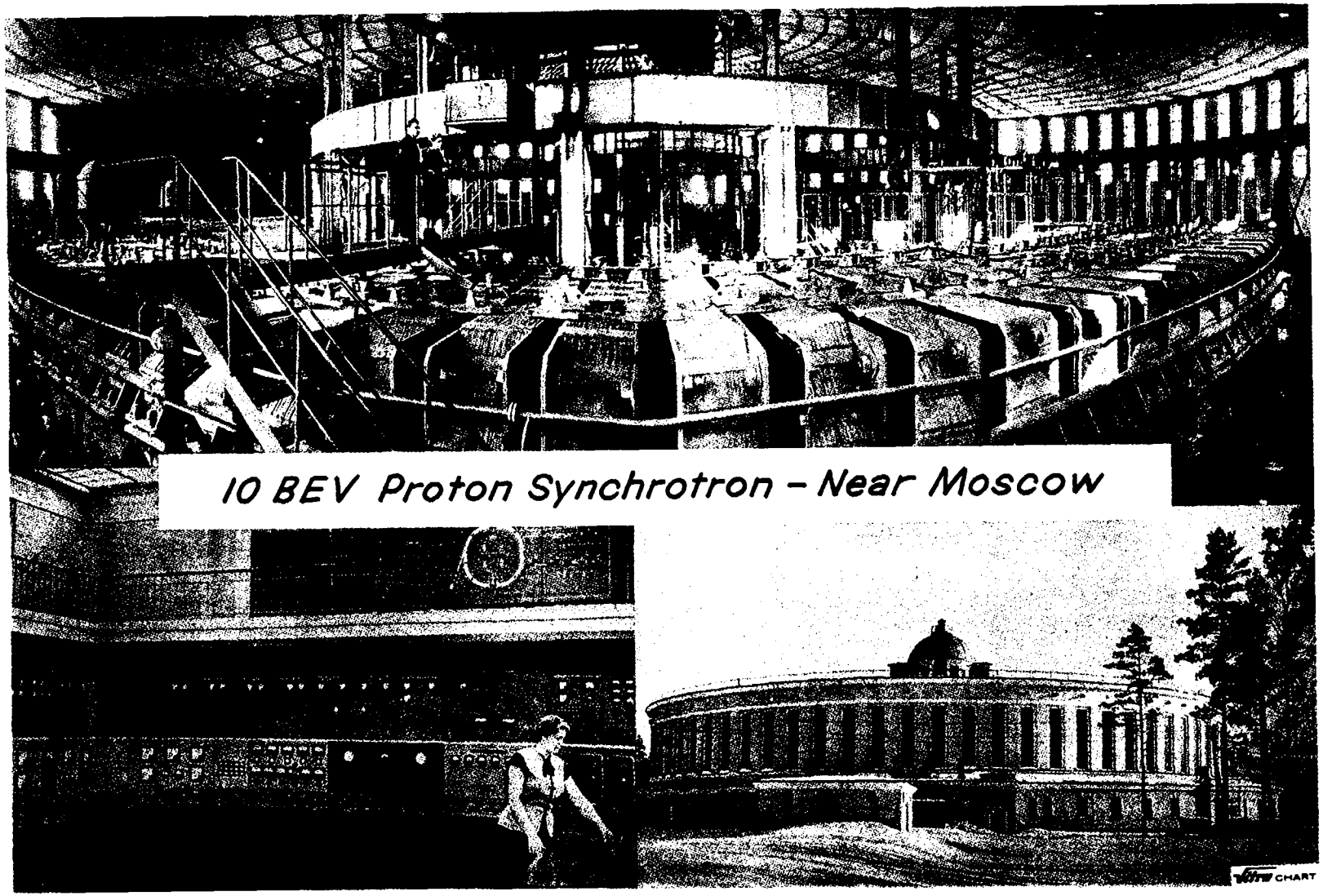
The technicums comprise an area wherein I believe our country is badly behind our competition. We do have a few schools of that character. California does a better job than most other states in that area of education. That is because California had to make herself industrial long after the east became so, and she found that this was a very useful way to utilize her manpower.

However, as a country we are not in the same league with Russia in this field. We do train our technicians--and you find it in the electronics industry to a greater extent than any other of which I have knowledge--to do work that engineers would otherwise have to do. If it weren't for this, the chart which will be shown later on the growth of the electronic industry could never have been prepared!

Chart 11, page 22.--This chart is put in as an example of how the Russians value research. The machine shown is the largest instrument existing today in the entire world for subatomic high-energy particle research. It contains six times as much steel in its magnet system as the largest operating American instrument.

Some professors of my acquaintance who were invited to Russia and saw this machine told me that it embodies no principle that is unknown to us, but to my very great surprise, they said unanimously that the engineering equipment is superior to that on any American instrument. We pride ourselves on our engineering, and it's rather shocking to get from high-grade scientists a report that the Russians, in building an instrument for fundamental research, do a better engineering job than we do.

CHART 11



I refer to such things as the vacuum pump system, such things as the particle gun system, and such things as the electronic pulse system.

Notice the control room. Our company designs plants of this type, among others; and we agree that we have here a most modern functional control concept.

Last but not least, there is the architectural treatment. Russia is a country, mind you, where you're given in the order of 150 square feet of living space per citizen for living quarters. This means that the instrument shown is a symbol by Russia of her recognition of the role of basic research and of her determination to catch up to the western nations and to go past them in science.

Now I want to come to the part of my subject that I believe is the least understood, but to me is the most significant for this audience. When you gentlemen concern yourselves with political attitudes, psychological warfare, economic warfare, and, finally, combat warfare, you are concerned, not with the number of men, but with the economic might of a nation that will provide those men with the tools and weaponry which they must use to be effective. This means that we have to manufacture and supply such weaponry in times of war. We have to transport it. We have to supply and maintain it. And our Nation has to supply the civil population who will make this weaponry. All this is part of our, shall we call it, military posture--a term that I hear from time to time.

Well, what is a measure of a country's ability in this area? Let us take some statistics.

First off, an engineer, in looking at the nations' economics, is always baffled by the language employed and by the semantics and the use of terms and their fundamental meanings employed by the economists; so he reaches out to try to get something solid when he is reading such material, and he often has great difficulty.

If you will reflect a moment, you are bound to see that the number of automobiles, refrigerators, goods, and the services that make up your standard of living have got to be manufactured and supplied. They don't grow on trees. And the art of manufacturing is the application of energy to the fashioning of material. These are engineers' concepts.

If this be true, then the amount of power available to a nation represents within reason its standard of living, its total productive capability.

Chart 12, page 25.--So on that theory I set out to get statistics from some of the oldest statistical sources in the United States--using The Edison Electric Institute, and the National Industrial Conference Board. They were obtained for the purpose of comparing the standard of living per unit of population in the United States versus the power available per unit population into the total power generated and use the Department of Commerce figures for the standard of living in terms of constant or standard dollars.

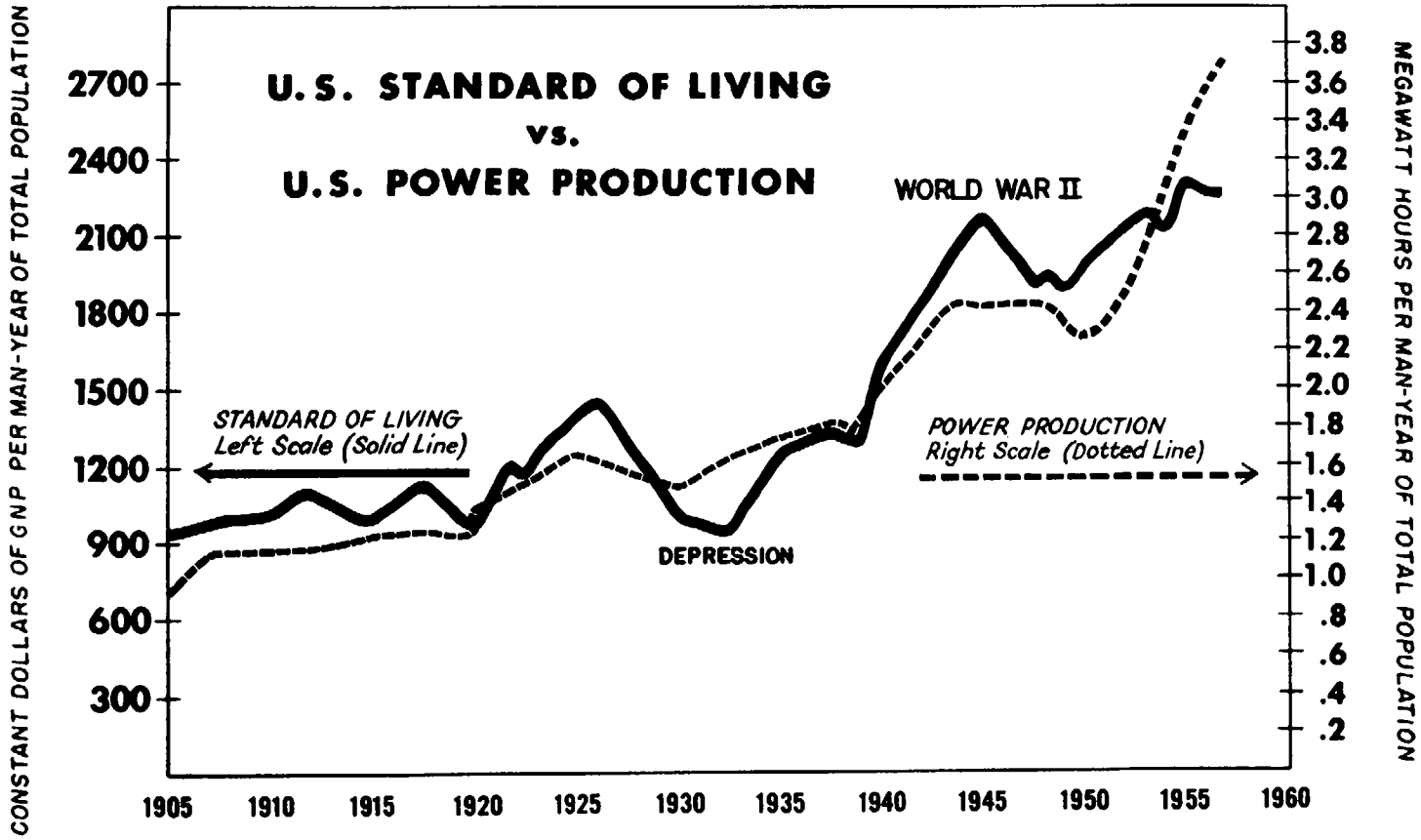
In terms of a standard dollar, which I have never seen, and using the Department of Commerce's census statistics we derive chart 12. This shows a curve which indicates the standard of living in the United States since 1905. It shows what happened through World War I, the depression, World War II and down to today.

