THE CHEMICAL INDUSTRY IN WAR PRODUCTION

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THE CHEMICAL INDUSTRY IN WAR PRODUCTION

20 February 1951

GENERAL VANAMAN: Gentlemen, I am sure that all of us recognize the importance of the chemical industry in the production of munitions and in peacetime production as well. We invited Dr. Greenewalt here this morning, first, because of the position that his company occupies in the chemical world; second, because of his proven personal qualifications as an industrial leader. We in the college are interested in both of these subjects—that is the chemical industry in the production of munitions and in the proven qualifications of what makes an executive tick. Dr. Greenewalt kindly accepted our invitation and I have the great honor and pleasure of presenting to the students of the Industrial College and our guests Dr. Greenewalt.

DR. GREENEWALT: Well, gentlemen, this has been a difficult assignment because I didn't know quite what I should talk to you about. Nevertheless I have prepared some remarks and I have timed them, and I shall take just a half hour. I wrote them out for two reasons: First, when I don't write things out, I am inclined to ramble; and second, General Vanaman told me there was to be a question and answer period following my formal remarks and it seemed to me it might be more fruitful to you and to me if I made sure I left adequate time for that period. Please feel free to ask me anything you like after I am through.

My assignment this morning is to tell you something about the state of the chemical industry in the United States today. That I am glad to do, for we are in a period that presents many grave and important problems and on some of them we want very much to have your understanding and support. Let me emphasize at the outset, however, that I am not qualified either by knowledge or experience to speak for the entire chemical industry, and so I must of necessity confine myself in great part to the problems of the du Pont Company. The extent to which du Pont is typical will determine how applicable the picture is to other segments of the industry.

The chemical industry today, I might point out, is a large and very loosely defined entity. The Bureau of the Census has a classification which it calls "Chemicals and Allied Products" and lists about 10,000 companies in that classification. It does not, however, include the oil industry, certainly a most important producer of chemicals, nor does it include many other companies whose prime interest is in some other field of industrial endeavor, but who produce chemicals more or less as a side line.

The General Electric Company, for example, is known primarily as a manufacturer of electrical equipment, but it is also an important producer of plastics and insulating compounds. The United States Rubber Company is interested primarily in tires and other rubber goods but has in addition a large and thriving chemical division. On the other hand, there are companies classified as chemical manufacturers by the Bureau of the Census whose connection with chemistry seems rather remote.

The du Pont Company sometimes finds aggressive competition in strange places. Our cellophane, for example, finds itself in competition with products of the paper industry and with aluminum foil. We compete in certain areas with the meat packers who have developed chemical divisions through their efforts to dispose of some of their by-products. We compete with many companies in the oil industry and in limited areas even with the United States Steel Corporation.

I make these points simply to show you that the chemical industry is an industrial area which is difficult to chart. But perhaps we can, for purposes of discussion, accept the classification of the Bureau of the Census and consider that the 10,000 companies designated by it as manufacturers of chemicals and allied products are, in fact, the chemical industry.

"Chemicals and Allied Products" according to statisticians comprise 6 to 7 percent of total United States manufactures. That is not a particularly impressive figure. I think we must realize, however, that the significance of chemicals in our industrial scene is far greater than the modest statistic would imply, because chemicals are essential ingredients in virtually every article of commerce. The portion of the cost of a given article represented by its chemical ingredients may be quite small, or even negligible, but it is frequently the chemical that makes the article.

For example, the value of the nylon fiber in a typical all-nylon dress is only 4 percent of the retail price; the value of insecticides used by the American farmer is only one-third of one percent of the farm crop income; the value of the dyestuffs used in a typical civilian suit or military uniform is perhaps one percent of its retail price. Drugs and pharmaceuticals are a minor percentage of the cost of medical care, yet they are frequently the difference between life and death.

If you would like to make the experiment yourself, look at the various items in your home that contribute to your daily life and comfort. I suspect that you will have a difficult time finding even one to which chemistry has not made an important--perhaps even a vital--contribution.

