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FOOD AND AGRICULTURE IN GERMANY
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GENERAL McKINLEY: Gentlemen, this afternoon we are very fortunate in having with us Colonel Hugh B. Hester, who happens to be a lifelong friend of mine. Particularly am I glad to have him here because he has been operating in an area where I had a little experience during the war.

Colonel Hester was out in Australia for about three years, at Sydney, where he did the American purchasing from the Australians, principally in food, on what we called reverse lend-lease or reciprocal aid. From there he was sent to Germany. In Germany he headed up the food and agriculture activities for the American Allied Government. I know you are all aware of what a front-page topic that is at the present time.

I may add further that Colonel Hester is now on his way back to Australia as military attache'.

With that background I think you can appreciate how much first-hand knowledge he can give us on this topic. Since he is a graduate of this school, I take great pleasure in welcoming back to the platform Colonel Hugh B. Hester.

COLONEL HESTER: General McKinley and gentlemen: I would be less than insincere if I did not say that I appreciate greatly the honor of coming back and talking with the student body at my old alma mater. I took this course in 1938-39. At that time we did not have these spacious accommodations you have here. We had about two wings of the old Munitions Building. We were five or six deep in each room. At that time we were trying to solve the world's problems, the world conflict developed. Our solutions were unacceptable. I hope, General McKinley, you are able to do all of the things we were discussing this morning--to bring some other departments of the Government into this school. I think, primarily, the reason we were not able to put our Industrial Mobilization Plan into effect at the beginning of the late war was because we did not have other government agencies sold on the idea, or informed of our excellent plan.

I have spent the last twenty-six months in Germany with the Economics Division, in charge of our food and agricultural program. But before I talk about that specific subject, I would like to give you just a summary of how the operation takes place over there in our Military Government.

You will recall that at Potsdam the United States, Great Britain, and Russia set up four military governments to govern the occupied areas of Germany. They provided, at the time of unconditional surrender, for an Allied Control Authority, composed of the military commanders of the United States, Great Britain, and Russia. France, unfortunately, was not a party to the Potsdam Agreement. That oversight has plagued us somewhat ever since. Later, they permitted France to join the other three big powers and gave her a small section down in the southwest corner.

Under the Potsdam Agreement, one of the cardinal principles enunciated was that of economic unification of Germany. They provided, under economic unification, that they have a single agency throughout the four zones, controlling transportation, communications, foreign trade, industry, and finance. At the Moscow Conference last February and March they added to that the food and agricultural organization, making six central agencies that are supposed to constitute the economic unification of Germany. I do not need to tell you how far from economic unification we are in Germany today. Whether we shall ever attain it, or not, it is something earnestly to be hoped for.

We start with the Allied Control Authority, composed of Marshal Sokolovsky, Russia; General Robertson, Great Britain; General Clay, the United States; and General Koenig, France. Directly under that is the Coordinating Committee composed of the deputy Military Governors of the four powers. Under that organization we have directorates in the following fields: Economics, Politics, Finance, Internal Affairs and Communications, an Armed Forces Directorate, a Manpower Directorate, and many other less important ones.

Under those directorates there are many committees from the branches of the respective divisions. Of course, the work, as you would expect, is done, in the final analysis, by the working parties under the directorates.

I mention the above just to give those of you who have not had the experience of serving in one of the occupied areas something of a broad outline of the organization itself and its functions.

Since we were unable to accomplish one of the principal directives, Economic Unity, of Messrs. Truman, Attlee, and Stalin, at Potsdam in 1945, the United States and British Zones have effected an economic unification of their two zones, with headquarters at Frankfurt. We have purposely avoided the establishment of any political unification and restricted it, to date, entirely to an economic unification composed of the six principal branches of the divisions I have indicated: food and agriculture, foreign trade, communications, transportation, industry, and finance.

I do not need to tell you gentlemen here, who are studying industry and politics both, that to separate politics from industry is an extremely difficult thing. But there isn't anything being done in Germany, to date, that is not difficult, either inherently so or made so by men.

The whole problem of trying to get four powers to agree to the minutes of a previous conference frequently takes up hours. I have attended conferences in which we met at ten o'clock in the morning, adjourned for lunch, then proceeded again after lunch to try to agree to the minutes of the previous meeting.