The broken line curve in the chart shows the amount of energy available in the electrical systems in the United States per unit of population since the very first statistics were gathered, in 1905. Is it not remarkable that the standard of living in the United States, the highest in the world, and the amount of megawatt hours of electrical energy per unit of population have run a close parallel for 50 years?

Please note we did not take any specific year as a standard unit. We could prove almost anything by using that method literally. We believe that the experience of the period of over five decades leads to this astounding conclusion: that the strength of a country is no better than the availability of its energy sources and the knowledge of how to use them.

Chart 13, page 26.--This chart gives the projection of the amount of power which the major utilities are going to produce in the next few years. Strangely enough, it doubles every 10 years. And this means that in 50 years, for instance, it is 2 to the 5th power, that's 32 times, the curve gives the projection for the next few years. Some recent work in Europe indicates that their rate of growth is the same.

CHART 12



SOURCE: *EEI and NICB, 1958*

Vitro CHART

CHART 13

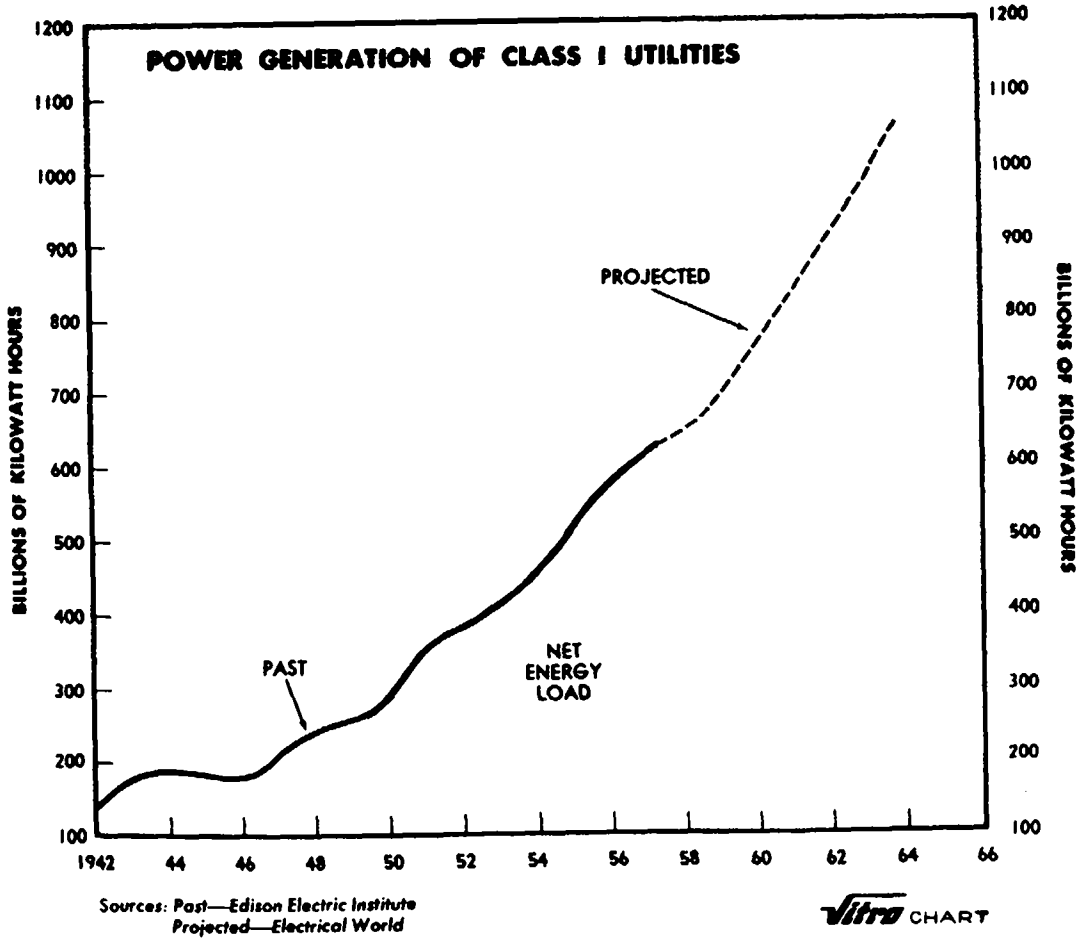

POWER GENERATION OF CLASS I UTILITIES
BILLIONS OF KILOWATT HOURS
1200
1100
1000
900
800
700
600
500
400
300
200
100
1942
44
46
48
50
52
54
56
58
60
62
64
66
PROJECTED
PAST
NET ENERGY LOAD
Sources: Past—Edison Electric Institute
Projected—Electrical World
Vitro CHART

Chart 14, page 28.--This chart shows electric power production in billions of kilowatt hours. Note the figure of 1235 for the United States and our allies, Western Europe, and Canada, compared with our enemies, the USSR, its European satellites, and China, and their total of 315. This is a good measure of present war-making capability, manpower excluded. It is the capability of the production of weaponry. Assuming the Communists were equal technologically, which I doubt, see the enormous advantage we have. If Russia could overrun Western Europe and transfer those resources to their efforts, an entirely different balance of power becomes obvious. However, in such comparisons we must keep in mind that the Communists do not permit their civilian requirements to take a large share of their resources, as do the United States and its allies.

In other words, we divert a larger share of our power to support electric refrigerators and two-tone convertibles and this would even be true to an extent in wartime with our traditional higher standard of living.

Chart 15, page 29.--This chart shows the standard of living throughout the world as computed by social scientists based on gross national product per capita. These are the latest figures available, and the Industrial College faculty helped to obtain them, although they were also checked from other sources. Note the position of the USSR compared to the United States at the top. Also look at Canada, in the second place, because she has developed a very similar economy. And here's Iceland, of all places, to be in third. Then Sweden, New Zealand, Switzerland, Australia, United Kingdom.

You will notice that this top group of countries are chiefly nothern countries, with energetic temperature environments and democratic forms of government. Now note the position of the USSR.

It is interesting to observe that the power production in the Soviet land divided by its population has closely the same ratio as in this chart for the standard of living to that for the equivalent parameter in the United States. Thus you will see further evidence for the theory that the amount of available energy in a nation determines its gross national product capability and its defense capability as well.

CHART 14

ELECTRIC POWER PRODUCTION
1957

	BILLIONS KWH
UNITED STATES	716
WESTERN EUROPE	428
CANADA	91
TOTAL WEST	1235
USSR	210
EUROPEAN SATELLITES	86
COMMUNIST CHINA	19
TOTAL SOVIET BLOC	315

SOURCE: *ICAF, Based on Economic Indicators, U.S. Dept. of State.*

Vitro CHART

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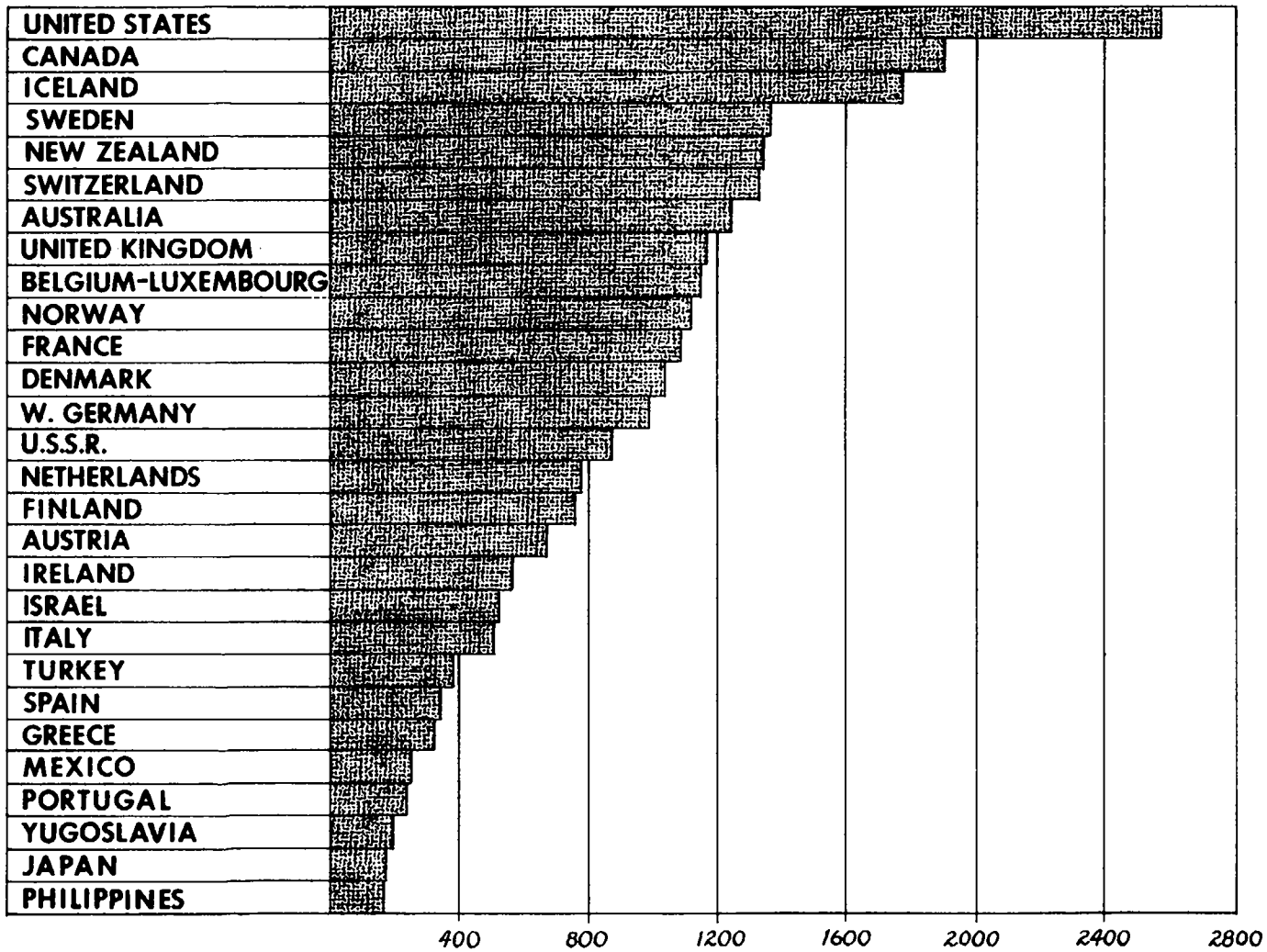
CHART 15

