THE IMPACT OF TECHNOLOGY ON MODERN CIVILIZATION

5 October 1953

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

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ADMIRAL HAGUE: General Craig, members of the faculties, and student bodies of the National War College and the Industrial College of the Armed Forces: It is with great pride that I introduce to you this morning Mr. J. Carlton Ward, Jr., one of the members of the Board of Advisers of the Industrial College, who will speak on "The Impact of Technology on Modern Civilization."

Mr. Ward is a man of many geniuses. As an engineer he is widely known and respected. As an author he has been responsible for numerous papers on technical subjects. As a public-spirited citizen the President of the United States has called on him frequently to serve on important boards and committees. As an educator he is a trustee of Cornell University. As a corporation executive through the years he has held many very important jobs, finally retiring as Chairman of the Board of the Fairchild Aviation Company. That was in 1949, when I suspect that Mr. Ward began to think that really all these irons in the fire were just too many to handle at once. It was no surprise to me early this year when I learned--I suppose he might have found he was getting into mischief--that he had accepted the presidency of the Vitro Corporation.

His work throughout the years has always been in technology. Since he has appeared here eight times, addressing either the joint colleges or the Industrial College, we know what a fine treat we are to receive.

Gentlemen, Mr. J. Carlton Ward, Jr.

MR. WARD: That is like predicting a football score before the game. I hope I can live up to that, Admiral, and kick over the goal. Right now I will take the odds the other way.

I find that with the passage of years the subjects assigned here get more and more difficult. I even, in a desperate moment, wrote down here for some charts and found that two of my exhibits had already been presented to the Industrial College in the National Resources course. So some of my ammunition was taken away.

Now, the subject, as I understand it, is a sort of introduction into your technological and production courses at the Industrial College. It is called "The Impact of Technology on Modern Civilization," to be dealt with in one hour, with 30 minutes for questions. Since

this is a joint lecture, I will perhaps in some instances duplicate a little work that the Industrial College students may have had.

I have no written speech so I don't know how this is going to come out. I am like the saxophone player who always felt that he blew in such beautiful music, but was always amazed at what came out.

I don't know whether this title means the same thing to all of us. I don't know whether we all have the same thinking about definitions. I looked up these words, as usual, in the dictionary, and became very much perplexed at some of the things in the definitions. However, I think the nearest I could find in Webster's Unabridged Dictionary to what I think is our mission today is this: Civilization is the state of social culture characterized by relative progress in the arts, sciences, and statecraft. Then alternatively it states: "An advanced state of material and social well being."

"Technology" is defined as, "The science or systematic knowledge of the industrial arts." I think that is a little bit deficient. I would try to define the arts another way--by presenting what I conceive to be their concept and getting on with the subject.

Modern civilization, as all of you know because you are in it, is a pretty complex envelope. It involves what the humanitarians call culture, the social scientists call the adjustment to modern living, and the scientists call technical development.

Those are names; and I deplore the fact that in some universities there are groups who attach themselves to one or the other of these names and then look down on the other forms of culture as sorts of lesser craft. There are no divisions in knowledge, in truth. There are gray areas that shade from one to the other. I hope you will see how, as you go through the course further and further--I hope I can develop it today, what we are going to consider today affects culture and the social sciences, although I think that all of us here today feel we are talking more directly about the influence of science.

Now, science for our purpose today can be defined as merely the knowledge of the physical universe and its behavior. That is a manmade definition. It means a little more today than some of the classic words seem to indicate.

It would be easy to demonstrate that, if you go way back into man's history, you don't have to deal with these terms "civilization" and "science." Life then meant essentially survival, food, clothing--the primary needs.

Perhaps we had better put man in his proper environment. According to the cosmologists--who are divided as to how our universe came into being--if the earth is properly dated, it is 2.5 billion years old. Life appeared in the earliest ages in the form of very primitive cells. As life developed, man appeared, in the earliest forms that are known today, about a million years ago in East Anglia. But he was then quite a fellow, because he had built a fire; and that showed he had been around. How much earlier he was here than a million years ago we don't know; but in terms of 2.5 billion years, his advent was quite recent.

Where is he going? What are we looking forward to here today? According also to the cosmologists, the source of the friendly environment in which life has been created on this planet is the energy derived from the sun. The sun creates this energy by an atomic reaction which is now well understood. Furthermore, physical measurements indicate that the sun has been doing it for this period of a little longer than 2.5 billion years; and that, with its present bulk and content, it can provide a happy climate for what we choose to call mankind here on the earth for about 5 billion more years. It will continue to be a sun for something on the order of 10 billion years; but, as stated in the Bible's prediction, the later stages of the sun will make it impossible for man to live here. The sun will grow and become like the star Alpha Betelgeuse, which is so large that the sun looks small in comparison; and the earth then will be inside the sun. But let us today dwell only on the fact that it is up to man to find out how to live with his fellow men in the environment of this earth for what our Creator has laid down as at least 5 billion more years.

I think that is the envelope I want to erect for you for looking at today's problems. The Paley Report came as a shock to a great many people. Most of you students of the Industrial College are familiar with that report, I am sure. In effect the Paley Report simply said: "You are fellow members of this planet. You are using up the Creator's heritage at a fantastic rate." Within the past several weeks the final, edited scientific report points out the fact that in the year 2023, only 70 years from now or three generations, in the time of your grandchildren, we will cease to have enough of what we choose to call fossil fuels--coal, oil, and gas--to provide for the demands of modern civilization. That is not very long.

Turn back the pages and look at Newcomb and his steam engine. He developed that in the early seventeen hundreds to pump water out of mines from which coal was being taken in Britain. That was the beginning of the power age. That was a great turn in the history of man's civilization. Up until then he had depended upon the muscles and the backs of animals and his own contribution as the primary source for the creation of goods and his standard of living. He had used a little water power, which is an indirect contribution from the sun. But essentially, animal power and manpower were the predominant forces on which he depended for improving the standard of living and the lot of man.

It is very interesting to note that this steam engine generated an industrial revolution, which the social scientists have been studying, because the relation of man to man underwent a vital change after the beginning of the industrial age. I cite that example to show you that we cannot disconnect scientific advances from what you may label as culture or humanitarian or social science. They are completely interrelated. And so the age of power brought to the world a new set of tensions, a new set of causes for war, which we will talk about a little later.

That was an early and a startling impact of technology on civilization. We will use that as an example, although we are living through a still greater one. This one will probably be the greatest in all time, but it is certainly the greatest in history. I mean the birth of atomic power. That poor old phrase has been hammered and hammered from all angles, in all concepts, and in all meanings. The uneducated humanitarian has viewed it as man's final death, as his final ability to harness forces with which we will destroy himself. Believers in the Bible will certainly deny that as a prophecy therein. It happens to fit the cosmologist's prophecy, because "to be destroyed by fire and brimstone" literally means the sun, as it takes on its later role in life.

However that may be, this atomic age in which you live, and in which you as defenders of a civilization must perform, will have more and more to do with your future, and more and more to do with the causes of the tensions with which you must deal, as well as the solutions to the tensions with which you must deal. So, whether you be a humanitarian by instinct, trade, or profession, or not, if you want to be a truly educated man, you had best understand the implications. They are tremendous. They are far reaching. Without being a prophet, one has only to look backward to see what Newcomb and his steam engine did to civilization and to the art of statecraft, as it appears in the definition, and to man's social ability to get along with himself, as it appears in the definition.

Now, without belaboring that any further, I would like to talk about the first of these charts. But first let us start by looking at the scope of my talk. This scope, so cleverly designed by some master brain in the college--I think I know which one--reads as follows: I give you the whole words first, and then we will take it apart "A brief historical review of some outstanding technological developments that affected the conduct of warfare. A discussion of the changing pattern of our social, cultural, and economic complex--the trend toward the 'fuller life' contrasted with 'the good old days' as brought about by technological advancements. A future development of this theme as it applies to the community of nations. Considering

our diminishing natural resources, how is science overcoming this threatening depletion while still maintaining our accelerating rate of production?" This fellow has an appetite that I have never seen equaled. "How does this affect the economic outlook for our country and for the world in general?" And now the punch line, as they say in TV spheres. "To what extent can technology assure us of achieving peace on earth, good will toward all men?"

How would you like to pass that exam in a hour? Well, here we go. We are now on the brief historical review of some outstanding technological developments that affected the conduct of warfare. This is in no sense scholarly or complete. This is a frantic attempt to get something together.