A great deal of that difficulty, of course, comes out of the different backgrounds of the people involved in it, and the differences of language. But I do think that among all the powers in Germany, that is, the people actually on the ground, there is a sincere effort being made, within the limits--and this is very important--of the directives from their own governments, to make quadripartite matters work.

But if you have irreconcilable instructions from your respective governments, there is very little that men of the best will can do to accomplish the desired results. I, myself, have met a great many very fine Russians in Germany--I mention this because I think it is important to know it--and when their instructions permitted them to reach a reasonable agreement, I am confident we were able, in most instances, to reach those agreements. But when instructions come from their government in Moscow, which do not permit them the latitude that we, the Americans particularly, are allowed by our government, there is not much area for agreement.

In food and agriculture we have been more successful than they have in many of the other divisions, largely, I think, because, in the first place, we have been dealing with an industry that is not being restricted but expanded to the maximum; and, second, we are dealing with an industry that is as nearly unpolitical as any subject that comes up for quadripartite discussion. So, we have been able to get a measure of agreement. We know pretty largely what the Russians are producing in their zone in the way of food. We know pretty accurately what ration-scale they are feeding. True, it is more cumbersome than ours, but we do know essentially what they are feeding. We have agreement as to all common statistics. We have agreement as to certain quarantine regulations. And we have also engaged in considerable interzonal trade of animals, livestock, and other food products they have in excess.

I will not devote any more time to that subject, but I thought you might want to have the views--and they are purely my views--gained from dealing with all of our Allies over the past twenty-six months.

Now I do not think you can understand much about the food situation in Germany unless you understand something about the food situation in the world. The United States today is trying to bridge, in food, an almost unbridgeable gap. All through Asia, as well as through Europe, the agricultural industry has been greatly destroyed. In addition to the actual damage that has been done to the machinery, equipment, and horsepower in that industry they have suffered for six or seven years from an inadequate supply of fertilizer, inadequate and improper seed, and inadequate manpower. As a result, all of the East that used to have surplus food, particularly rice, have had to call on the United States for tremendous tonnages of wheat and other foods to supplement their inadequate supply.

You all know of the great droughts in addition to the things I have mentioned as the basic causes of the deterioration of the agricultural picture. The winter last year throughout Europe was terrible. This summer, there was an equally, or possibly more, disastrous drought. That extended right up to and considerably beyond the so-called "iron curtain."

Europe used to produce, supplemented somewhat by the Danube Basin, almost enough food to maintain the 280-odd million people living in that area. France had less than a fifty percent crop this past year. If you draw a line from Greece right on up to the Scandinavian Countries, including Sweden and Denmark, you will find that that whole area was twenty-five to fifty percent deficient in its food production. Asia was almost as bad.

I attended a conference in Paris in July at which the requirements of all the nations were stated; then the availabilities to meet those requirements were also stated. Out of some forty-odd million tons required, in the opinion of the nations that were represented there as customers, there was actually less than thirty million tons available for export to meet their demand. That meant, of course, a tragic gap between what these countries represented as their minimum requirements and the surplus countries as their maximum contributions. That, gentlemen, is why food, primarily, happens to be one of the most difficult problems confronting our foreign policy as well as our domestic policy today.

Prewar Germany, before its expansion, was a country of some seventy million people. Since the war they have taken away from Germany, at least temporarily, all of the area to the east of the Oder and Neisse, and East Prussia, and apparently they are going to take away the Saar.

The area removed and placed under Polish and Russian administration (I use the word "administration" rather than "government" because the permanent lines have not been agreed upon; they may have been settled, but they have not been agreed upon) took away from Germany twenty-five percent of her agricultural production.

To compound that difficulty, they shipped back from Poland, Czechoslovakia, Hungary, and Austria about ten million people who formerly occupied the areas that now are no longer in Germany. It represented in our two zones, that is, the British and United States Zones, about a twenty to twenty-five percent increase in population over prewar.

Now I will give you an illustration of how that compares with the U. S. In considering the arable land in the United States, we have about three acres to one individual. In the combined areas of US-UK, they have seven people to one acre. The density of population, so far as arable land is concerned, is just one to twenty-one, in our favor.