GROSS NATIONAL PRODUCT PER CAPITA
1957



SOURCE: Industrial College of the Armed Forces

Vitro CHART

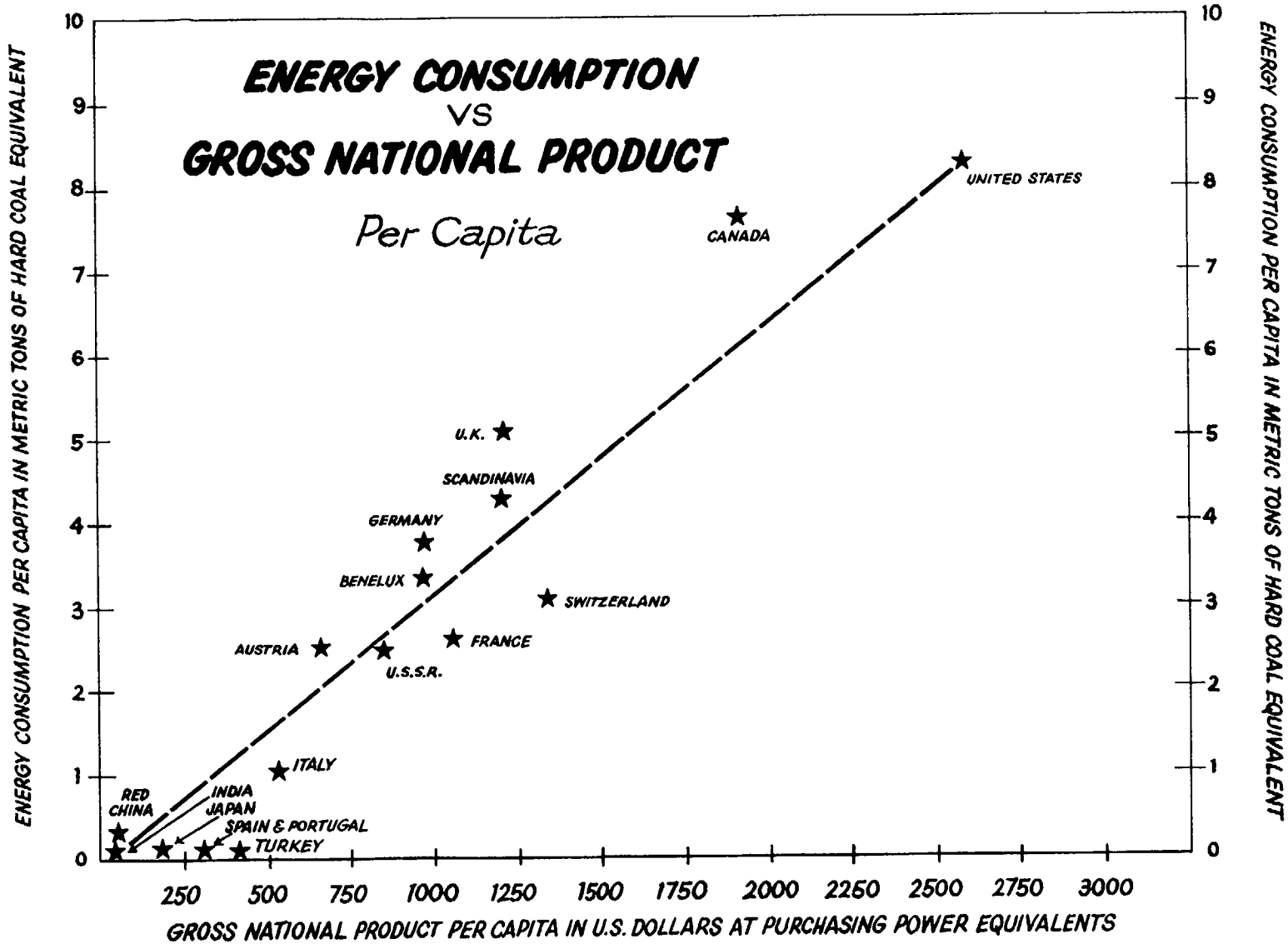
We can make the same calculation for other countries until you get down into the now industrial countries. It does not apply there, for a very simple reason. Too much of the work of these economies is done by men and animals, and we can't measure them in equivalent kilowatt hours. So that such figures are really misleading. Such countries are not as poor vis-a-vis the industrial nations as this chart indicates. Here again we see the limitation of statistical methods.

Chart 16, page 31.--This chart is new. The statistics involved come from the intelligence reports of the U.S. Department of State. Various other sources were used, as a cross-check. This chart is a little more abstruse and fundamental than some of the others. It shows the gross national product per capita in United States dollars, as purchasing power equivalent, for all the countries shown, versus their energy comsumption per capita in metric tons of hard coal equivalent, which is the measure of available energy.

Note the United States again. This chart says that we have the highest standard of living and that we use the greatest amount of energy. And again observe Canada, lying just above the median line. But look where this median line comes--right through all the mass of statistics for most countries, again indicating that the high standard of living is in the high-energy-absorbing countries; or, putting it the other way around, their capabilities are no greater than their capability to manufacture and distribute electrical power. And again, I believe this is really the fundamental basis of our war-making capability, especially after the initial phase of a war when existing supplies must be replaced.

Chart 17, page 32.--This chart indicates our energy sources over a period of a hundred years. The power situation in the United States was somewhat analogous to the present position of nonindustrial nations on the other chart. Observe the amount of work that was formerly done by animals in 1850, then the amount done by men, and the amount by useful windpower. Compare the amount of energy generated by waterpower, by bituminous coal, hard coal, and finally by wood. Remember that the Civil War engines were fired with wood, and the Ohio River steamboats and the Mississippi River steamboats were fired with wood. It was quite an energy source.

CHART 16

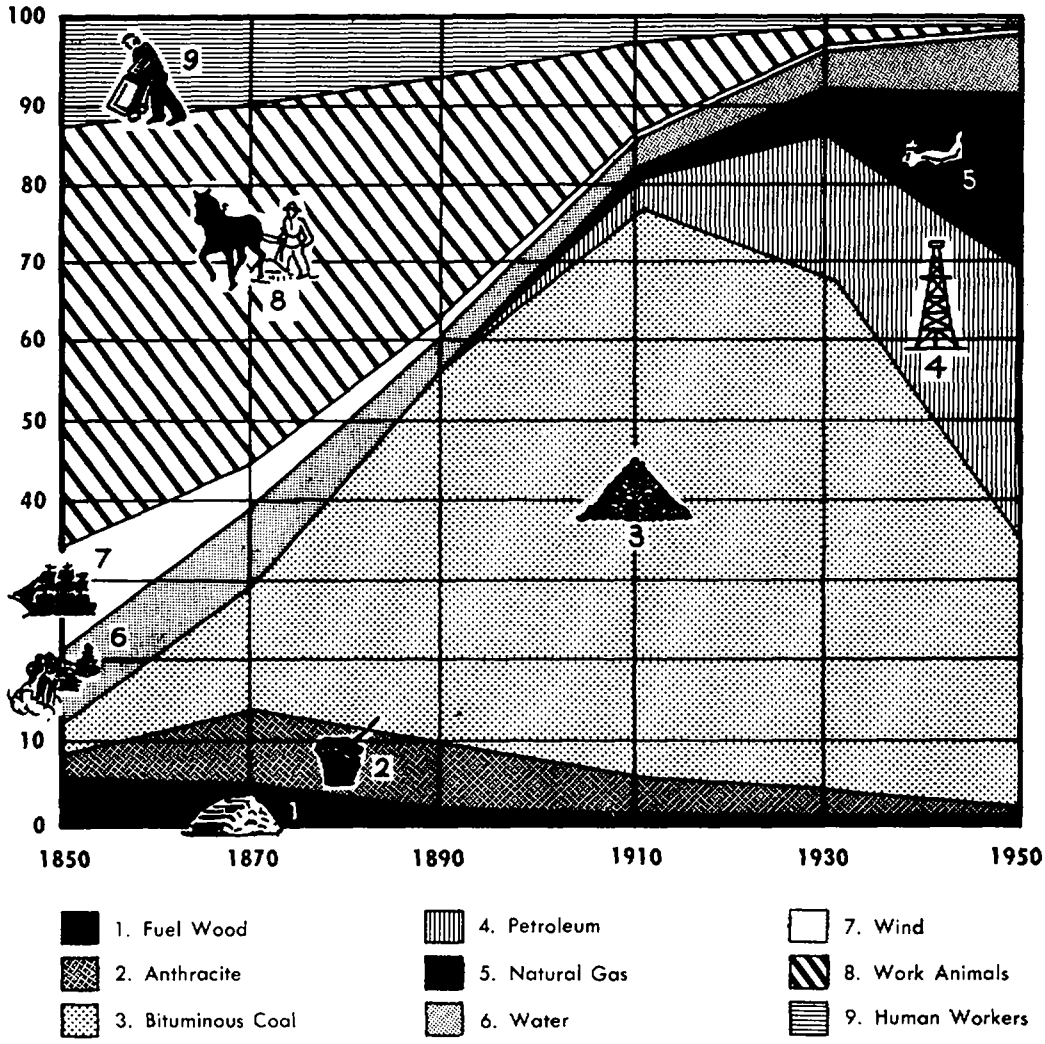


SOURCE: *Intelligence Report, U.S. Dept. of State, 1958*

Vitro CHART

CHART 17

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



SOURCE: Twentieth Century Fund

Now, skipping over the whole period and bringing ourselves reasonably up to date, to 1950, we see that energy from wood has about vanished, hard coal practically. Bituminous coal is now about equivalent to oil, and natural gas is rapidly catching up to being equivalent to oil or coal. And if you take coal, oil, and gas, the three fossil fuels, they make up 90 percent of all our energy, with waterpower and animals and manpower insignificant.