This has not always been the case for the chemical industry is, relatively speaking, an infant. At the end of the First World War the chemical industry of the United States was scarcely worth classifying. In the

thirty-odd intervening years its growth has been dynamic, well beyond the average of other American industries, and its products have entered into every nook and crevice of our daily life. To the layman the nature and function of chemicals is difficult to appreciate because their identities in the end products are more often than not obscured.

In times of military emergency, such as we face today, the chemical industry differs from most other industries in one vital respect: There is little or nothing that it can do to convert its manufactures to alternate products of greater military significance. A hard-goods industry, such as the automobile industry, can shift its assembly lines from the manufacture of passenger cars and concentrate on trucks or jeeps or tanks; a typewriter plant can shift to gun parts; but a chemical plant designed to produce a given chemical must by its very nature continue to make that chemical and nothing else. Equipment is tailor-made for a specific purpose, and there is no way to change. Capacity can be increased somewhat and production records improved, but a sulphuric acid plant, for example, must continue to make sulphuric acid, for it can make nothing else.

In times of national emergency, therefore, the problem of the chemical industry is to adapt its finished products to military needs, not to convert its plant and equipment. Nylon, for example, will go into parachutes, into glider towropes, and into the host of military uses for which it is suitable, and the ladies will have less of it for their hosiery and lingerie; dyestuffs manufacturers will concentrate on olive drab and blue and gray; and plastics will go into military aircraft or other essential uses. The processes and the plants will be the same. It is the uses that will be different.

As this process of adaptation continues unprecedented pressures will be placed on the chemical capacity of the country to supply the military demand, and at the same time meet, as well as may be, the desires of the civilian economy. As military needs increase, it may be that there will be less cellophane, cleaning fluid, phonograph records, or insecticides and other specialties for civilian use. We have already a demand for many products beyond our normal capacity to fulfill, and at some point obviously it will be necessary to allocate scarce materials. Two products may each require the same raw material, and, if so, the product that is most essential to our defense program will obtain its priority, and manufacture of the other will have to be curtailed. Should wood pulp, for example be allocated to essential products such as smokeless powder and rayon tire cord, we will have no alternative but to cut back the manufacture of cellophane. There is nothing else we can do with the cellophane manufacturing equipment.

I cannot emphasize too strongly the points I have just made. The chemical industry's manufacturing plant is inflexible, not by choice, but because of the inherent nature of the chemical process. In time of emergency it must be used as is. Its technical capacity must be

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directed toward the adaptation of its existing products to military needs. It cannot be converted in the sense in which that word is ordinarily used.

Over these 30 years the chemical industry has grown, quite literally, from the spreading roots of its research laboratories. Research has brought about a continuous face-lifting of the entire industry--a long stream of new products have been poured into our industrial economy. It is a characteristic of the industry to spend large annual sums for research. How much the total would come to, I don't know, but it is quite substantial. Our own company spent last year about 38 million dollars, and has quite consistently spent for research between 2 and 3 percent of its sales dollar.

An unhappy characteristic of research and development is that they cannot be hurried. In research it is literally impossible to "buy time" beyond a certain point. And so the road from laboratory to plant remains a long and difficult one, in spite of the time and thought that have been given to ways and means of shortening that critical and expensive period. Let me give a few case histories.

Much of the fundamental research that was basic to our development of nylon had been carried out by 1930. In spite of an all-out effort to get nylon fibers into commercial production as rapidly as possible, it was not until 1939 that our first commercial unit at Seaford began operating. The cost of the development up to that point was 27 million dollars.

In the middle of last year commercial manufacture of "Orlon" acrylic fiber began in our plant at Camden, South Carolina. That fiber first saw the light of day in our research laboratories in 1941 and the expenditures involved in bringing it to its present stage amount to 25 million dollars.