A further complication is the fact that Germany never was self-sufficient in food. One of the things Hitler stressed most in his preparations for World War II was the increased production of food. He used every known technique of a totalitarian government to slip up production. In 1937-38, when there was the highest yield of food production on record, he reached eighty-five percent of self-sufficiency. That included, however, the importation of fodder concentrates and fodder of some four million tons which, in the final analysis, meant he never attained, actually,, more than seventy percent self-sufficiency in Germany as thus constituted.

To summarize, he was never more than seventy percent self-sufficient, really. Since then, Germany has lost twenty-five percent of its food production and has increased her population inside the U. S. and British Zones, as now constituted, by twenty to twenty-five percent.

In bizonal Germany, an area comparable to Pennsylvania, we have 43,250,000 people. It is evident, I think, from that that Germany can never become a self-sufficient nation in food, at least the part that is presently occupied by the United States and U. K. So that means that they must export if they are to live.

I hope no one in this audience will get the impression I am pro-German. I am not. They have interrupted my way of life rather seriously twice. But I do think we have to be realistic in the development of our foreign policies as well as in the development of our domestic policies.

I have just finished--I hope I have finished--about two weeks of testimony before the Senate and House Appropriations Committees and they have had one fact drilled into their heads, despite the fact that they have asked me many, many embarrassing questions, which is the fundamental fact that, if we are going to accomplish our objective of a peaceful world, we are going to have to permit Germany to export in order to pay for her imports, primarily her imports of food.

I would like to state that as a basic fact: When we are considering Germany and considering our policies of tariff and trade in any shape, form, or manner, we must recognize that if we are going to have a revived Germany somebody is going to have to make available markets for her to dispose of her industrial products in order to pay for the minimum imports of food.

Now what are we trying to do about it in Germany? Our primary mission was to maximize production of food in order to reduce the cost to the people of the United States. We have forced the Germans to adopt a production program this year that is greater in acreage than ever was produced in this same area before. There are seven million two hundred and sixty-odd thousand, I think, hectares (2.471 acres per hectare) of crop production under this 1947-48 plan. Seven million was the most ever attained under Hitler. We are importing something like fifty million dollars' worth of fertilizer in nitrogen and phosphates and something like thirty million dollars' worth of seed in order to increase the production, on the theory that for every dollar spent for fertilizer in appropriate proportion we will get about seven dollars return in food. That, of course, as many of you who are familiar with farming know, will depend upon the climatic conditions under which the crop is grown. This year we did not realize that by any means because a great deal of our winter crop was destroyed and the harvest was much smaller in yield because of the unprecedented drought. But that is the theory we are operating on.

But even if we are successful in getting maximum production of food in Germany, it will represent--again going back to my basic thesis--only about fifty percent of her normal requirements. Prewar Germany consumed just under three thousand calories, on the average, per person. We can produce, if we are able to maximize production up to our estimated limit, only about 1350 to 1400 calories of food of all descriptions to maintain the German people. Whether they will ever get back to the very high standard of living they had prewar is a matter that depends upon the future of Europe.

The number two problem in Germany today, after food, is coal. There has been a direct relationship between the ration that has been furnished the German coal miner and his family and production out of the German coal fields. Prewar Germany reached an average, for the last two years prior to the war, of about 400,000 tons of coal in the Ruhr per day. Last winter we had the second food crisis and our rationing dropped from 1500 calories to about a thousand or eleven hundred; coal production dropped down to 189,000 tons from considerably over 200,000 tons per day.

We are constantly working on our food ration and giving incentives and preferential treatment to the German miners. Last week we reached a German production of 284,000 tons, almost a hundred thousand tons more than we were producing in the winter, with the same number of miners and with the further fact that production of coal normally goes up in the winter.

If we cannot solve the food problem in Germany, we cannot solve the coal problem. And if we do not solve the coal problem, there will be not only no real industrial recovery in Germany, but the whole Marshall plan of industrial recovery throughout Europe will be adversely affected.