Someone asked what man was doing now in the way of direct energy, and I said: "It's a little difficult for me to find out. He now wakes up with an electric clock, which turns on his own radio program and news, and he has an automatic coffeemaker down in the kitchen, and his wife mixes her biscuits with an electrically driven mixer, the toaster even pops it out on the table, and the dishwasher does the dishes and the garbage disposal grinds the garbage. It's pretty hard to figure out what muscle is needed. He then eases himself into a car and gets transported by gasoline power to his office, steps into an electric elevator and gets hauled up by kilowatt hours to his office floor, and sits in a chair, and so his day of work goes on."

The question is, What is left for his muscles to do? This poses a hard problem, and I have finally decided that the only thing left for us is motor-driven zippers.

Chart 18, page 34.--The three sources of energy shown in chart 18 were put down 300 million years ago. They are not inexhaustible. The National Resources Report of the United States Government published a few years ago shows that by the year 2020 the United States would cease to have a dynamic economy based on these fuels.

These graphs are therefore bad medicine for those who speak on behalf of the Coal Institute, the Petroleum Institute, and all the rest who feel that we are safe because currently we have plenty of fuel. We are in a fuel-rich country.

But do remember that these fossil fuels were laid down 300 million years ago. And when you go driving down the boulevard in your automobile, remember you are riding on the sunlight of 300 million years ago. This fuel is not replaceable.

CHART 18

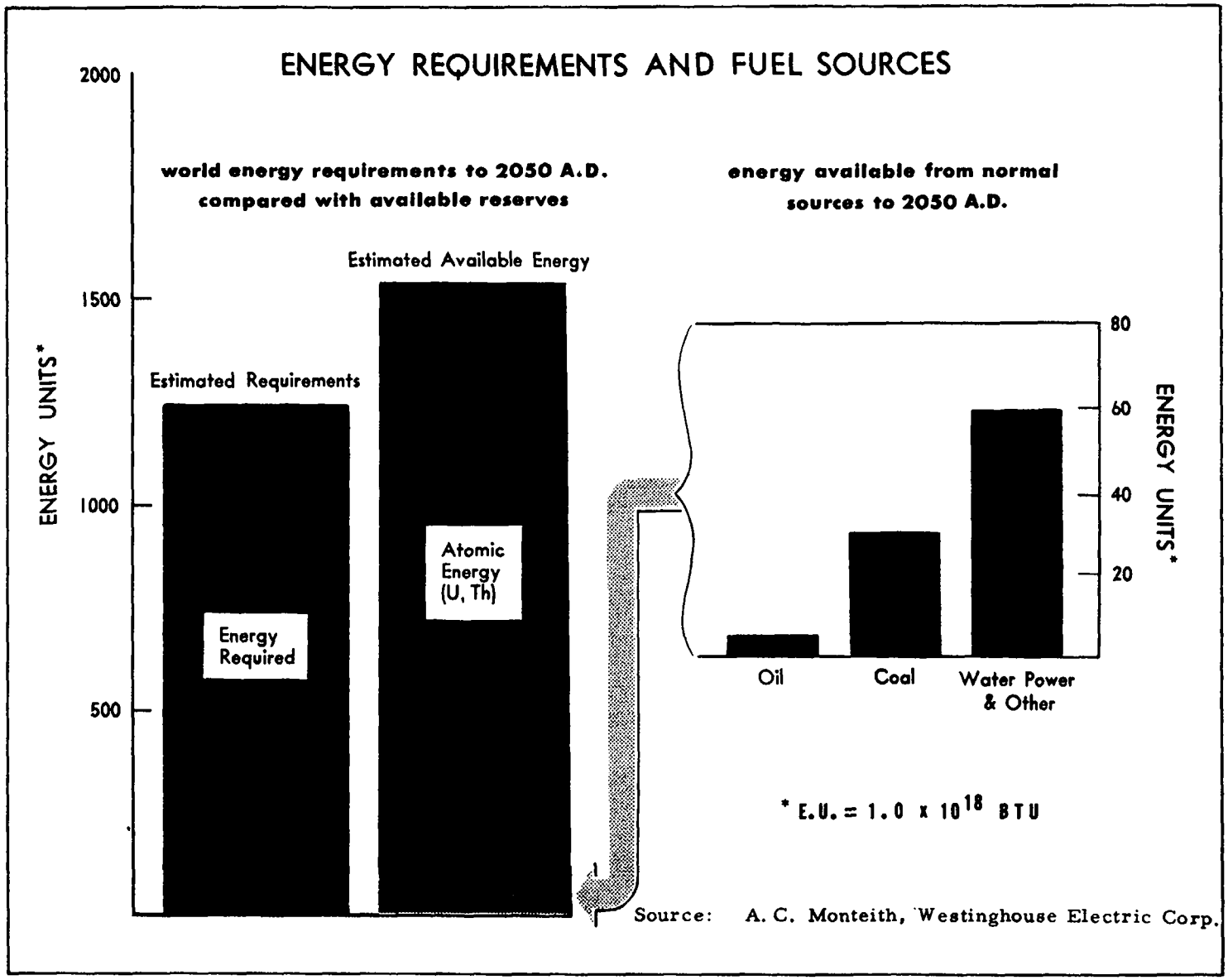


Chart: Vitro Corporation of America

Where, then, will we look for our future capability? We cannot spend much time on that factor today. But in terms of enormous energy units shown in the chart, we can see the energy estimated to run the world by 2050.

On the right-hand side of the chart is shown the amount of oil there is in the entire crust of the earth, under the continental shelf and on land and believed in the Antarctic. Then shown is the coal also estimated. Last is waterpower, which seems large by comparison simply because the rain falls every year. It is solar power really; and the longer off we choose a final date, the larger the item looks in terms of the other fuels, because we just keep on multiplying by the number of years.

Since the total amount of undeveloped waterpower and the supply of fossil fuels in the earth wouldn't run the expanding economy of the world for 100 years, it's obvious that we must look elsewhere.

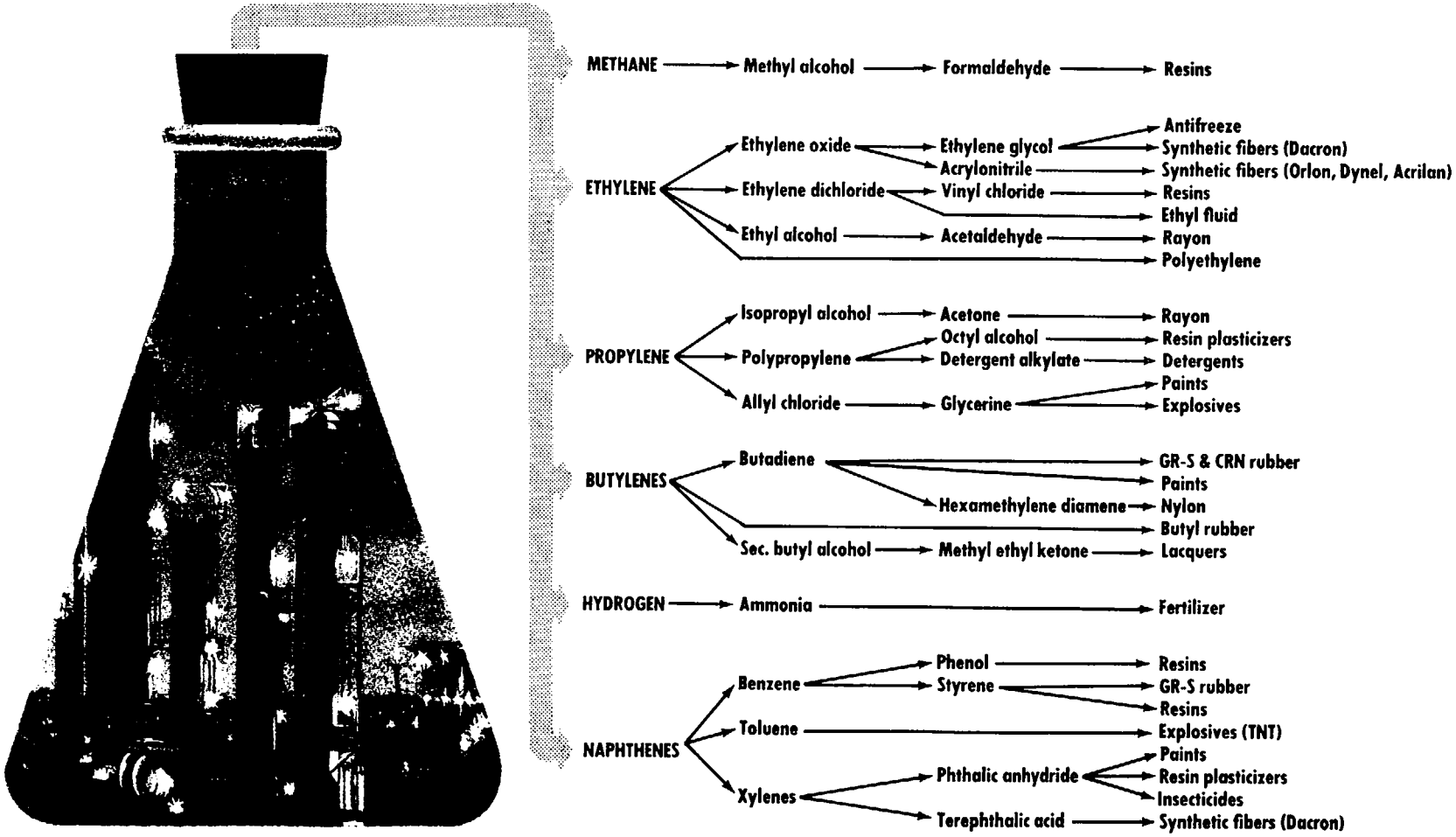
The taller of the two stacks at the left shows, about the fossil fuel block, the calculated energy equivalent of the uranium and thorium now estimated to be in the earth's crust. The quantity is probably an underestimate, because we're discovering more and more uranium as time goes on. But let's double these figures if you like, or take whatever quantity you wish. You will see that even in terms of 100 or 200 years we must look for still other sources of energy; and, of course, the only ones available at the moment are solar energy or thermonuclear (hydrogen) reactions or earth core energy. This exhibit is to show the need for research and what has to be done in our day and age to save the future for our grandchildren's grandchildren. Such scientific-technological challenges require not years, but decades for their solution.

Chart 19, page 36. --This chart shows all the useful things that come out of oil in the form of chemicals, an exhibit taken from an oil company publication.