Some of you may have seen announcement of our development work in connection with the production of titanium metal. Titanium is one of the light metals, its density about halfway between that of aluminum and that of iron. It appears to have some rather unique and useful properties. We have had many indications from the armed services of their interest in this metal and of their desire to make use of its properties in connection with certain military developments. We started our research work on the production of titanium in 1946 and after four years of intensive effort we are still only at the stage where we can manufacture it in pilot-plant quantities. The point is simply this: Had someone in the armed services come to us today and asked us to develop a process for making titanium metal, the emergency might well have passed before the job could have been completed.

Countless other examples could be brought forward from the experience of the du Pont Company and from other chemical companies. The moral is that in time of national emergency the chemical industry must be taken

as it is. We would find it difficult, if not impossible, to pull rabbits out of the hat under emergency pressures. Our ability to meet the needs of the Nation in time of emergency or war is wholly dependent upon the strides we have made during times of peace—on the new products we have added to the Nation's storehouse. Our contribution will be the productive capacity brought into being during the peaceful years, plus the technical ability to adapt the products of the industry to military requirements.

Of course, there are exceptions. The atomic bomb development of the past war—a huge task—was carried from laboratory to practical realization in four years. In that development vast sums of money and a huge technical and industrial task force were devoted to the project. And even so we had a great deal of luck on our side. Research can sometimes produce miracles, but rarely overnight.

The adaptability of the products of chemistry has, I think, been clearly demonstrated by the experience of World War II. I suppose that the average person would think of military explosives as the most important contribution of the chemical industry in time of war. In World War II the du Pont Company, operating a number of government powder and high explosives plants, turned out the largest quantity of munitions ever manufactured by any company in history. Yet even this huge volume amounted to less than 25 percent of the company's total production. The rest was made up of hundreds of different chemical products that went into military or essential civilian uses.

It is difficult sometimes to appreciate the extent to which chemicals play their part in military requirements. One of our statistically minded people counted up for me the number of chemicals and chemical products involved in outfitting a single squad of infantry and came up with something over 200 even after allowing for a certain amount of duplication among the basic raw materials.

That example is typical. It could be applied with perhaps even greater force to the air corps. I remember that there were as many as 86 chemical products from just one du Pont plant that went into the building of a large bomber during the past war. A Naval example would be equally impressive. But I want simply to emphasize the important role played by chemical products in modern living, be it in time of war or in time of peace.

And so when we consider the ability of the chemical industry to meet the requirements of the present emergency, it is somewhat reassuring to report that we are in far better position than we were 10 years ago.

Since 1940 the chemical industry as a whole has doubled its plants, and in the four years following World War II capital expenditures in the industry hit a rate reported to approximate one billion dollars a year.

The result is an overwhelming increase in production facilities representing the translation of its huge research program into actual available goods and services.

To be a little more specific, the developments of the past decade in the du Pont Company have been somewhat as follows:

From 1941 to 1945 we were operating under the forced draft of war production. Many new ordnance facilities were built but very little was done in the way of expansion or improvement of our own plants. After the war, we brought into production new plants and plant expansions representing an investment of one-half billion dollars--literally 100 million dollars a year for five years. As a result of this program and technology advances in our existing operations, we now have productive capacity about three times as great as was available to us before Pearl Harbor.

The list of materials for which new capacity is available is long and impressive. It includes such products as tetraethyl lead, cellophane, titanium dioxide, chlorinated solvents, neoprene synthetic rubber, methyl alcohol, and host of others. In the synthetic fiber field the gains have been particularly notable. In 1950 we made more than twice as much acetate rayon as we did in 1940; we made 12 times as much rayon tire cord; more than 30 times as much nylon.

We have also brought certain new materials into the picture, all of them developed for their peacetime uses, but with important defense applications. I might mention our two new synthetic fibers--"Orlon" acrylic fiber, which has just gone into commercial production and Fiber V, for which the first commercial unit is under construction. These two are the first synthetic fibers that appear to match wool in most of its properties. I believe you all are aware of the current wool shortage and the high wool prices arising out of that scarcity. We hope our two new fibers will help to relieve that situation and so contribute to the defense effort, either directly in military applications or indirectly by releasing wool from the civilian economy. In fact, it is quite likely that these new fibers could well prove to be as important as nylon was in World War II.