The following shows technical progress weapon development:

1. Historical Weapons Inventions

   Bow and arrow
   Catapult
   Gun powder
   Guns

2. Technological Development of Recent Weapons

   Machine gun
   Poison gas
   Tank
   Recoiless rifle
   High explosives
   Submarine
   Torpedo
   Mines
   Aircraft
   Radar systems
   Jet propulsion

3. Future Weapons-Development of New Science

   Atomic weapons
   Radiation products
   Bacterilogical
   Chemicals weapons
   Advanced communications
   Plastic ammunitions
   Rochet propulsiom
   Guided missiles
   And others

The first of these weapons that have come with technological progress is the bow and arrow. You remember the classic battle in Europe in which the bow and arrow turned the course of warfare.

The second on this list, the catapult, predated the bow and arrow. It was used as far back as the siege of Syracuse, where Archimedes, so we are told, first introduced engineering into warfare. He set pitch pots on fire and tossed them at the enemy ships; he did all sorts of things.

Gunpowder goes back to ancient China. I am sure there was some Chinese philopher, if we could find his writings, who, when the first blast of gunpowder went off, said: "Man has finally found how to destroy himself." We have some of those people in our generation. I don't know whether they are Chinese or not, but essentially they belong to the same school of thinking. They are just off the beam, because that first blast of gunpowder was the portent of the chemistry to come, the first chain reaction with the liberation of chemical energy. Today that is one of the very great forces in civilization, promised by the chemists for our better welfare and for a better civilization. Its impact on civilization is right in that one subtitle.

Guns you all know about; obviously, they followed gunpowder and are historical. There were other developments that followed gunpowder. You are much better versed in that field than I am. You know what they did to change your craft and the science of war in general.

You also know that all these things have had peacetime applications--every one. Gunpowder, I don't need to tell you, was used as a means of performing great civil works, by blasting away obstacles. Guns and the bow and arrow have been used to supply food,

Now, going on to technological developments in recent weapons, you can read down that list and see that there has been an increasingly diversified harnessing of technology. The man who first produced the concept of the wheel technologically rocked his civilization. Why? Because the early civilizations were extremely primitive. They consisted largely of a man as a unit, in a cave as a place. When the time came he went out armed with a club and when an attractive member of the opposite sex entered his vision, he whacked her on the head and hauled her off; that was the first social unit. Those little social units fought with all other social units, because the supply of food, shelter, warmth, and clothing was essential. Civilization was founded on the concept of man's need, as just that.

However, since he had to depend on his own feet for his foraging radius, he never really got mixed up in international affairs. But the chap who came along and contributed the wheel greatly enlarged the scale of conquest. The man could go farther. He could harness animals and haul material farther. The impact of that technology on that civilization was tremendous, as was the earlier impact of the man who first found he could utilize chemical energy, namely, fire. Those were two enormous contributions of technology toward the subject we are dealing with today, and they go way back.

But they are so primitive in the light of today that their enormous influence has been forgotten. In this period in which these group 2 weapons, page 5 were created, we find that animal power and human power have been largely done away with. We find chemical energy taking their place. And as we do we find that technology finds new uses in war for these new forces. But they had their corresponding reverberations on the civil front. They caused enormous changes in the social fabric which we call, in a sense, civilization.

The third class of weapons, as shown on this chart, is future weapons. That is not a complete list.

Atomic weapons are now appearing. We already know how they have completely changed statecraft, politics, international relations, and warfare. And if we ever wanted a clear explanation or example of the relationship between technology and civilization, we are living through that one, the greatest of all.

Radiation products are merely another version of atomic weapons.

Bacteriological warfare is known only too well. And there comes the contribution of what we call the life sciences, which are making comparable strides with the power and physical sciences.

Chemical weapons are something else. Our company has just finished a 90-million-dollar plant for the Chemical Corps of the Army, for use in chemical warfare. We have actually built a huge plant to make a chemical which has never been put in production, which in a sense was a scientific curiosity, and which is toxic, corrosive, and explosive. If it were not for the advanced technology of today, it would obviously still be a scientific curiosity. As it is it is being produced in a 90-million-dollar facility, and God help the enemy.

Advanced communications you all know about; communications are another of the great impacts of technology on civilization. In the old days, when a famine in China would not be learned of for months and months, by the slow wafting by nature's breezes of ships halfway around the world, it didn't appear to be pertinent. The probability was that

the famine was over when you heard about it. So the impact on our far-off civilization was minor, if it even caught you at all. But with the advent of practically instantaneous means of communication, starting with the telegraph and the cable, followed by Marconi and the wireless, then the telephone, and then the wireless telephone, and now that giant of the industry, television, you and your children know how that has changed the pattern of family life, one of the great ingredients of civilization.

These things are the directing forces of civlization, not the creatures of civilization, as they are so often put. The busy little engineer who built the first automotive vehicle never thought he was destroying the centralization that was occurring in great cities and dispersing those great cities into the countryside. He never realized that he had changed the pattern of the lives of all the people by roads and the automotive engine.

So the first adoption of steam, combined with the wheel, and in conjunction with the slow acquisition of speed in communication, shrank the world, until during the war one great aircraft company advertised: "In Jules Verne's day the world was 80 days large. Today it is 40 hours large." Jet propulsion shrank it further. As you know when now in the United Nations a cause of world tension appears, technology transports, not only resident ambassadors to a place of meeting, but the makers of policy, the prime ministers, in a matter of a very few days. International problems are dealt with by the principles face to face. And that is changing the art of politics and statesmanship and international relations.

The impact of the airplane is only too patently and too obviously changing the relations of people. The difficulty, frankly, is that the busy little engineer, in creating these new objects that stem out of the new science, is bringing the world together faster than the minds of people can come together with their inertia. And mental inertia, gentlemen, in my humble opinion, is a far more rigid medium than physical inertia. We can deal with physical inertia after a fashion, but mental inertia is still not a science, and dealing with it is an art. The art is in its very early stages.

But it is technology that is doing this. The culturalists and the humanitarians are doing it in reverse. They think that man's mind should enhance progress fast enough to assimilate these impacts of technology. But, frankly, it is not and has not.

So this subject that you are about to embark on in your course is, if anything, the hub and the substance of what you must study and learn and apply. Whether you be in the War College or the Industrial College, it is the determining medium that builds the envelope within which framework you must harness your skills.

I won't go on to the rest of the new weapon systems. They are too many, and this list could be greatly enlarged.

Chart 1, page 10, shows the changing pattern of our social, cultural, and economic trend toward a fuller life, contrasted with the "good old days," as brought about by technological advances. This is a curve that I presented two or three weeks ago to the committee hearing testimony on the new bill to supersede the McMahon Bill on atomic power.

In essence there is a little abracadabra in this thing, and I want to explain it. Everything on this chart is true; but, like the definition of a statistician as a man who draws a straight line from an assumed objective to a foregone conclusion, this is partially tinged with that. On the other hand it represents a great truth, one which I find difficult to deal with, because it is obvious.

It says in fact--and I will try to show you why--that the standard of living is exactly commensurate with man's ability to utilize the forces of nature. This curve lacks certain elements, but it is substantially correct within the limits of statistics. You will find accurately plotted on there, as far as the economists can measure it, the direct curve which is the standard of living. You can see the depression very clearly. You can see the accelerative effect of the production for World War II. But, if you will notice, the standard of living integrates through those hollows and those rises. You will find the sweep of the curve to be identical with that of the power production of the United States.