Note the symbolic beaker of oil and then the basic compounds and the derivatives, intermediates, and finally end products such as resins, antifreeze, chemicals, synthetic fibers of various kinds, rayon, polyethylene, detergents, paints, explosives, nylon, buna and butyl rubber, and so forth and so on.

CHART 19

CHEMICALS FROM OIL



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

In other words, we should husband our petroleum, which is very valuable to us in other ways than to burn only for heat. The fact of the matter is that oil, natural gas, and coal are the only available materials for carbon chemistry, and we can't run our civilization without the products of carbon chemistry. There will come a time when competition for these useful end products will boost the price of oil to where we have to have other energy sources even if we haven't burned up our oil.

Chart 20, page 38.--This chart shows the users of power in the United States. Here are our public utility stations in millions of kilowatts. Here are the industrial stations, meaning factories. "Agricultural" means farm tractors, farm machinery, and the like. The requirements are enormous, although the farmer uses only his equipment during harvest time or planting time, and therefore the utilization factor is low. But the utilization factor is very high in industry, less high for railroad diesels, where the utilization ratio is fair; and finally the vast equipment potential needs of our military establishment. Now we see why energy sources in times of war are most critical.

Look at the domestic and automotive loads. If these cars were on the road 24 hours a day, there wouldn't be energy sources enough anywhere to provide for them. Sometimes when I am driving I think that they are on the road 24 hours a day. This gives you, then, a perspective on what it takes fuelwise, energywise, to run an economy like ours, particularly in times of war.

Chart 21, page 39.--This chart shows an interesting curve, taken from the U. S. Census of Manufactures. It shows the increased increment caused by manufacturing per million of population in the United States. Note the increase of worth of products and goods by manufacturing. This indicates once more the utilization of energy, and gives us a measure of the state of technology in the country. The curve is a technological curve, and illustrates how the country is dependent more and more on the fruits of science and engineering.

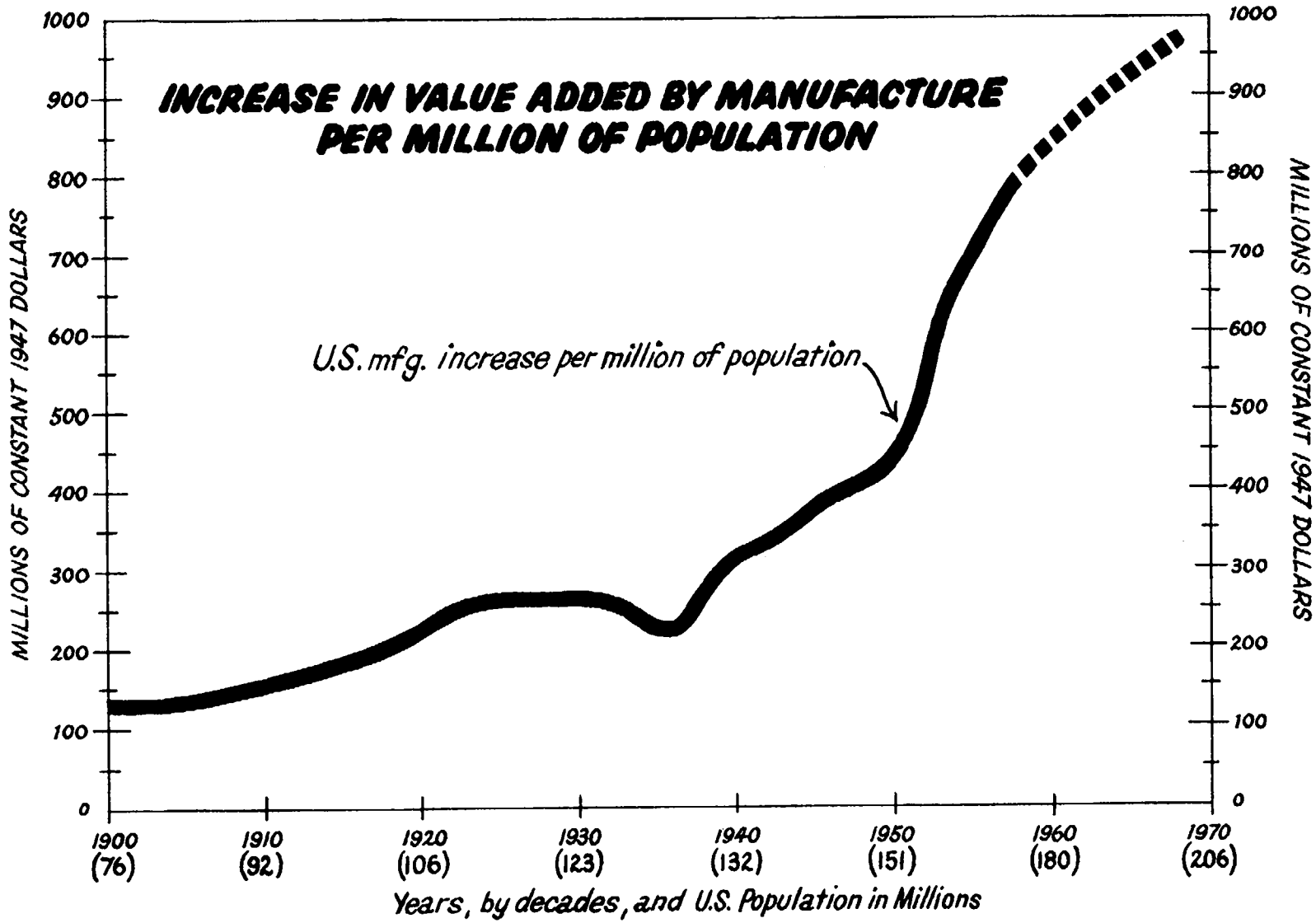
CHART 20

APPROXIMATE INSTALLED CAPACITY OF U.S. POWER PLANTS

	MILLIONS OF KW
PUBLIC UTILITY CENTRAL STATIONS	120
INDUSTRIAL	30
AGRICULTURAL	50
RAILROAD	90
MILITARY ESTABLISHMENT	1000
AUTOMOTIVE	5000
OTHER	60
TOTAL	6350

Source: Theodore Baumeister, Columbia Univ.

CHART 21



SOURCE: U.S. Census of Manufactures

Vitro CHART

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Chart 22, page 41.--This chart shows the growth of atomic industries. For comparison is shown the first 25 years of aircraft production, largely through military requirements plus a curve showing the start of a civilian industry in aviation and its early history.

It is interesting to note that the Wright Brothers first flew back in 1903, and The New York Times wouldn't publish the account of the flight because they said it was too ridiculous. The big jump in the upper left chart shows the effect of World War I, when the early military theory was that an airplane goes up just to spy on the other fellow. Then they fired pistols at each other for a while, and finally, as you remember, we developed some primitive types of ordnance, and bombing techniques.

But note what World War I did in terms of demand. It's an interesting lesson because it illustrates that military needs so often are the father of new industries and thus major improvements in the civil economy. However, right after the war came the days of barnstorming the Jennies, and so forth, until later on, when the military services were ordered to fly the mail, with rather unfortunate results. And then followed the real birth of civil aviation. Look at the chart on the upper right which indicates the birth of civil aviation in 1920, and you will see its growth characteristics. This illustrates technology at work, and shows the rate of growth of air transportation and I have only taken its first 25 years. Note that the only setback occurred in 1933 when a new administration seized all the airlines and tried to have the Army fly the mails--with disastrous results.

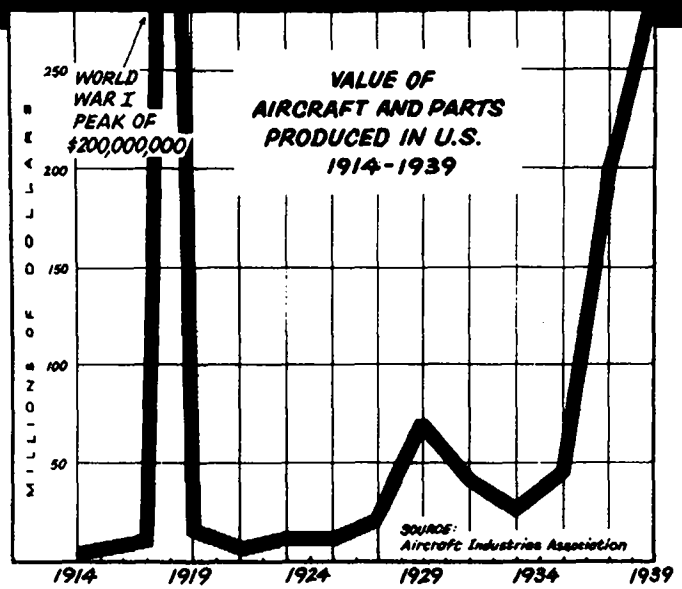
The bottom chart shows the growth of atomic industries, which hasn't yet reached the 25-year period. It is based on U. S. Atomic Energy Commission expenditures. This is put here to show that all these vast new technological industries take a somewhat similar course. If we will compare one curve with another, you will find they have similar characteristics except that a bump in one isn't as high as the bump in another. This is chiefly because they start and end in different years.

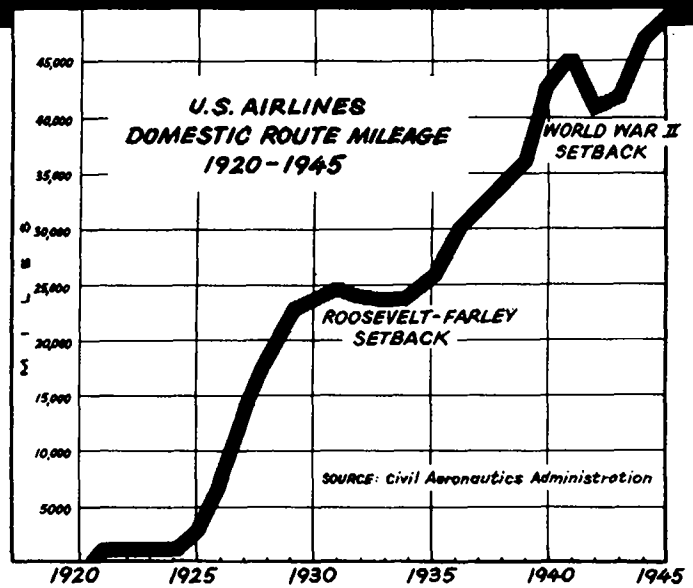
In other words, 1942 to 1945 shows the Manhattan District effort. In proportion, because the scale is different, it does not have the same coordinates as you have in the chart for aircraft in World War I, primitive as they were, although the ultimate curve has the same characteristics.