I hope you will forgive me for talking so much about developments made by the du Pont Company, but, as I told you at the beginning, that is the part of the chemical industry I know best. There are of course many other developments fully as important to the economy as anything we have done in our limited bailiwick.

Perhaps one of the most far-reaching developments of recent years is the research which has been carried forward on chemical applications for petroleum products. This work has opened up a great new source of raw materials to the chemical industry. (Let me hasten to say that du Pont had little or nothing to do with these discoveries.) The immediate effect

of this development is immense and the potential is even greater. The large-scale synthetic rubber program which frees us of dependency on the uncertain Far East rests firmly on petroleum chemicals made principally from oil and natural gas. The production of toluene from petroleum was essential to permit us to produce the quantities of TNT required during the last war. Ethyl alcohol, essential for the manufacture of smokeless powder and for many other military uses, can now be made from petroleum sources. Glycerin, heretofore a by-product of the soap industry, is now made at low cost from petroleum products. Today the petroleum industry is turning its talents to curing the shortage of benzene, which, as you know, is basic to many essential chemical products. We in du Pont have taken advantage of these developments by constructing two of our largest chemical plants in Texas where use is made of cheap and abundant petroleum raw materials for such important products as methyl alcohol and nylon intermediates.

Let me not leave you with the impression that the chemical industry has no problems for that would be far from the truth. We face today many shortages of materials, but I doubt that any are so serious as to embarrass the military program. We shall have to struggle to stretch available materials to cover both military and essential civilian uses, but even on this score I am not pessimistic.

Sulphuric acid, benzene, chlorine, soda ash, and glycerin are in short supply. We find it more difficult to fill our needs for copper, stainless steel, nickel, cobalt, zinc, and lead. Wood pulp, on which we rely for rayon, cellophane, and numerous other products, is scarce and the price has soared; wood pulp is sensitive as are so many things to the supply of sulphur.

We view these stringencies without any particular alarm, for I think means can be found to overcome or at least to mitigate foreseeable shortages. Fortunately, we are old hands at improvising and finding alternatives when necessity demands.

Many times during the last war we found ourselves trying to find a substitute for a substitute, which in turn had been employed as a substitute. We are forced into that kind of activity increasingly now—we have a large number of chemists already working on a search for substitute materials. Of course there are limits beyond which this cannot go, and there are still many critical materials for which no alternatives have yet been found, but I am confident that reasonable solutions will be developed in many cases.

So far I have had much to say about products and processes, about greatly increased productive capacity, and about streams of new products. These are real accomplishments and they are vitally important. I think, however, we are prone to give them undue emphasis and to lose sight of the fact that back of them are the people of the chemical industry.

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They are our real and irreplaceable resource. We have today a reservoir of technical talent and know-how that stands in stark contrast to the situation 35 years ago, when there was scarcely an organic chemist at large in the United States.

Our scientific manpower, although it is less than one percent of the entire United States labor force, is the vital and essential ingredient upon which our entire economy depends for growth, stability, and security. To survive in war or in peace, all modern nations must rely upon their technologies, which means that an adequate supply of scientific, professional, and specialized personnel must be maintained. In fact, the state of technology in any country is usually directly proportional to the number of trained persons available to nurture it.

At the present time our company has engaged in research and development activities a total of 893 Ph.D. graduates, 618 M.S. graduates, and 1403 B.S.—a total of 2914, of which 136 are women. This compares to a total of 1813 in comparable activity only five years ago or a gain of 50 percent. We regard possible losses of technical personnel as the most important long-range problem facing the industry today. One of the reasons we now face a shortage is the interruption in advanced education occasioned by the draft laws during World War II. This is particularly noticeable in the number of those going on into graduate study, for a young man who has spent three or four years in the service is less likely to undertake three years of graduate work than one who was graduated at the normal age.