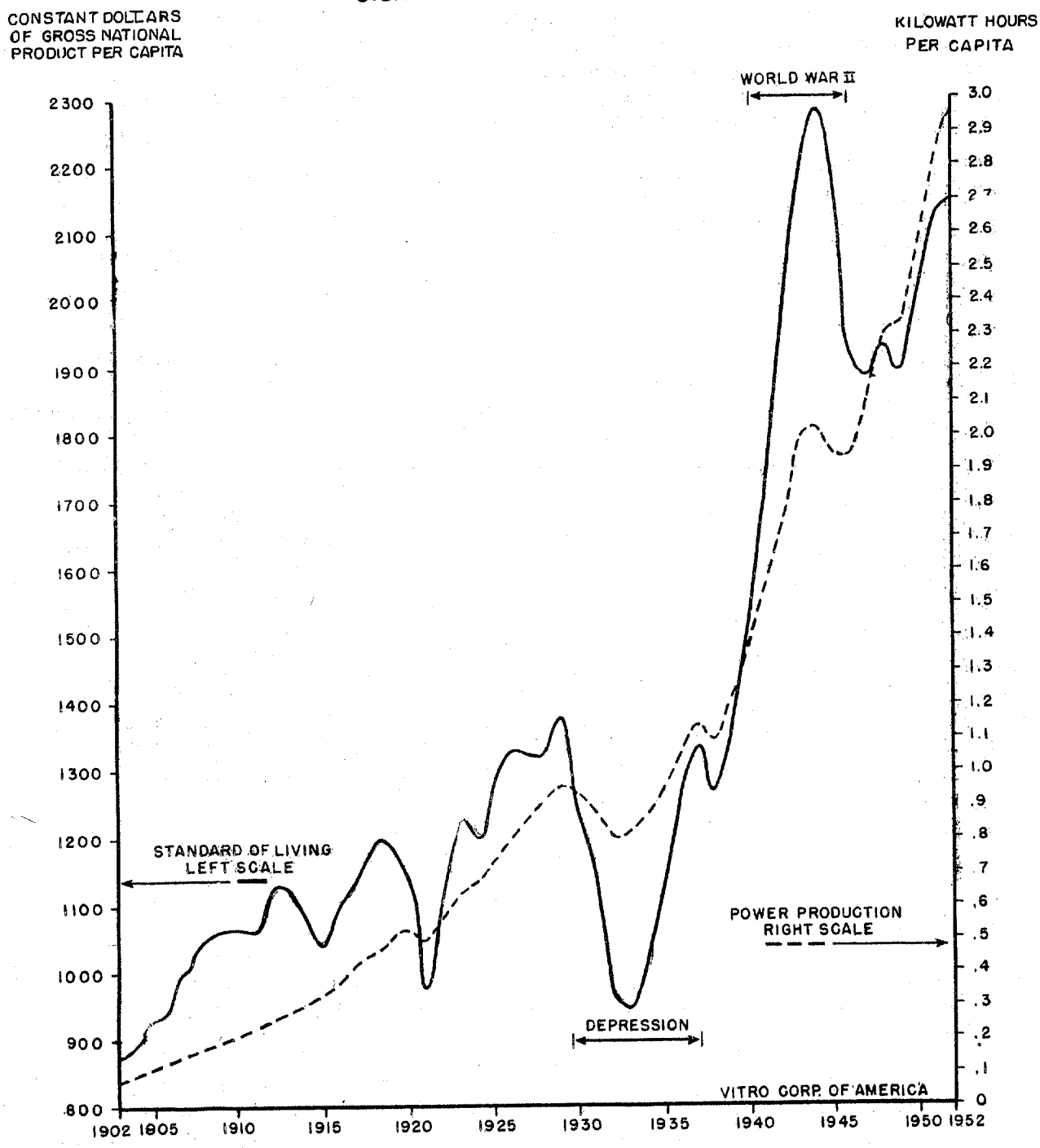
In other words if you merely take the statistical figure of the kilowatt-hour generation in the United States in any year, you can immediately find the standard of living in the United States by dividing that by the number of the population in that year. And if you go at it in the complex way of the economists and the social scientists, by taking the total goods produced in the United States and dividing that by the total population in the United States for the same period, you will arrive at the same spot.

The finagling in this chart came about in this way: The favorite trick of the statisticians and the economists is to fix upon a certain year, a certain period, and say, "This is the normal." Of course it isn't. It is normal only by definition. You can do almost anything by definition. So when you read many of these curves, you must question whether the normal is really normal for what you are going to apply it to.

I did not do that. I picked no normal. I drew the actual curve of Kilowatt-hour output. I took the actual curve over as long a period as I could get the proper statistical figures. You will see that it goes back to 1902, long before World War I. You can call it back to the good

CHART 1

U.S. STANDARD OF LIVING
VS.
U.S. POWER PRODUCTION



old days, to go back to the terms of my assignment. You will find that those two curves virtually overlap. They are not based on anything being normal. They are just two curves. They are compatible.

Now, further, they are reduced to a common dollar. Somebody asked me what that common dollar was. He said he would like to meet it. It doesn't matter. It is a dollar. Let us call it a pfennig, a kopek, a yen, or anything. It is a common unit of monetary measurement. I don't care what year it is either, as long as it is all reduced to the financial measurement of that particular year's currency. That is one thing you don't see in most curves and the lack of it gives them a very distorted effect. A curve expressed in dollars of goods produced this year versus those produced 10 years ago doesn't mean a thing without that common dollar. The dollar today is 50 cents. So if you take a curve for 10 years ago, you have to make enormous changes in it.

This curve of mine does away with that distortion. I spent some time on this, because I wanted to show it to the Atomic Energy Committee of Congress. I wanted to show it something that the Paley Report brings out--that if technology doesn't find a substitute for our waning resources of fossil fuel, civilization will halt. Certainly we won't be here 5 billion years from now when the scientists say that in the year 2023, the time of your grandchildren, they will no longer have enough fuel, oil, and gas.

I know I am using precious time, but there is one more point that I do want to make clear; that is the difference in the standard of living between countries is so great that, if we were to lift the rest of the world up to our standard, we would have to perform this calculation: We have one-sixteenth of the world's population, I believe. We produce half the world's goods. If the other fifteen-sixteenths have to come up from their low production to our level, the depletion of our natural fossil fuels will be so stupendous that perhaps in the lifetime of some people here it will be a headache.

Now, the social scientists, the "do-gooders," the Point Four boys, and others, would like to see this done, because, obviously, it would remove the great cause of international tensions. But, if we do that, we must have technology, because they could not have public utilities and kilowatt-hours in the absence of technology. So this great outpouring is the engineer's challenge to put technology to work. Heaven knows, he is putting it to work. But it also is an underlying cause of war, as well as a tool with which to fight war.

So let us understand the impact of technology. Let us see it in its framework. Let us see what happens when we apply it more skillfully.

Let us cut out the argument about whether this piece of research can be afforded or not. If it is fruitful research, we cannot afford

to be without it. The emergence of the United States from a nation of practically no research in World War I to a nation spending over 2 billion dollars a year on research today is a perfect example of the intrusion of technology.

Chart 2, page 13, is a very interesting chart. It shows the raw materials used in making synthetic rubber. In the first group there are coal, grains, sugar, molasses, petroleum, and natural gas. Together they form styrene, the basis for a great family of plastics, as well as one ingredient of buna S rubber, which is the big classification for synthetic rubber.

Just below that, in the second group, there are the raw materials for the other ingredient of buna rubber--butadiene. Again you see our olf friends petroleum, natural gas, grains, sugar, and molasses. All of these are not used at the same time. They are alternates. Both molasses and sugar are not used. Grains can be used to get sugar. In fact it is an interrelated group of raw materials.

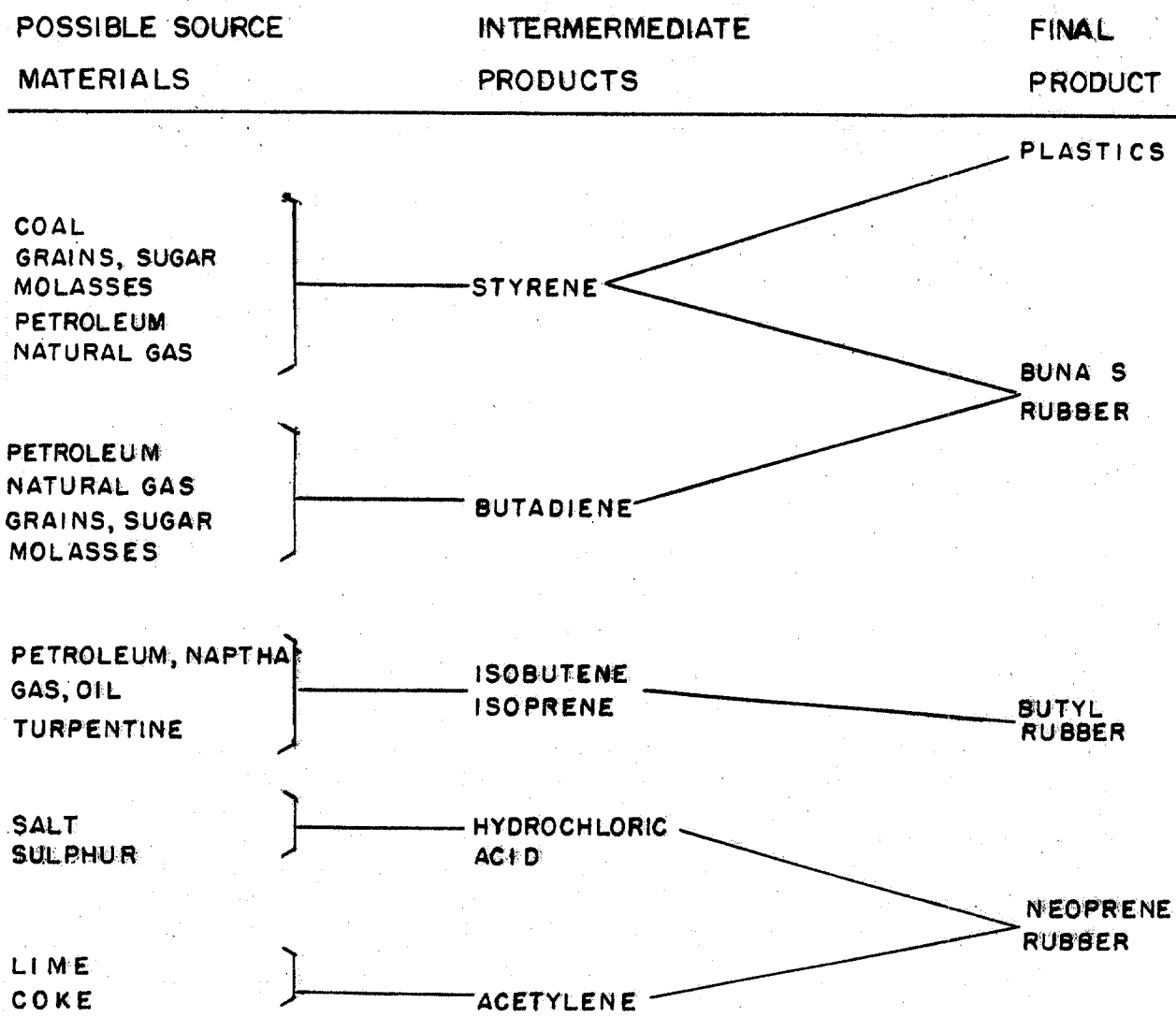
In the third group you see again your old friends, petroleum, naptha--a derivative of petroleum--gas, and oil. Together with turpentine, they form isobutene and isoprene, which give butyl rubber. That is a very new one, just coming in, but important. It is very unique, because it will do things that buna rubber cannot do. In the field of electric wire and cable the great development of the moment is butyl rubber, because it will stand high temperatures. The fellow on a battleship who has a great fire-control cable running through an area where the temperatures may become high is pretty certain that his fire-control system will operate under conditions where there is damage, under battle conditions and the like, where otherwise that would not be the case. That is just one of the fundamental uses of butyl rubber.