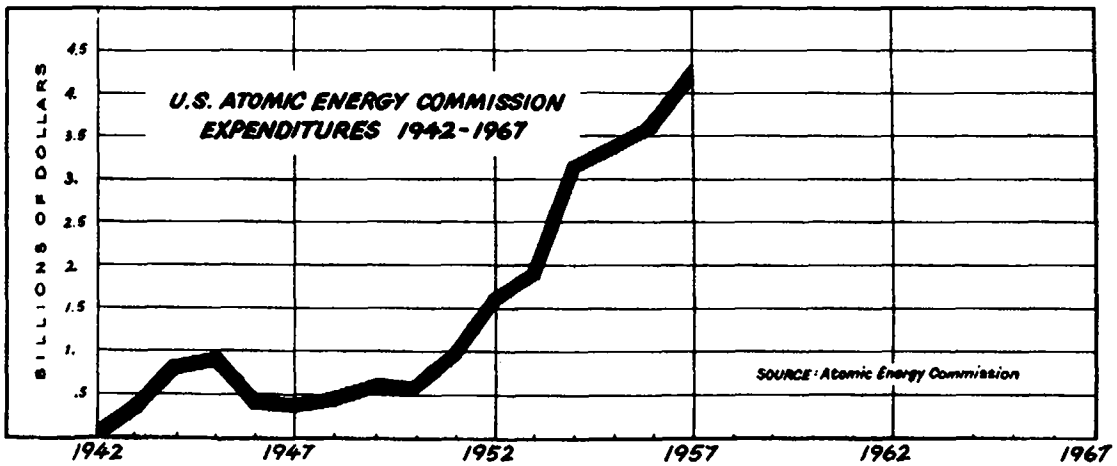
CHART 22

AVIATION vs. ATOMIC ENERGY

Growth Patterns of the First 25 Years







Ultra CHART

An interesting point is that there is no counterpart of the civil aviation curve today for atomic industry because the industry is being born only now. You will not see the real genesis of this civilian atomic energy curve for five years. However, technology is at work, and it is necessary to have enough scientists, engineers, research, and technology to accomplish this goal and to develop the industry.

Chart 23, page 43.--This chart shows the growth of electronics. Note again the World War II demand. How similar that is to the aircraft surge in World War I, or World War II for that matter. And notice where the electronics industry was in 1940--Radar had not been born, computers and simulators were practically unthought of and automation was in its infancy. Then see what happened when the Battle of Britain came on and showed the great value of radar and its many military applications. Notice again that any strictly military-accentuated development in any phase of technology has a marked decline after a war effort. But look how quickly it picked up in this instance. And, of course, it accelerated tremendously in the Korean War, and then--on it went to new concepts and applications. So here we can see the World War II effect, the Korean War effect, and the subsequent growth, which includes the tremendous commercial development, television, and so on.

Chart 24, page 44.--This chart shows clearly the relation between new basic science, its applied science, technology, and the application. At the top are indicated the years when basic principles were being developed. They began as far back as 1890, with Dr. Hertz discovering electromagnetic waves in space; through 1895, with Dr. Roentgen's X-rays; in 1896 was the discovery of radio activity by Dr. Becquerel, then the discovery of the electron by Thompson in 1897, then by 1900 the German, Max Planck, had postulated the quantum theory which paved the way for Einstein's special theory of relativity in 1905 and later on the refinement of the quantum theory and Dr. Broglie's wave mechanics--the language of the atomic scientists.

By 1911 Lord Rutherford had revealed the nucleus of the atom and in 1912 Nils Bohr postulated the complete structure of the atom. The 1930's saw Chadwick identify the neutron, Enrico Fermi the transuranic elements, and Hahn and Strassman the phenomenon of fission in 1939. All of that was the groundwork, which was all in the field of basic research and scientific discovery. Nobody then knew how this theoretical new power was going to be harnessed, if ever, or what would ever be done with it. Now let's look at the fission side of the chart.

CHART 23

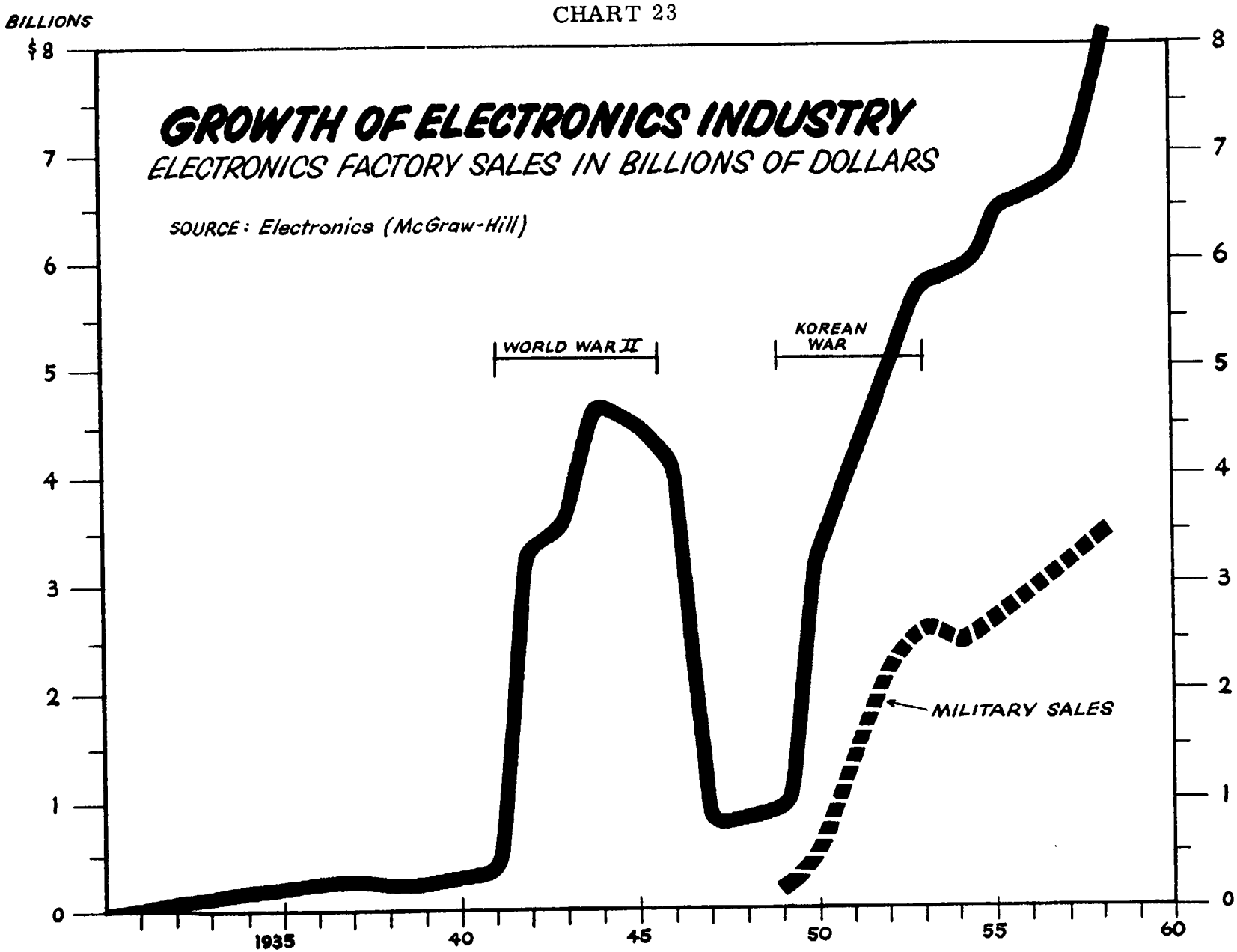
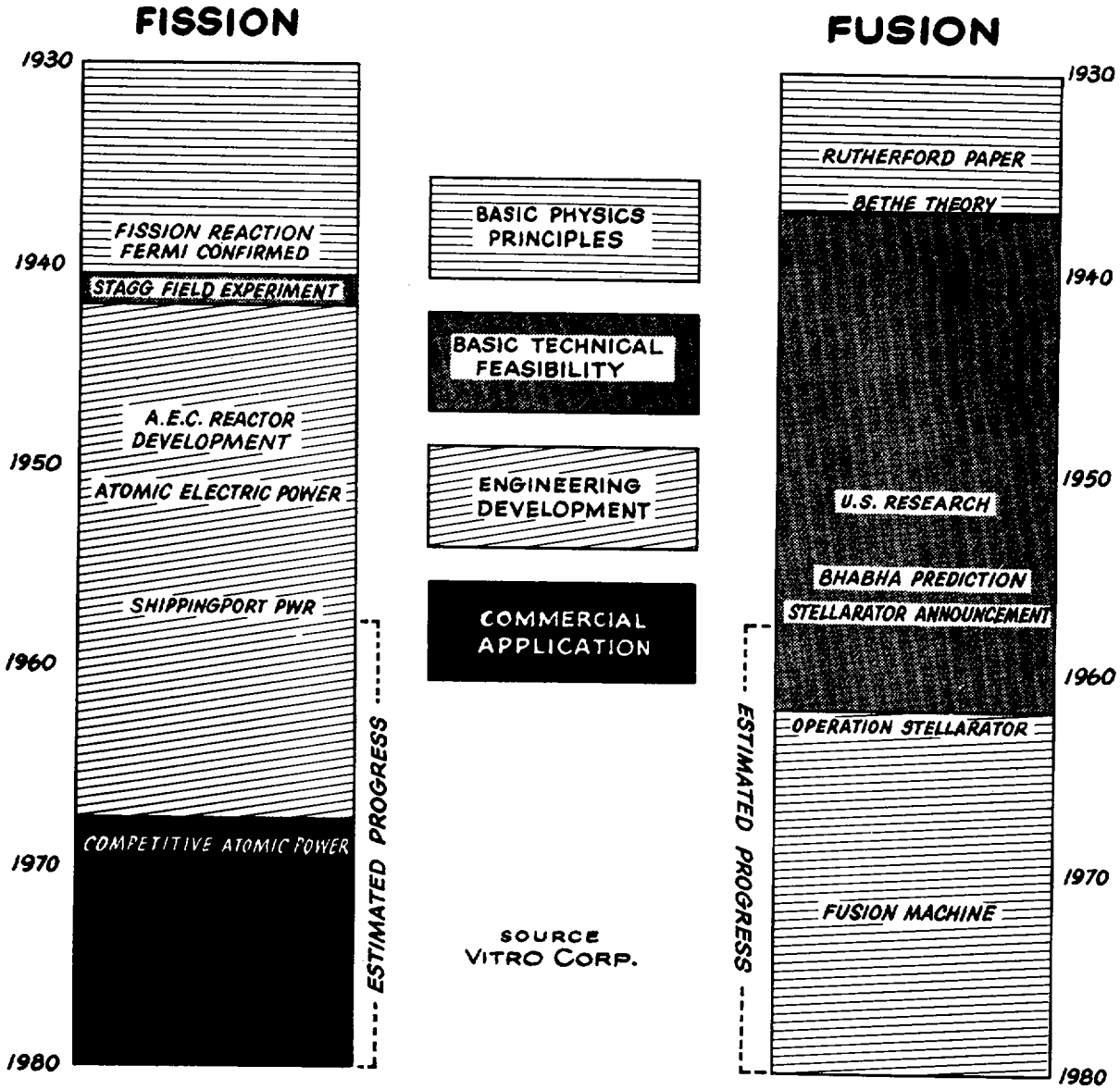