Now we are facing another such period of interruption, and in addition many technical people now employed are subject to military recall. Out of 375,000 scientific and technical people employed in industry, an estimated 100,000 are Reserve officers or are otherwise liable for service. About 65,000 are of draft age, 19 to 25.

In our own company, out of 6,400 technical men we have 1,600 who are reservists. Of our 2,800 men engaged in research or other technical activities not related to production, about 25 percent have reserve status. The loss to the military of any appreciable portion of this group would be crippling particularly to research.

Technical projects for the Government alone require the shift of many highly skilled people from their regular duties. For example, the project we have undertaken for the Atomic Energy Commission will require the transfer of several hundred of our top-flight technical people.

As technical processes have become more and more complex, it has been found necessary to employ a great percentage of men with advanced training. This is true throughout the chemical industry. And there are not anything like enough Ph.D's. to fill the demand.

At this time we estimate the need of the country for engineering school graduates at 30,000 per year. If Selective Service proceeds as now seems planned, some educators feel that the number graduated in 1952 will fall to 18,000 and in 1954 to 9,000. The same situation exists with respect to all scientific students.

It seems to us that anything limiting the number and caliber of men going into graduate study in the sciencies, or which removes trained men from the laboratory, is bound to have an adverse effect on our technology. We appreciate the problem facing the armed services, but we earnestly hope that serious consideration will be given to a liberal deferment policy for scientific personnel. This is no time, as we see it, to fall behind the rest of the world in what may—ultimately—be the means of survival.

QUESTION: Dr. Greenewalt, could you tell us a little more about the shortage of sulphuric acid, how much of that is due to lack of capacity in the chemical industry to make sulphuric acid and how much of it is due principally to the shortage of sulphur itself?

DR. GREENEWALT: Well, that is an easy one. It is due to the shortage of sulphur. There is ample sulphuric acid manufacturing capacity. As a matter of fact, we have been living on our sulphur stocks and very shortly they are going to run out and we are going to have to cut back 20 percent simply because we haven't the sulphur to make sulphuric acid. Of course all of you know that sulphuric acid is probably the most basic chemical that exists. It enters directly or indirectly into almost everything. But it is the sulphur shortage that causes the sulphuric acid shortage.

QUESTION: Dr. Greenewalt, are there any products that your company produces, or the chemical industry in general, that might be cut back or shut down during war as a result of a product needed elsewhere when the thing you produce is not needed? In other words, do you produce things not needed in war?

DR. GREENEWALT: Oh, yes, a great many. As a matter of fact in World War II we had many situations where a product we made was considered nonessential and the raw material for it was required elsewhere, so we had no alternative but to shut down.

QUESTION: Does that result in any appreciable percentage of change?

DR. GREENEWALT: No, because our technical people were usually able to find ways around a great many of these problems. I recall the paint situation in World War II. The quality deteriorated as a result of the many substitutions we were required to make but we managed to keep going on a limited basis. In some cases we had to shut down some of our producing units, because, as I said before, in a paint plant you can only make paint.

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QUESTION: What is the ability of the plastic industry to replace metals in certain products, for example, cabinets for radios in military aircraft and other things that require metal?

DR. GREENEWALT: That was done to a very great extent in the Second World War. As a matter of fact, that was one way in which the chemical industry helped to alleviate the metal shortage by making plastics available which were used in making many things that had previously been made of metal. Some of those uses were uneconomic and stopped immediately when metals became available again. Some of them, on the other hand, persisted postwar and created a large new business for the plastics industry. That frequently happens.

QUESTION: Dr. Greenewalt, for the long pull in peacetime economy does the chemical industry feel there will be a shortage of raw materials which will handicap further expansion in the development of new products?

DR. GREENEWALT: I suppose that is one of those things that depends upon who is making the forecast. I remember when I graduated from college in 1922 that one of the people in the Chemical Engineering Department was forecasting that supplies of petroleum would be exhausted in five years—that would have been in 1927. I suppose you will still find people forecasting that the petroleum supplies will be exhausted in five years, but petroleum still seems to be abundantly available.