Down further in the next group there are salt and sulphur, which go to make hydrochloric acid. In the last group are lime and coke, which make acetylene. Put those two together and the result is neoprene rubber, which has very unusual properties, such as chemical resistence and weather resistence.

Those are all primitive research. I remember the director of one of the great Du Pont laboratories talking from this platform about research. He said: "The amazing thing at the Du Pont Company today is that, whereas at first our research was devoted entirely toward finding new materials that we could harness and sell to the public, we have found out how to make no many new materials that now we are directing our research toward trying to find out how to sell the public on some of the ways to use the ones that we have." And that is a real task, because they spent 22 million dollars to bring in Nylon. After they knew how to bring Nylon in, they spent another 22 million to bring Orlon in. So it is a very important area of research, but the whole accent has changed.

CHART 2

RAW MATERIAL IN SYNTHETIC RUBBER



What you are seeing now is that at the very same time that technology has advanced so far that there are so many more things that can be harnessed for the betterment of civilization, we haven't enough people to put them to work. There is a challenge in the impact of technology on our civilization.

The following is a list of new materials derived from research and technological development:

1. Butyl and buna rubber, neoprene, and plastic.
2. Nylon, orlon, dacron, rayon, and acrylon.
3. Ureas, nitrates, and formaldehydes.
4. Elemental metals and rare earths.
5. Antibiotics and pharmaceuticals.
6. Silicones and fiberglas.
7. Cellulose products.
8. And others.

First, are our old friends--butyl rubber, buna rubber, neoprene, and plastics.

Second, we have these new fibers--nylon, orlon, dacron, rayon, and acrylon--which are now making waterproof suits, grease-proof suits, and so forth.

Third, there are ureas, nitrates, and formaldehyde, which go to make another new family of plastics and other new materials.

Fourth, we have the elemental metals and the rare earths. These new rare earths are not rare at all in terms of what we think of as rare. They are going to revolutionize metallurgy in a very fundamental way. There you have a new impact of technology on civilization. There are the materials such as lanthanum, dysprosium--some I can't even pronounce, let alone explain--and a very strange one called hafnium. These are things for the future. There are titanium, zirconium, columbium, cesium. We are already dealing with the first three. All of these are coming into very important use. Their properties are being studied for new atomic reactors. They have been great, new additions to the metallurgist's spectrum, because now he has a strange new world of semiconductors, out of which vacuum tubes are being replaced for several uses. Again the impact of technology.

This list shows the technological developments having future potential.

1. Atomic power.
2. Ultrasonics.
3. Coal hydrogenation.
4. Oil shale extraction.
5. Chemistry of radiation synthesis.
6. Food sterilization and preservation by radiation.
7. And others.

The first one, atomic power, we have to discuss in particular. I don't like that name. It is not really proper to speak of it as atomic power. We ought to call it the atomic age, because the atom is going to have many uses entirely separate from power. In the Atomic Energy Commission there is a large body of thinking that the really great contribution of atomic science lies neither in weapons nor power, but in the very strange field of isotopes.

I consult with a large company that is very remote from atomic power, and I have been telling its representatives about things they can do with isotopes in their daily production. And so, after two years of examination, they have found some of these potential uses for isotopes. They are invading all areas of life.

The first invasion of isotopes was in the field of health. There the science of isotopes is making terrific contributions--such things as measuring the speed with which nutriments can pass through the walls of the digestive tract; how valuable, life-giving chemicals are transmitted through the cells of our circulatory system; what chemical balance is and what factors affect it. It is providing means for curing diseases that only had names and couldn't be explained. It is giving us definitions of diseases that had names but weren't understood. The life span of the human being will obviously be extended. Heaven knows what that will do to this obvious need for more power, as shown on the other chart, when we have less coal and fuels. The impact will be compounded.

Ultrasonics is a very strange and interesting area. It has been shown that ultrasonics can kill bacteria by high vibrations. It can sterilize milk and food. It can also destroy metals, shatter atoms, do very strange things. That field is relatively unexplored.

Coal hydrogenation is merely a method of using our resources in fossil fuels to a better degree.

Oil shale extraction means getting more fossil fuel out of the earth. One-sixteenth of all the fossil fuels has been used up since Newcomb's invention. The present rate of use is given on the power chart; hence the 2023 year as the year of exhaustion or beginning exhaustion.

The chemistry of radiation synthesis is an almost completely unknown field. It is being worked in by only a handful of scientists, who see in it some of the greatest of all developments for the future. It offers a means of putting together chemical elements that cannot be put together by any process of chemistry. You are using there the great energy of radiation for hooking together valences of chemicals which otherwise cannot be brought into chemical union. New materials have been made by the chemistry of radiation synthesis which cannot be made by ordinary chemistry. This field offers great possibilities, even with a minimum number of people working in it, because it is a terrifically rich field. We lack competent scientists to explore it.

Food sterilization and preservation by radiation come into use in many interesting ways. This was a byproduct of the plutonium reactors at Hanford and other places.

Chart 3, page 17, shows the relationship between manual labor, animal labor, machine labor, hours of work, and national product.