BILLIONS
$8
7
6
5
4
3
2
1
0
GROWTH OF ELECTRONICS INDUSTRY
ELECTRONICS FACTORY SALES IN BILLIONS OF DOLLARS
SOURCE: Electronics (McGraw-Hill)
WORLD WAR II
KOREAN WAR
MILITARY SALES
1935
40
45
50
55
60

CHART 24

FISSION vs. FUSION



In the 1930's the first fission of uranium occurred as an accident in a German cyclotron.

In 1940 the "basic technical feasibility" section of the chart shows the time it took, under war pressure, for Fermi and his associates to build the first reactor at Chicago. This was the first step in the applied science phase.

Then, in 1942 there began the era of reactor development. It will take from then up to what is estimated to be about the year 1968 in order for the prior work in basic science, then the work in applied science, and finally the resulting development, to be reduced to a state of significant commercial and economic feasibility.

This exhibit then, is a vital life chart to show that certain technologies can't necessarily be unduly accelerated during a war emergency. And we point out that this basic atomic science, that was needed for the atomic bomb, ran through a basic research period of 40 years. It was done by a very few distinguished, perspective, imaginative scientists, men who towered above their generation. We can't hire such men. They existed only in the university atmosphere, and there they produced that know-how, that knowledge, of the basic laws of the universe.

Under the pressure of war the applied phase of the work was accelerated. With all the pressure of economics--even then--it took some years to reduce the theory to practice.

Now let's turn to the fusion or thermonuclear approach. On the right the so-called thermonuclear phase is pictured. Note that the science of fusion phenomena was worked out before the science of fission, although many people are not aware of this. In the 1930's Dr. Hans Bethe stated the basic theory of the sun's energy, which is essentially the hydrogen fusion reaction.

You will observe the time it has already taken--and which should continue until about 1962--to hope for the first successful demonstration of fusion in a manmade device. It could be in the stellarator at Princeton University, or it could be from the mirror machine at California. We now don't know which, and we also don't know whether! But the scientists are willing to gamble that by 1962 they will have reduced the fusion theory to its first demonstrated application in applied science.

Now, then, what about reducing fusion to practice? You will notice that there is not on this chart such a thing as a projected commercial application of thermonuclear power generation. That doesn't mean, because this is a crystal-ball type of chart, that we can prove it. But it means that there isn't a chance of such a development in the immediate future.

So when you read newspaper accounts of "breakthroughs" and other spectacular developments, try to measure them against these fundamental facts.

Chart 25, page 47.--This chart indicates economic, or if you will "war potential" capacities of the USSR and satellites, Communist China and satellites, versus the rest of the world. Notice that the population of the rest of the world, if we could only have it on our side, would vastly overshadow China and Russia. In agricultural land, the rest of the world could feed much more than China and Russia. In crude steel production--the rest of the world is vastly superior in terms of Russia's capability. The same thing in coal production, and even more so in crude petroleum production, which of course includes the Middle East. You can see what an awful dislocation would occur in the petroleum statistics if we lost the Middle East. Also, compare electric power production, which is really, after all, the sinews of war.

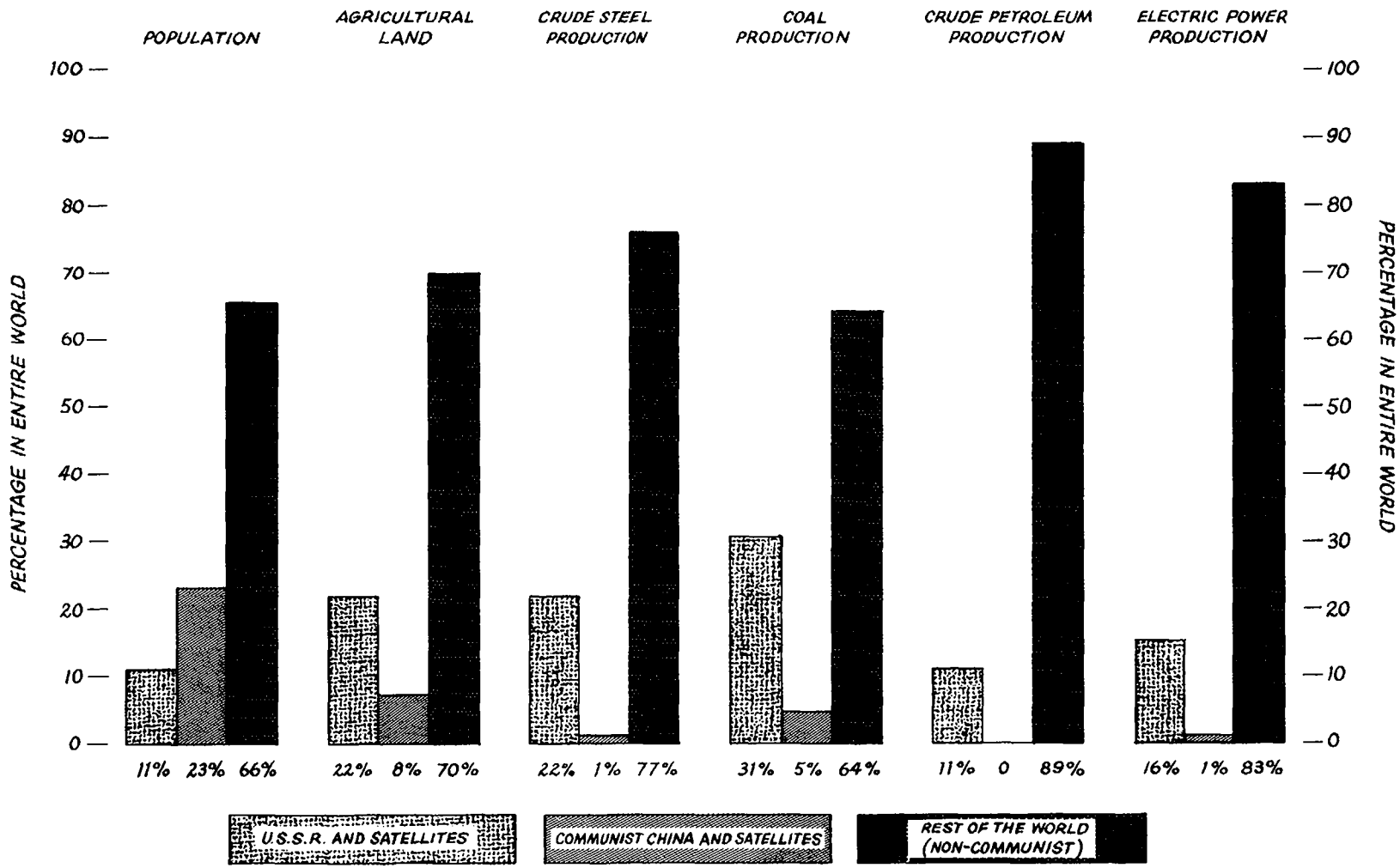
If I were a Russian, and saw these statistics in the Russian columns, I'd be scared to death. Furthermore, I would say, if ever there was an argument for Russia to use subversion to capture this portion of the free world, it would be in such a chart. The Russians haven't got a chance if the rest of the world stands together, except by subversion or by neutralism in the rest of the free world.

It is intended that my opinions in all these matters are certainly of secondary importance. Your opinions are what count. I've alerted you about the limitations of statistics, including those given you here today. I'd like to have you question all of them. But I would like to have you think in terms of facts, and not headline opinions, and preferably not theories--theories from this platform or theories in the press or even theories of your own.

CHART 25

INTERNATIONAL ECONOMIC COMPARISONS

1957 FIGURES



SOURCE: *Economic Indicators, U.S. Dept. of State. 1958*

Vitro CHART

I hope we have made a case that in this world struggle, gentlemen, it is science and technology which will count. I don't want to fight with the humanists in education. I don't wish to fight with the social scientists. Certainly the human spirit is more important than anything that has been shown on these charts. But our souls and the ensuing generations of souls cannot exist except in the kind of environment which we believe embodies our traditional philosophic views of freedom, and our belief in the worth of each human being, including our free political ideas, our national heritage, and our form of government. Our kind of government will prevail only as long as science and technology provide the might to prevent those who do not wish our ideas to prevail, from obliterating them; and this will continue to be the role for our science and technology.

CAPTAIN WRIGHT: Mr. Ward is ready for your questions.

QUESTION: Is a significant portion of our research and development funds being devoted to research and development of things that will have civilian application?

MR. WARD: I think most of our research expenditures are significant in this respect. I'll say "yes." The idea of research in industry has spread widely. There was a period where it was often only a form of boondoggling. An industry that didn't have a department with the word "research" on the door was looked at a little suspiciously by the financial fraternity. There was something magic about the word. So that research was badly abused in that period.

You hear the term "research" used loosely in other ways, such as "market research." Well, market research merely means finding out what your competitors are doing, and where you may be able to sell your products.

So all such statistics are very like semantics. The best proof of the inaccuracy of language is to look at any word in the dictionary and find a dozen meanings for it. Then if you want to get really confused, take a foreign dictionary that translates from English to a foreign language and you'll find that there are probably a dozen foreign words for each one of the dozen American words, which means there could be possibly from 100 to 150 variations of meaning for one word.