Take the matter of benzene--as you know it is a by-product of the coking of coal done for the steel industry and, of course, there is a limited amount available, which depends entirely upon the productive capacity for steel. That shortage is beginning to be felt and were there no other solution to the problem there would be a very real limitation on the things we could make starting with benzene. On the other hand, now comes the petroleum industry and it figures out a way to make benzene from petroleum. So with that source available we should have an abundant supply again.

Another example--du Pont makes nylon, as I hope you all know by this time, and the first process we developed for making nylon intermediates used benzene as a raw material. The demand for nylon, fortunately for us, has grown beyond our wildest hopes and we found ourselves, some years ago, using a very substantial percentage of the total production of benzene in nylon. So our chemists got to work and found they could use a product made by the petroleum industry known as cyclohexane and we are using that now. Then technicians got to work again and found they could make nylon from furfural which is made from corncobs. We have still another process which involves butane as the raw material.

We have a considerable degree of flexibility and that is generally characteristic of the industry. The organic chemical industry used to be engaged almost wholly in the manufacture of aromatic chemicals, based

upon benzene and coal tar. That is what it was 30 years ago. The advent of petroleum research has brought about a tremendous stimulus to the manufacture of aliphatic chemicals. Of course for gasoline, petroleum may be in short supply but for chemicals which require much less smaller quantities there is no supply problem. Granted sufficient technical ingenuity, I don't think that there is any real handicap facing us because of the raw material situation.

QUESTION: If I might pursue it one step further, in regard to sulphur, for example, are you working on sulphur substitutes or will the big companies take the whole supply?

DR. GREENEWALT: The question of sulphur supply is a matter of economics. As long as we have the deposits in Louisiana and Texas, where all you have to do is pump it out of the ground, natural sulphur will be the preferred raw material. But there are many other sources of sulphur for sulphuric acid if the economics are such as to make it worth while using them. For example, a British chemical company makes sulphuric acid from anhydrite, which is a calcium sulphate. Now anhydrite is abundantly available and, furthermore, there are all the smelter gases from the refining of metals from sulphide ores which can be used. Native sulphur will be used as long as those supplies down there in Louisiana and Texas are available because it is cheap, but absent that, and if the price goes up, then other raw materials will come into the picture.

QUESTION: You mentioned your discovery of making nylon from certain basic chemicals such as benzene--Does the nylon you make from those different basic chemicals have in most cases the same characteristics?

DR. GREENEWALT: Yes.

QUESTION: Is one just as suitable as the other for anything you want to use it for?

DR. GREENEWALT: Yes, when you get through the nylon is identical. The two processes are different but when you get to the final product, it is a chemical entity in itself.

QUESTION: May I take that a little further then? We were told a few days ago that dibasic acid was very essential in making certain types of nylon which had characteristics of toughness.

DR. GREENEWALT: We do make one nylon from sebacic acid, but that, as I understand it, goes into bristles for brushes and things of that sort. It is a very small percentage of the nylon we make. It is quite true that sebacic acid comes from castor oil and its supply is dependent on the castor oil supply. If it ever became important, I can assure you that somehow we would figure out some other way to make it. It is not that important yet.

QUESTION: Is du Pont doing any combining of organic and inorganic chemistry, and, if it is, can you tell us something about it?

DR. GREENEWALT: Well, we make tetraethyl lead. I suppose that is an organo-inorganic compound.

QUESTION: This is just paraphrasing the question, but are you tying up an organic compound and an inorganic compound and making something brand new?

DR. GREENEWALT: The fact of the matter is we have done very little work on the twilight zone between the two chemistries. We have done a great deal of work in straight organic chemistry and also in inorganic chemistry. Very little has emerged from organo-inorganic research. The only important commercial products in that class that I can think of are tetraethyl lead and the silicones.