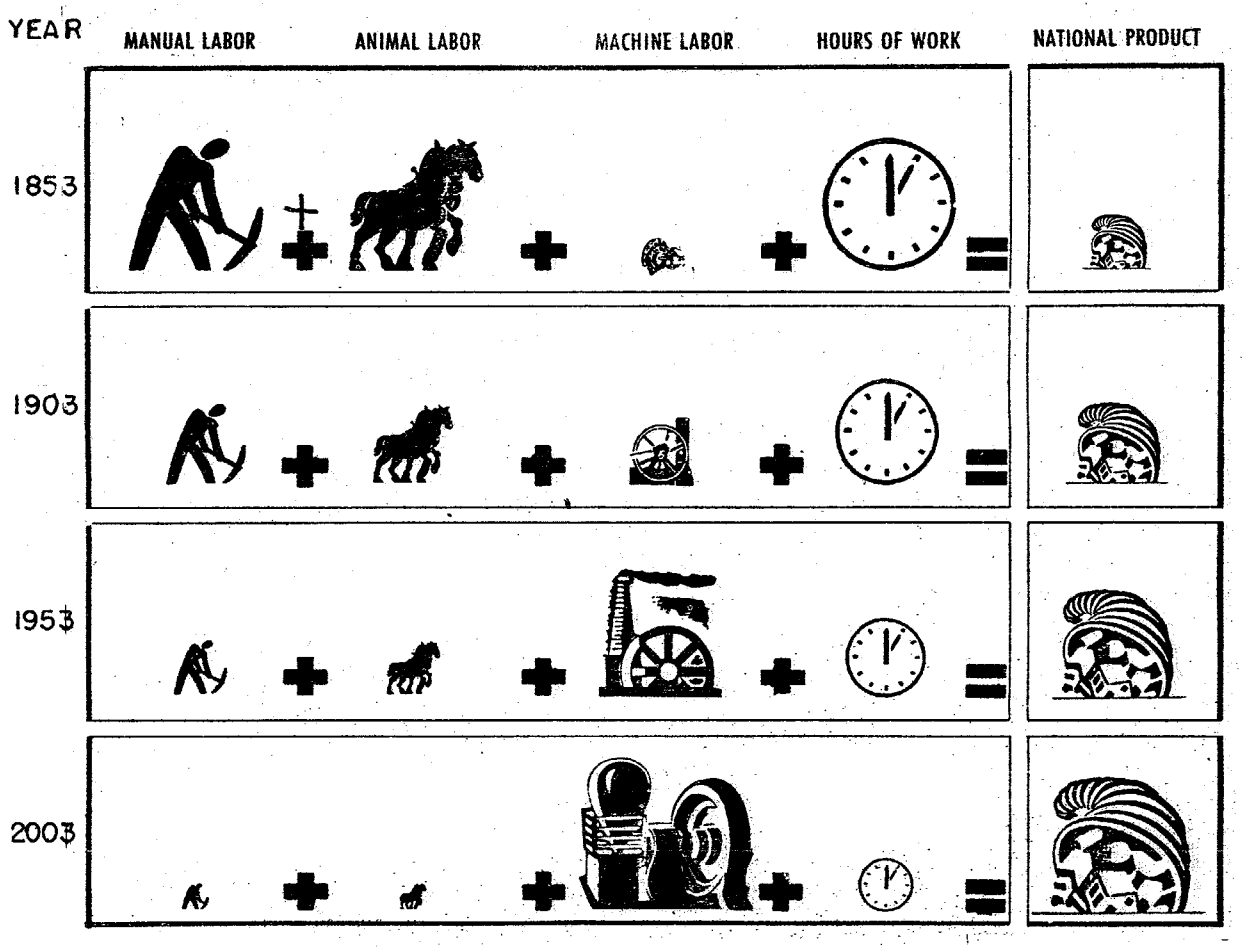
This Chart is a Du Pont exhibit. It shows for the years 1853, 1903, 1953, and 2003 the relative importance of manual labor and animal labor compared with machine labor. It shows the major contribution made by machine labor to our national product. We can see in 1853 the very long hours worked and the very low national product. In effect this chart tells that as manual labor goes down and animal labor becomes almost extinct, machine labor comes up. As we harness natural forces and chemical energy, the hours of man's work become less, but the production becomes more. Therefore his culture becomes more. As the humanitarians say, it gives you more time to think. The question is, Think about what?

Chart 4, page 18, shows a further development of this fact as it applies to the community of nations. This should not be the subject of a one-hour lecture, but a whole course. This shows some of the principal nations of the world. The horizontal black line indicates the standard of living. Here you have the standard dollar, I am told.

Now, if you follow down this column, you come down here to poor old Burma and you see that it is one of the 20 leading nations of the world in standard of living. This does not include them all, because some of them, like the aborigines of northern Australia, have a standard of living so low that it would not even be a dot on this chart. This takes in only the principal ones.

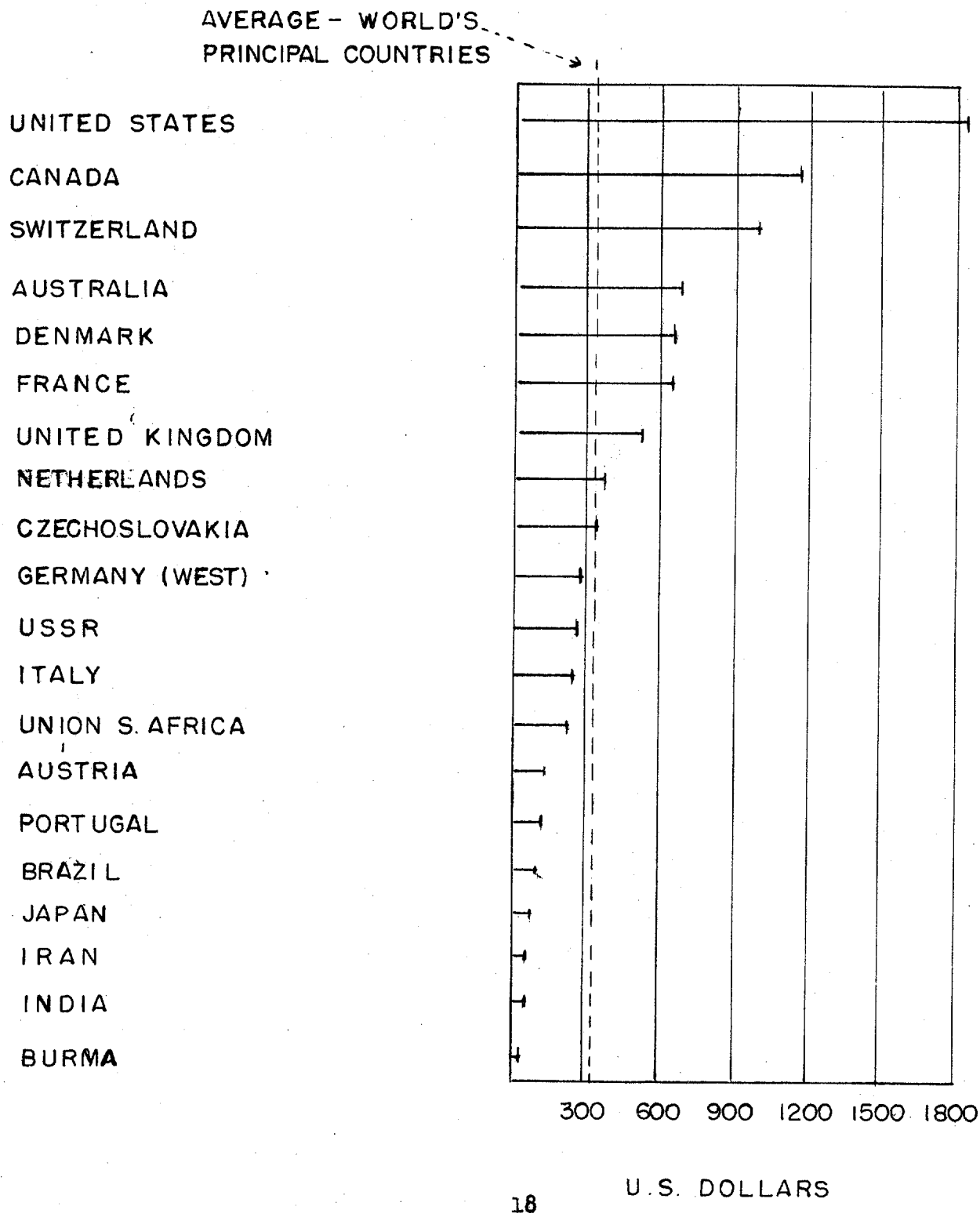
Look at the average standard of living and see where we are in the United States. If you should try to bring up the standard of living merely in the 15 principal countries, the best nations, to that of the United States, think what that would do in the way of depleting the natural resources of the world. Do you wonder about the impact of technology?

CHART 3


YEAR
MANUAL LABOR
ANIMAL LABOR
MACHINE LABOR
HOURS OF WORK
NATIONAL PRODUCT
1853
1903
1953
2003

PER CAPITA INCOME CHART 4
1951

(EQUIVALENT U.S. DOLLARS)



I am not going to spend any more time on this subject. The difference between different countries in the standard of living is a cause of war. It certainly is one phase of civilization. For instance, in the USSR, which you see on this chart in the middle bracket, perhaps what you might call a low average, its people have done a perfectly amazing job of bringing up their standard of living in our time. But look at the distance they still have to go to catch up with us.

No wonder Malenkov is having a little difficulty on the consumer end of his home front when we consider what he is doing with respect to war. War certainly plays a part in civilization. Half of Russia's production goes to preparation for war. Therefore, if we cut that line for Russia on the chart in two, taking out the half that goes for war, we would have a true comparison between the poor consumer in Russia and the consumer in the United States.

There is a field for the impact of technology for anyone who wishes to eliminate one of the primary causes of world tension and the creation of war.

See chart 2--now we are going to this part of the scope: "Considering our diminishing natural resources, how is science overcoming this threatening depletion while still maintaining our accelerating rate of production?" That is the 64-dollar question.

We are back to our old friends again--the raw materials used in making synthetic rubber. If you look at this list closely, you will see that you can divide these raw materials into two classes. One class is the fossil fuels, or stored-up resources, and the other is annual resources. Let us think a moment of that.