Thus the word "research" has many different interpretations. A lipstick company is always researching, because it has constantly to get

new colors for the gals. Then they have to give the new one some name like "Moonglow" or give it advertising sex appeal. If you like, it can be called research simply on names.

So we can perhaps say yes, there is some form of research done across the board in industry. It is not all the kind of research that would lead to weapons, at least not those we have considered here.

QUESTION: Mr. Ward, would you care to comment on the quality of the scientists that are being produced in such countries as France, the U. K., USSR, etc.

MR. WARD: Yes. That's a good question. Fundamentally, the British, the Continental, and the Russian systems of education deal more thoroughly with scientific theories and mathematics, which latter, is the queen of the sciences. Engineers from those countries, by and large, are extremely well grounded in the theories and the mathematical application of theories.

They do not teach, to the extent that we do in the United States, the applications. I think that is changing, however. I think we're going more into theory and they're going more into application.

Khrushchev made a statement three weeks or so ago in which he blasted the Russian system. And it's interesting, if you'll read between the lines--I can't quote it exactly, but he says roughly this: that there has to be a revision in the Russian system, because statistics--here it is again--show there is too low a percentage of graduate students getting degrees whose fathers and mothers were either peasants or factory workers. This meant to him that the system was wrong.

He added the further thought that examination showed that the white-collar bureaucrats in the party and in the government, somehow or other managed to get their children into the Russian higher institutions, and also their friends' children.

Human nature is not very different around the world, even in the Kremlin's tightly controlled atmosphere. He's very unhappy over this situation. And it led him to pronounce--which means that it will be carried out--to the effect that what we would call secondary school graduates, must go to work on the farm or the factory for two years before they can go to any institution of higher learning.

He uses as his argument the fact that otherwise they lack the discipline of labor. They lack the knowledge of labor. So there will be a revision in the Soviet system based upon the normal practice of undoubtedly announcement from the Kremlin.

Now, as to quality. The National Science Foundation and other agencies have made a study of the Russian curricula. There are many times as much attention given to sciences in the secondary system as there are in the United States. In fact, it would be, I believe, impossible for a student to graduate in a secondary school without a good grounding in mathematics, physics, and chemistry, and biology too. In our system, as you know, the reverse happens every day; the number of students taking physics in American secondary schools is less than one-fifth. So you see a sharp difference.

The Continent of Europe is very similar to Russia. French secondary schools are very strong in science and mathematics, the British likewise. They also study the classics in their better schools to a very high degree. And all of the foreign schools go in for history. But in the sciences their grounding is ever so much more thorough than ours.

Apparently their students learn to read well, which is surprising to some of our own modern educators. Our universities tell us that a great many of our secondary school students can't read properly, and so the colleges are giving courses in remedial reading. This applies to quite a large number of students. And the colleges are also giving refresher courses in mathematics of a secondary school level.

I think a significant observation was made a short time ago when I was told that an agricultural college was having to put in a course in remedial mathematics, because the secondary school mathematics was not suitable for the teaching of the practice of agriculture.

My opinion is that the foreign system of education does a much better and more thorough job of disciplining students, teaching them to work hard, and grounding them in the basic courses in education. I don't limit it just to science by any means.

You know that in many institutions in our secondary school system students get credit toward graduation for learning to sew, or draw pictures or run an automobile; such skill course credits are not generally permitted in the foreign systems.

So the National Academy of Sciences came out with this observation that the Russian engineers are every bit as well educated as ours, every bit as capable; that their system has more discipline in it, and more basic scientific knowledge is taught.

I must add one other comment. From many other sources comes this fact: that in the Russian technical courses a man is educated more in depth and less in breadth than in the United States. It means that he's likely to come out more a specialist. He may come out as a structural aeronautical man. He might not be so good, for instance, on static bridge structures, because he would have had depth only in aeronautical structures.

The Soviets tend to produce people who go to work "tomorrow" when they get out of their courses. Many of our colleges avoid this. They tend to try and give breadth into the thinking processes and give broader acquaintanceship with more different things.

Now, if I consolidate my answer, I do it this way: To paraphrase a well-known quotation I think the American system tends to teach more and more about more and more until at times it teaches nothing about everything. The Russian system teaches more and more about less and less until it teaches everything about nothing. Two different approaches.

QUESTION: In line with your reasoning, and in line with what you mentioned earlier about the number of people going into sciences, is there any real way that we could get people into taking science courses? Is the program that we have now lacking in some way? What should we be doing?

MR. WARD: Yes. Wherever a result is poor, something is lacking; and our result is poor. This is, of course, quite a complicated subject. The psychologists and students of education tell us that everyone is not fitted to go into science and mathematics. I've seen various percentages, and they run generally less than 20 percent. So if something less than 20 percent of all of the students in the United States went into science and engineering and technology, it would mean that we would have everybody that really would be proficient.

The Russians have a method of determining scientific capability. A very good method, incidentally. Decisions are made while the students are in secondary school, through their state educational agencies--and

all students are graded, men and women. They make no distinction, incidentally. And then the students are approached by an agent of the state if they're above a certain limit, which is very carefully appraised by the academicians. The student is said to be approached in this fashion: "You're good in math and the sciences, so for the good of the State we'd like to have you accept a scholarship, with all expenses paid, at any university of your choice, in any subject in the sciences or technologies of your choice. And if you do this, and if your grades are above [and they furnish you with a level] you will then have employment upon graduation at such-and-such a level. You will have additional privileges of this, this, this, and this."

Now, these are very extensive fringe benefits, far beyond anything we offer. If the student chooses to say "no" and that he wants to go back and work on the farm with his father, he's allowed to do it, strangely enough. Most Americans won't believe it, but he is. But the difference is that he doesn't get to a university and he doesn't get the benefits. So, obviously, human nature being what it is, and the family link in Russia not being anything like as strong as it is here, the bulk of these students do go into these desired areas of technical education, for the good of Mother Russia.

In this country we don't have anything approaching this system. The parents often leave such questions to the schools and the schools leave it to the parents. The result is that the student, as he grows up, may build a shell around himself. He doesn't discuss his future frankly with his parents, or what he wants to do. If they ask him a question, he's likely to say he wants to be a spaceman or something like that.

The point here is that we don't condition our children into thinking in terms of their adulthood. We try to preserve them as children. We protect them. We even drive them two blocks to school, and all that kind of nonsense.

That's because we're trying to protect our children, an essential difference. The result is that the schools and the parent-teacher associations are hurling epithets at each other as to who really is supposed to do what. And out of this there is, because of Sputnik--and I'm almost inclined to say "Thank God for Sputnik"--a real look at our educational system, which is going to produce good. I think we should try something between the Russian system and our present one.

Now, if I may, I'd like to read something at this point that I had in mind. This is from the Soviet Academy overseas--it indicates their research and development effort.

"Soviet Russia's 250-year old Academy of Sciences has been integrating and directing the nation's entire research and development effort since 1920, keeping the programs in line with Soviet political objectives, according to Rear Admiral John E. Clark, Deputy Director of the Advanced Research Project Division. The Soviets, in rather marked contrast to the cultures of the West, regard the sciences as being fundamental rather than incidental to the entire cultural and social life of the nation."

There's the answer to one question. He says:

"It is important for us to understand this feature if we are to understand where and how research is being done, or where it is going. The Russian Academy is the largest scientific organization in the entire world, with a combined staff and membership of more than 20,000. Of these, 1,600 are technical workers and 600 of the 1,600 are full professors.

"Technology and science in warfare have advanced so fast and far, and are advancing faster and farther, so that in any kind of war, be it limited--which is far more likely--or all-out nuclear war, that side with the highest order of technology and science on its side will prevail," Admiral Clark says. That, in effect, was the theme of our talk here today.

QUESTION: As I interpreted one of the charts you had here, it showed that for only 3 percent of our research dollars, our universities are responsible for 6 percent of our research effort. This to me would indicate that we should place more of our research responsibility with our universities. If this is so, can they assume this added research role without too much detriment to their basic responsibility for education?

MR. WARD: Well, your question shows one of the errors of my presentation. It's a perfectly logical question, but the facts themselves aren't true, for this reason:

While the universities furnish 3 percent of the dollars and do 6 percent of the work, the other 3 percent of the work they do is with somebody else's dollars. Which isn't a measure of efficiency. What it really means is that even hard-boiled industrial concerns drain off some of

their research dollar and go to universities to hire Professor X to do a job. But when they do, the funds come from industry.

The Government does the same thing. They get Professor Y; and when they do, the funds come from Federal funds. You may remember the Federal funds, dropped all the way from about 30 percent to 15 percent in terms of what the Government does in research, or in terms of the money it furnishes. And that additional money flows into both industry and the colleges.

The Office of Naval Research was a good example of how Government money flowed into that 3 percent pie chart. I have pie charts going all the way back to the end of the war, and they have changed some during this period. The Office of Naval Research had the most brilliant idea that the Defense Establishment has ever had in reaching for the problem we discussed here today. They recognized, as Vannevar Bush said, that we were using up fundamental research; that this country doesn't go in for fundamental research, as they do abroad. That was a deficiency in the American scene. And so to encourage it, they placed research contracts with universities.

But such contracts were anathema to congressional investigators and other lookers-over. They objected because the contracts said to a university in effect: "Here is X dollars for you to investigate the properties of the rare earths (for instance) the contracts didn't specify that the university had to turn in a report with all the properties duly stated or risk failure of the contract, nor did it have any other onerous requirements. The university merely received the money and was told: "This is what we want you to work on." And even that requirement was not defined very closely.

However, this concept of research contracts saved many university staffs after World War II. This was one of the most constructive and vital things that the Defense Department ever did outside its own field.

But it wasn't too long afterward that the congressional lookers-over found out that this research money was not flowing to their favorite universities. Then they began to put the system on the grill, saying: "Why look, you just opened the Federal till to these long-haired people. You didn't tell them what to do. You haven't measured the results. You haven't got a report. You haven't got a thing for this money. Where is the thing you bought?" And departments like the Office of Naval Research had to back-track and switch from the field of fundamental science

to the applied sciences. And the contracts were tied up so the poor researchers had to deliver something specific. And when he did, the efficiency of that research money was badly hurt, and is today.

CAPTAIN WRIGHT: Mr. Ward, on behalf of all of us, we'd like to thank you very much for coming down this morning and giving us a very wonderful talk and an interesting discussion period. Thank you very much.

(15 April 1959--4,150)B/en/bn