QUESTION: Dr. Greenewalt, I want to get back to that question of castor oil. You seem to be very optimistic about it, but it probably goes back to someone of our Government getting together with industry and perhaps someone from the Munitions Board to try to determine the armed forces requirements for basic chemical materials--plastics and that sort of thing, how much construction aluminum, copper, steel, rubber, and petroleum and such things, in the hope that the chemical industry will be able to find something new and be able to fill the gap.

We find that du Pont makes a certain type of nylon using dibasic acid from castor oil and that nylon is very tough and is specified by the Signal Corps for field wire. If the Signal Corps puts in an order for all the field wire it is thinking about ordering, it will take more dibasic acid than the industry is capable of producing. It might be able to do that by sending a lot of castor beans to Taxarkana, somewhere, in the fall. But we also find that the Air Force is greatly interested in castor oil as a lubricant for jet engines. Now if both the Signal Corps and the Air Force come forth with this terrific requirement for dibasic acid and castor oil, you will have to get something new awfully fast. Have you gone that far?

DR. GREENEWALT: That is the process of adaptability that I think the chemical industry can do for you if we know what you want and it is intelligently specified--and that is not always done. If the Signal Corps comes to us and says that it must have 610 nylon made from sebacic acid and nothing else will do, then the only thing we can say to you is that we will make 610 nylon up to the limit of the availability of castor oil and that is all. However, if the Signal Corps says it wants a plastic with certain functional properties, we can go to work and see if we can turn out something to fit that will perhaps not be as good as 610 nylon but good enough to let you go ahead with your program.

To pursue that for a moment, the peacetime uses for 610 nylon, which require sebacic acid, are very small, very minor. We have done some research on a completely synthetic process for making sebacic acid and we have carried it far enough to know we could probably finish it, given enough effort and enough years, but for peacetime markets it doesn't pay because it just isn't important enough. So we don't carry it forward. If you had to have sebacic acid and came to us enough years in advance, we could probably do something for you, but if you came to us and said that day after tomorrow you want to get so much 610 nylon, we would have to tell you "Get us the castor oil."

QUESTION: That is what I wanted to ask. Have government representatives come to you in the chemical industry and said that the requirements for mobilization are so much and for all-out war so much?

DR. GREENEWALT: They are more prone to do it the other way, which, I might say, is a limitation on our ability to be of service.

QUESTION: Dr. Greenewalt, during your discussion you mentioned two substitutes for wool which you are developing, one of them being Orlon. I believe--I forget your wording--you said "with limitations." I wonder if you would elaborate a little on the differences between the native product and the substitute?

DR. GREENEWALT: I am just being modest. We think that these two new fibers, between them, can, in due course, compete with wool in all its uses. Now I have to be somewhat conservative because at this point our main effort has been to develop blends of these fibers with wool. That we know will work and that will stretch the wool supply. I think the time will come, given enough effort, when you can make all "Orlon" or all Fiber V fabrics that will be fully equivalent to wool in all its uses. For example, I had a summer suit out of this Fiber V that was simply remarkable. Ordinarily a tropical worsted suit needs pressing about every other wearing. The Fiber V suit was light in color and got soiled before it needed pressing. I had worn it a dozen times.

Progress is being made. We are building plants now to make both those fibers and I think they are going to have a beneficial effect on the wool situation. Either the civilians can use synthetics and the military the wool or vice versa. The military should always be willing to leave a little flexibility in its demands. If you want wool, then of course you will get it, but if you say you want a uniform fabric that will have this, that, and those properties, you will greatly simplify your procurement problem.

CAPTAIN MARCY: Dr. Greenewalt, would you care to expand that remark on titanium. We are all, I am sure, interested in the possibility of titanium. Would you care to go out on a limb a little bit and forecast when we might have quantity production of titanium?

DR. GREENEWALT: Well, we have spent four years of research on the titanium metal program. We are in business to make money and so any process we develop, before we put our capital in it, has to produce the new product at a price at which it can be sold and yield us a profit. Now we can make titanium metal today. As a matter of fact, Mr. Boyd of Defense Production wants us to build a plant today. We will build it, of course. But it won't be an economical unit. It is not a unit we would be prepared to build for commercial purposes.