A strange group of scientists have been examining this field for some time now and have come up with the background for a new applied technological science, that is, the harnessing of things that can be grown in the field for use as raw materials for things that are to be manufactured, not eaten. You will note that molasses, grains, and sugar are three annually produced raw materials in the first group. You see grains, sugar, and molasses again in the second group; and turpentine in the third. From there on we are dipping into permanent resources.

It took, according to the geologists and the geophysicists, 300 million years to deposit our fossil fuels, all from secondard energy received from the sun. We are using them up in 300 years, a ratio of a million to one, historically. That is an impossible equation by any formula of arithmetic.

Where is the solution? Well, it lies in a very simple thing. Where did coal come from? It came from the sun. How did it come from

the sun? It came as radiation energy captured by a complex chemical, which, in terms of my theory--with no science to back me up--was brought into being by radiation from the sun. If I had time I could develop that theory. It isn't worth the time.

The fact remains that the sun's energy is captured and converted into these fossil fuels. The fact remains that there falls on the surface of the earth every day 2,000 times the total energy that man is using in all civilizations on the earth today. And that will be a continuing source for 5 billion years. If you want a challenge to technology and science, there is a dilly.

Now, we can capture the sun's energy that part of it that comes to our little orbit, our little zodiac. We can capture it by, using water power. We capture it when we generate electricity from water power, and also when we generate electricity by burning fuel, when we use chemical energy. But the whole world is doing that already. That isn't any solution.

We can capture the sun's energy by harnessing the wind. That has been tried. It has been captured in a limited area by technology. But it does not have an economic payoff. The apparatus necessary to capture wind energy is so expensive and elaborate in terms of the energy output that it is not a good approach, not with today's knowledge.

If we cannot capture the sun's energy as the wind or as the water, the rise and fall of the tides, how then? The real energy comes down as radiation. It bounces off the earth and goes back into space at night. It provides a climate at night which is healthy and salubrious as opposed to what would be the climate on the moon at night. No electric blanket would ever save the day there.

The capturing of that energy is a challenge to science. Chlorophyll, the only chemical which captures the sun's radiation by photosynthesis, has an efficiency cycle of not much over 1 percent. It can be brought up by selective plant breeding, but not much over 1 percent. But still, 1 percent of the sun's energy would be 20 times the total energy used on the earth today.

But there are other approaches to that problem of capturing the sun's radiation energy that we have not started on yet. Science is beginning to turn its beady eye in that direction. The next impact of science on civilization must lie in this field of man's perpetuating energy. If we want a good example to cite to the none-too-good humanitarian or the unread social scientist, there it is, because everything he does depends upon the solution of that problem. Everything our grandchildren can look forward to depends upon the solution of that.

The next subject is, How does this affect the economic outlook for our country and for the world in general? From the natural resources portion of the curriculum we learn that nations are not self-contained nor self-sufficient.

Charts 5 and 6, pages 22 and 23, (charts from ICAF report R157), show a very able and fine compilation of the lack of self-sufficiency in some of the primary raw materials for the United States if it is to continue its civilization, or if it is going to be able to fight a war. You will find that even in such simple things as copper we must import one-third of our total supply. Copper is a sinew of our power industry, which is a sinew or the background of our standard of living. It is true that aluminum is coming in as a competitor for copper. Electric wire and cable are using increased quantities of aluminum. There are plenty of areas where it can be substituted for copper, and with economy. Aluminum, with some further technical advantages, will increasingly become more attractive. In spite of all that, we still lack the sinews of distribution in our power resources as we stand today.

I picked that out as an example of what you will see when you read these charts. When you finally come to such things as tin, tungsten, asbestos, manganese and mercury, which you all know about, you will find there are some real deficiencies.

The list of deficiencies increases with time, as out technological impact increases with time. As we harness more and more of nature's resources, our deficiencies increase. We have definitely, as the Paley Report points out, passed from a self-sufficiency status into what is the reverse. That is a very serious problem for the leading nation of the world, with the highest living standard, the envy and target of all other civilizations, containing only one-sixteenth of the world's population. There is a formula for world unrest if there ever was one, and for a somewhat semistable condition in a world like that of today. That is our biggest insecurity.

Chart 6 gives a list of the mineral imports which we are now frantically seeking, of course in friendly areas. Therein lies an equally interesting factor in what the United States must consider now as a major technological need. But locating these resources in quantity and in countries friendly to us or that can be controlled by our armies, our navies, and our air forces enough to carry us through this period in world affairs, where our technology and standards of living create these enormous tensions, is also an invitation to warfare. That little formula perhaps is the best definition that I could give of the world's insecurity.

Now, to what extent can technology assure us of achieving peace on earth, good will toward all men? I happen to have believed for many years that the answer to this world's ills lies in the implications of that sentence. This I urge very strongly, and my reason is that selfpreservation is the strongest of all human instincts and needs. Intelligence to assess the world's tensions, coupled with a natural

CHART 5

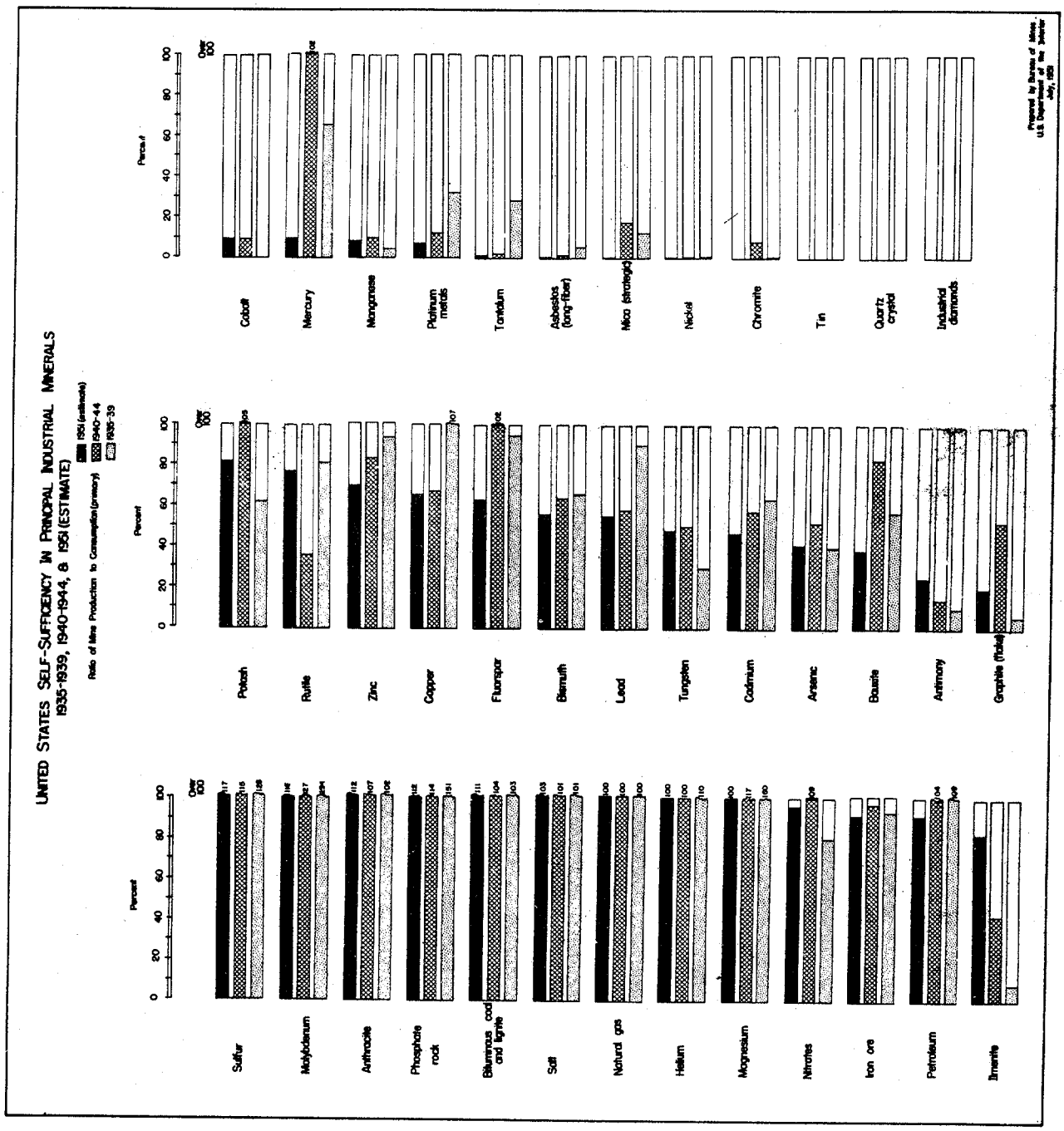
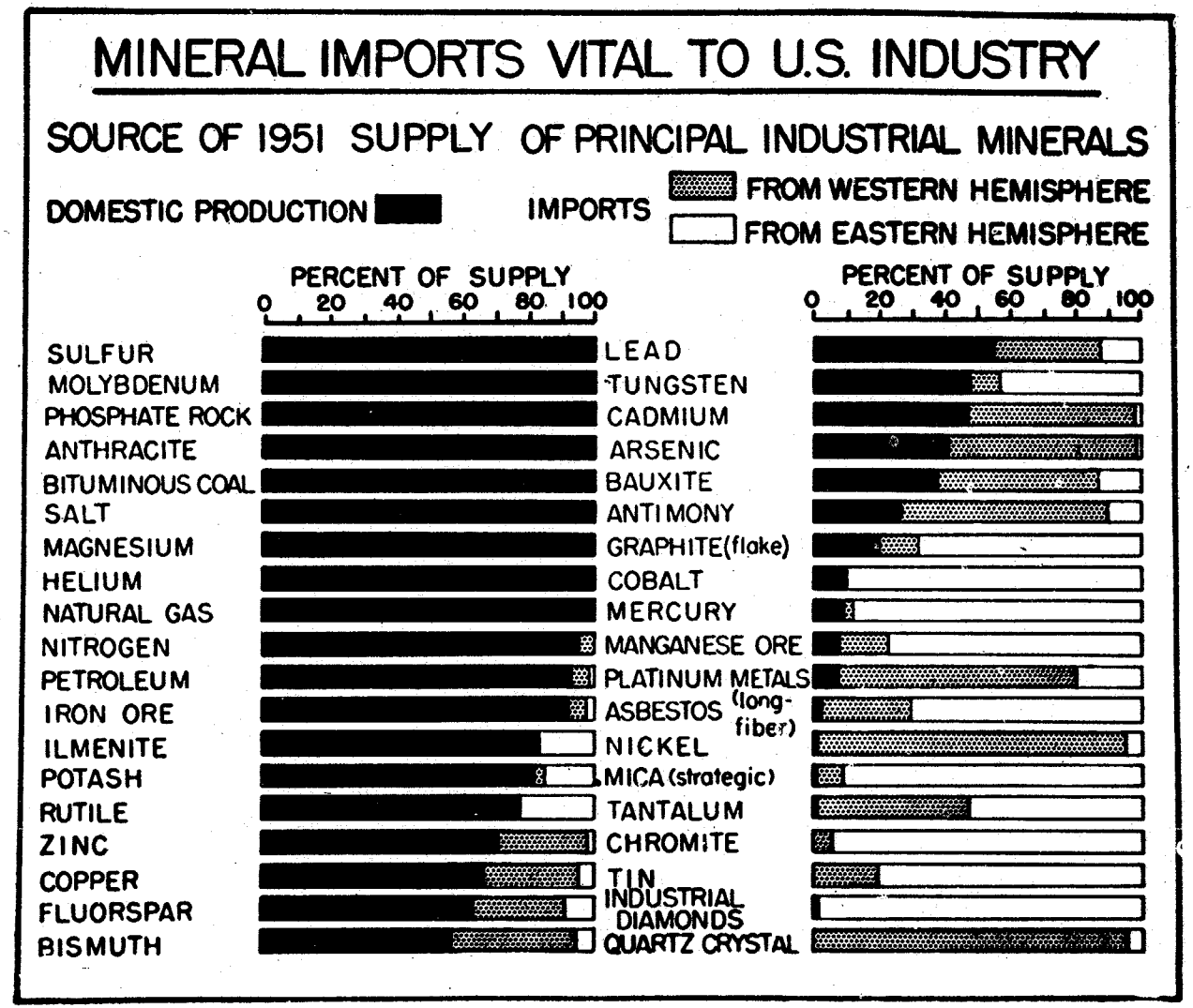

UNITED STATES SELF-SUFFICIENCY IN PRINCIPAL INDUSTRIAL MINERALS
1935-1939, 1940-1944, & 1951 (ESTIMATE)
Ratio of Mine Production to Consumption (primary)
1951 (estimate)
1940-44
1935-39
Percent
0
20
40
60
80
100
Over 100
Sulfur
Molybdenum
Anthracite
Phosphate rock
Bituminous coal and lignite
Salt
Natural gas
Helium
Magnesium
Nitrates
Iron ore
Petroleum
Ilmenite
Potash
Rutile
Zinc
Copper
Fluorspar
Bismuth
Lead
Tungsten
Cadmium
Arsenic
Bauxite
Antimony
Graphite (flake)
Cobalt
Mercury
Manganese
Platinum metals
Tantalum
Asbestos (long-fiber)
Mica (strategic)
Nickel
Chromite
Tin
Quartz crystal
Industrial diamonds

CHART 6


MINERAL IMPORTS VITAL TO U.S. INDUSTRY
SOURCE OF 1951 SUPPLY OF PRINCIPAL INDUSTRIAL MINERALS
DOMESTIC PRODUCTION
IMPORTS
FROM WESTERN HEMISPHERE
FROM EASTERN HEMISPHERE
PERCENT OF SUPPLY
0 20 40 60 80 100
SULFUR
MOLYBDENUM
PHOSPHATE ROCK
ANTHRACITE
BITUMINOUS COAL
SALT
MAGNESIUM
HELIUM
NATURAL GAS
NITROGEN
PETROLEUM
IRON ORE
ILMENITE
POTASH
RUTILE
ZINC
COPPER
FLUORSPAR
BISMUTH
PERCENT OF SUPPLY
0 20 40 60 80 100
LEAD
TUNGSTEN
CADMIUM
ARSENIC
BAUXITE
ANTIMONY
GRAPHITE(flake)
COBALT
MERCURY
MANGANESE ORE
PLATINUM METALS
ASBESTOS (long-fiber)
NICKEL
MICA (strategic)
TANTALUM
CHROMITE
TIN
INDUSTRIAL DIAMONDS
QUARTZ CRYSTAL

desire for self-preservation, are the forces which will utilize the tool of technology to hammer out the solution. It will not be in the minds of great statesmen, except insofar as they are instruments for carrying out this formula. It can be done only in the United Nations when these tensions have been lessened by the impact of technology.

In two ways technology, as I see it, contributes toward the problem of our future security. While it has created the disparate economi in the world, or accentuated then, it has also at the same moment, like a bacterial disease in the body, generated the antibodies to overcome the disease, if the patient lives. We can apply that exact simile to the very disease of disparate economies. It is offset in part by the antibodies of the technological forces for the preservation of peace.

We say: "Quite the reverse. It is Russia's atomic and hydrogen bomb versus our atomic and hydrogen bomb." I merely say that if we will turn backward and reanalyze our history of war from the early days, when it was fought by mercenaries or professionals to that frightening change that occurred to total war, and then from individual weapons of destruction to mass weapons of destruction, and add to that man's desire to perpetuate himself, we can compound a philosophy through which, by making war impossible because of its destruction of civilizations, not merely of cities, of armies, of navies, or air wings, will cause even men of passion, who will become victims, to withhold the statesman's judgment to unleash their weapons. Who in the Kremlin, where we assume there are no moral concepts, no religious concepts, no spiritual concepts, where Marxian materialism controls the politics of a vast area of people, would unleash a set of forces with a sure knowledge that the counterforces would terminate his existence?

Thank you.

COLONEL KLEFF: Mr. Ward is now ready for your questions.

QUESTION: You made no reference whatsoever to the future utilization of atomic power as such. Would you care to comment on that?

MR. WARD: Roughly it is this: So far as I have been able to have access to these figures, the assumption today is that, with the breeder principle as it is--we must recognize now that the breeder principle has only just been proven possible and the ratio of breeding is still practically unknown; but assuming the breeder principle as it is known today, and assuming the conversion of U-238 to useful fuel, then assuming that we can convert thorium 233 into useful fuel--we would have something on the order of, depending on our computation of their extractability from the earth's crust, maybe 10 or even 20 times the potential availability for power sources of what we have in fossil fuels.

However, we won't get the solution right now. The theory at present is that it will provide additional breathing time for the human race to solve the real problem, because, even if it should give you the full 20 times--which we must agree is somewhat optimistic--it would still not last too many years, because the standard of living will be growing in the meantime. It doesn't stand still. And if we bring the rest of the world up to our standard of living, our ratio of consumption of our power resources gets pretty fantastic.

Seemingly the only long-range approach to that is the direct harnessing of the sun's radiation. So your question is a very practical one and does indicate that the human race has more time to really solve the problem, provided it first satisfactorily solves the problem of atomic power generation.