QUESTION: The point is to expand the end use of the metal to the point where it is profitable.

DR. GREENEWALT: Oh, well, we are well aware that the demand exists. The difficulty is, we don't yet have in our hands a process for making titanium metal that we think affords a basis for a full-scale peacetime commercial effort. That is the problem. We can help meet the military requirements, but the metal is not going to be cheap and its manufacture will not be based upon what would be a commercial operation. If it is needed, it can be made but the price will be high.

QUESTION: How many tons?

DR. GREENEWALT: That is just a matter of defining the military requirements. Mr. Boyd has asked us to figure on a 10-ton a day plant. He has placed the same request with the National Lead Company. We can certainly build and operate a 10-ton a day plant on the basis of present information. It will not be an economical unit but it will make titanium metal of reasonable purity. Because it is not a commercial unit, we would also require a Certificate of Necessity to cover rapid amortization of full plant cost.

QUESTION: I have two questions. The first one: We have been making a study of the chlorine industry. We find there are a lot of indirect uses of chlorine which the military does not submit to the Munitions Board. Therefore, requirements that the Munitions Board sees by and large do not include anywhere near the total requirements of the indirect uses and also the direct uses. Is the industry aware of this, that there are a lot of indirect uses of chlorine which are not being brought into the board as requirements, and what are they doing about it? The second question is rather facetious. Is Orlon a good food for moths?

DR. GREENEWALT: Answering your second question first, the answer is no. Moths won't touch nylon or "Orlon."

Now as to your first question, the du Pont Company sells no chlorine. We produce chlorine in connection with our manufacture of sodium, but we consume what we make in our own operations. I know, of course, that there are many indirect uses for chlorine. For example, one important class of

materials which consumes chlorine are the dry-cleaning fluids. The percentage chlorine content is very large indeed and that may not be fully recognized. Nevertheless, there is represented in those materials a very large chlorine demand.

In our process for making titanium metal, large quantities of chlorine are required, in spite of the fact that none of it appears in the finished product. I don't know whether that answers your point.

QUESTION: I think it does. My point was the indirect use in such things as cleaning fluids. In fact, we had the statement made to us that for every plane and tank made there is a ton of chlorine required indirectly.

DR. GREENEWALT: I can imagine that is so.

QUESTION: We send our requirements to the Munitions Board. They don't come out as so many tons of chlorine; they come out as something else.

DR. GREENEWALT: That is true. In considering these basic chemicals, we must always remember the indirect use. We are very large producers of sulphuric acid and we are also very large purchasers of sulphuric acid. We also sell sulphuric acid, but our sales are small compared with our consumption. Every pound of rayon, every pound of cellophane requires substantial quantities of sulphuric acid in its manufacture. It is a difficult matter to trace all these secondary uses back to the basic chemicals.

QUESTION: You mentioned the fact that we would probably have to have some sort of allocation system here soon. As I understand it, during the last war it was controlled through the control of end products, what could be produced, and then allocations were made to the people who had to make the particular product. Having in mind the adaptability that you mentioned, so you can shift from one direction to another, do you think that is the best way—control the spigot rather than to allocate parts of it?

DR. GREENEWALT: To allocate chlorine would be a hopeless task. Simply to allocate any basic chemical, I think, would be difficult because so many different end products are involved.

QUESTION: The same thing would apply to intermediates?

DR. GREENEWALT: I think if you are going to control these things you have to control the end products.

QUESTION: Let the basic materials go?

DR. GREENEWALT: If you say, for example, that all the nylon must be allocated to military business—which is what you did say in World War II—then you don't have to worry about intermediates. I think the control of end use is simplest, if there must indeed be control.

COLONEL KLEFF: Dr. Greenewalt, on behalf of the student body and the faculty, I thank you for a most instructive lecture and discussion period.

DR. GREENEWALT: Thank you very much.

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