QUESTION: You mentioned the harnessing of the sun's power and referred to the 1 percent efficiency of chlorophyll. Perhaps I am alone in this, but I didn't understand the other methods that are being experimented with, that are being used or could be used.

MR. WARD: It is an old theory, of trying to concentrate the sun's rays so that we can get their energy in a small area and thus harness them mechanically. We can build sun engines that will run. There are houses that are being heated experimentally by that method. People are living comfortably in them in winter. We have to rotate the house to take care of the sun's orbit changes during the winter period.

Then there is another very interesting source of energy, which I did not have time to talk about--that is the energy of the earth's crust. It is assumed that the earth's crust is only about 20 miles thick, and that below that everything is in a practically molten state, at a very high temperature. As you progress toward the center of the earth, it becomes one solid iron ball of extreme temperature.

That heat presumably is all coming from an atomic reaction that is going on down in that area of the earth. That reaction is known and it is a fission source. As you know, as a miner goes down in a mine--I have forgotten exactly what the coeffecient is, but it is something like this: that for every 100 feet of depth there is one degree increase in temperature. Down in the South African diamond mines, which are very deep, it is not comfortable to put a hand on the wall rock. Those African natives cannot work long at a time down there in spite of the ventilation.

That heat can be used. As you know some companies are making a device they call the heat pump by which a house can be heated by just drilling a hole down in the earth below the house, not too deep, and taking advantage of the temperature differentials. By means of a

specially designed device, this rather low temperature differential can heat your house. Obviously, if we could heat all our houses from the energy in the earth's crust, we could take an awful load off fuel consumption. These are all impacts of technology on civilization, our subject for today. We don't have time to exhaust them all.

Let us say that it is possible to increase the efficiency of chlorophyll through plant breeding. Let us say that we use the earth's crust heat. Let us say that we find means to further expand the use of the heat in the earth's crust, as they are now doing in Italy, where they generate power directly from steam coming from the earth's crust. Of course, you could do it also in Yellowstone Park, in northern New Zealand, and a lot of other areas, where there are open steam vents that could be harnessed. But these are all drops in the bucket.

Man's destiny lies in the things I discussed in the lecture. These other things are all accessories after the fact. I think they will all be applied eventually. I noticed in a technical magazine that a large building has bought a complete heat pump system. This is not a home; it is a big industrial building. They say it is really practical. That heat pump for house heating is a very interesting development.

QUESTION: I noticed you confined your attention to getting atomic energy directly from uranium. Do you see any prospect that we might possibly be able to work with some of the other heavy metals in that area?

MR. WARD: Well, there is the actinium series. But there is very little of that in the earth's crust. Actually, uranium 235 is a decay element in that actinium series. I don't think there is very much of that.

When we get down to lead, we have run out of elements that are suitable for the purpose. And these elements that lie above uranium--neptunium, promethium, californium, and so forth--are all manmade. They are all very unstable. We waste more time making them than the energy is worth that we get back out of them.

The real source would be to go to the elements at the other end of the periodic table. There is more energy available in the light elements through a fusion system than there is in the heavy elements through a fission system. The very process by which the hydrogen bomb is being worked out is a fusion process.

On the other hand so far we can't get fusion to work unless we start off with a fuze that is based on fission. It is just like we explode many high explosives with fulminate of mercury or some other very unstable material in a percussion cap, which creates the initial

trigger energy that starts the chain reaction. So to start the fusion reaction off requires temperatures in the millions of degrees centigrade, and there aren't any such things on the earth. They are found only in great luminous bodies like the sun and the other stars. But by using the atomic bomb to create that high temperature, even though it may be only instantaneous relatively--a matter of a few microseconds--this fusion reaction can start. But the problem is, Are you going to be around after you start it?

Dr. Richter, down in Argentina, claimed to have solved this problem. Of course, it turned out to be just a hoax.

It means that there must be a way of controlling the thermal nuclear reaction. That is the goal of scientists. If they find means of doing that, then we can use hydrogen and lithium and some of the other light elements, which are all successive stages of atomic fusion in the stars. The stars start with hydrogen and use it to go to the next higher equation, up to six. Those are all potential fusion elements.

The future scientists may find this means of controlling what in the past has been uncontrollable. Just visualize for a moment; there is a reaction that starts with millions of degrees. Obviously, we can't have a boiler to contain that temperature of millions of degrees, because long before we reach that temperature, every known material that we have becomes an ionic gas. And we couldn't have a boiler made with walls of ionic gas and have it hold any pressure. There must be a lot of pressure. The problem is, How do we utilize this reaction, involving temperatures beyond anything on earth, beyond that at which any of our materials will remain in the solid state, and still have a mechanical engineering device? It's a neat trick.

QUESTION: Mr. Ward, most of your talk was concerned with material things which will aid technological progress. Man's life is sustained by two essentials. One is food and the other is water. Do you consider those people in the United States and other places as alarmists who are worried about our water shortage and what we are going to do about it?

MR. WARD: No. They are practical people, in the light of the way we use water, or the way we waste water, today. Water is the preserver of life. It is the universal solvent. Without water there would be no life as we know it on the earth today.

Actually, we don't consume water. We just spoil it. It can be reclaimed. But that is a matter of economics. When it gets worth reclaiming, science knows how to reclaim it. So water doesn't present the same kind of problem as power sources do.

Industrially it does present a problem, because the chambers of commerce of X, Y, and Z tell people to locate industry in their city because they can count on having plenty of water for 10 years to get cheap power. There are a lot of places where that is not true. There are areas in the West where they are concerned about the water that is being used to reclaim wastelands. They are pulling water out of the water table to a degree that they are trying to get the flow regulated. It is a vast undertaking.

To show you how man finds a way to do things, the Russians have a neat project down near the Caspian Sea. There is a geological trace down there of a river which now flows into the Arctic which in former times flowed down toward the Caspian Sea. That area was in prehistoric times a very fertile valley; today it is a desert. The soil, however, shows all the signs of being wonderful agricultural soil if it was watered. The Russians have a project of using atomic energy to blast through a mountain chain which rose up in that intervening geologic time and forced the river to flow into the Arctic instead of the Caspian. They want to reverse the river so it flows backward and then use it to reclaim that whole area.

Man will be engaged in great works of that kind, I am sure, to utilize vast water resources that do exist which are now untapped. It will be a problem, because there are vast arid areas of the world where the solution is not as simple as the Russian way of trying to use atomic energy to blast away a mountain chain and reverse a river's flow. But the fact that atomic energy is coming into this picture may prove to be the marvel of the world. I have no other answer to that question.

QUESTION: You mentioned that gunpowder was first predicted to be one of the destroyers of civilization and since has been proved not to be. You ended your formal talk by saying: "If the men in the Kremlin knew they would be destroyed, who would start war?" Is it statecraft or technology that is going to prove it to those in power, so that they won't want to start war; or are they going to go through the trial and error process, such as they did with gunpowder, to find out or to prove to themselves that it will kill everybody?

MR. WARD: That is the most potent question that could be asked. So far as concerns the men in the Kremlin and their culture and knowledge of the world, there are two schools of thought in this country, and many variations. One school believes that the Russians do a lot of things in ignorance of the outside world. I am sure if we applied that to the Russian people, that would be true. But it is a little difficult to think of the leaders of Russia being that ignorant, because they can tap world knowledge through their intelligence.

We found in dealing with Stalin that he was one of the best-informed men in the world. Therefore one has to assume that anyone who gets to the top in Russia is reasonably well aware of what is going on in the world, since he is the fellow at the top and it is only the person at the top of the pyramid that can make such decisions.

Since that is so, since the top of the pyramid has the intelligence to be well-informed, the only danger, as I think many people believe, in this second school of thinking, is that his own intelligence people are afraid to brief him on the truth, because the man who does it would be unpopular. That is a real danger. You fellows have often worked with a boss who doesn't want to be told the truth. If you tell him, he doesn't believe it. Those are different people to work with. If such a man should become the future Stalin of Russia, then we might face this terrible experience of two great areas of the world doing irreparable damage to each other.

If you should ask, What happens from there on? Will other nations perpetuate such a holocaust? I don't think so. I don't think, going back to my final conclusion, that we or any other great nation is going to run the risk of being experiment A. And I don't think that life ends right on this planet, even though it does for us.

I think the answer to your question is "No." I don't think the whole world is ever going to be destroyed in one crack of these new forces that we know about. The evidence today does not indicate that. So, if it is not a case of survival, I believe men will have learned their bitter lesson and learned how to live with one another.

COLONEL KLEFF: Mr. Ward, you certainly presented to us a most intesting and instructive lecture and discussion period. On behalf of both colleges, I thank you very much.

(22 Oct 1953--750)S/mmg