I am not willing to say here to this group that a failure to revive Germany economically is a condition precedent to the revival of Europe. But I am certain if we do not bring Germany's industrial production back to approximating a prewar production, we are certainly going to retard greatly the revival of Europe. It has been the industrial powerhouse of Europe for many, many years.

So, in your thinking of that, I wish you would consider that for our own interest it is essential that we export to Germany hundreds of millions of dollars' worth of food. It will cost us about one billion dollars in the Fiscal Year 1949. That is because of the fact that the British have actually now pulled out of the financial support of the combined area. You will recall that a year ago we entered an agreement with the British by which they would supply fifty percent of the funds for the importation of food and foodstuffs in the bizonal areas. Because of their critical dollar situation today, they have had to pull out of that to the extent of contributing possibly no more than ten percent of their original commitment.

That brings up a question very close to all of us and that is what effect all of this is going to have on our own economy. I do not believe anyone would be so bold as to say we could spend the great sums we are called upon to spend in order to establish some equilibrium in the world's economy--which is necessary, in my view, for any world that we can live in peacefully--without some difficulties here at home. I am not going to try to get into the foreign field here, but I do think, as thoughtful, important and influential Americans, you might just as well be prepared for the fact that it is going to cost us something more than just dollars to support and revive Germany during the next four or five years; and our contribution, largely under the Marshall plan, just simply cannot run uncontrolled without its having detrimental effects on our own price structure. But I am confident that the detrimental effects on our future, by failure to carry through what we are undertaking now, will be infinitely more costly. In that respect, gentlemen, each of us is tremendously interested.

General McKinley, I will be glad to answer any questions this group may have. If I cannot answer them accurately, I will so state.

QUESTION: Do we accept requirements of other countries for food and other items blindly, or do we make some investigation of their requirements after they give us the figures? And when we do give them aid, like we are going to give in the way of food, do we do any supervision of that?

COLONEL HESTER: The answer to the first part of your question is yes. But what we do is very limited, actually. We have some embassies and some consulates scattered throughout these countries, like Italy and France, for instance. On the staff of the ambassador in each country, or the minister, is an agricultural attache'. Of course, the other members of the staff are not entirely dumb about food matters.

So they travel around. They get as much information as they possibly can by observing the crops, talking to the farmers, determining what the yields are, and so on. But there really isn't a great deal anyone can do in a country the size of France about determining their production. You can do better by studying the historical statistics on it and applying the current weather reports. In that way, you will come out with a better estimate of what the production is than by going out and talking with the farmers. That estimate is being made in each of these countries. But I must confess I am very skeptical, myself, as to the adequacy of those reports. I think the agricultural attache' would be first to admit that their information is not accurate. They do not pretend that they are accurate.

Now as to the second part of your question I really think we are making a very bad mistake. Even though we would be accused by the Soviets, and others, of trying to impose our ideas and interfere with the aid countries economies, it seems to me very dangerous to turn loose all this food in these countries without any controls as to its distribution. I spent two weeks in Italy. I saw more food in their restaurants than I find in the restaurants here at home and at prices I could afford to pay. I could get as fine a dinner in Rome for $2.50 as you can get in the Mayflower down here for $10.00. Of course, I was not using the official lira; but no one else in Italy was using it either, so far as I could discover. I went up to the American Express Company, got my checks cashed at 650 lira to the dollar. I did not ask them for that much; they gave it to me. I could go into their restaurant, give them American money and they would give me 650 lira for it.

GENERAL McKINLEY: Just what is the value now?

COLONEL HESTER: It was 350. I understand it is now 550. They are going to revise it every month. We cannot determine what its purchase value is, for reasons best known to all of you. But certainly if we could supervise the distribution of this food it would get to the places where it is required rather than greasing the palm of somebody in the process of distribution.

QUESTION: Colonel, could you tell us what the caloric intake is, as supplied by the Russians in the Russian Zone, as compared to what we are able to give them, and what political effect that has on the German people?

COLONEL HESTER: I meant to cover that in my principal remarks.

So far as we can discover, it is about the same in the Russian Zone as with us, just in the neighborhood of 1300 to 1350 calories for the normal consumer. Now a lot of people get mixed up over the term "normal consumer." We did not coin the word. That is the Department of Agriculture's word. It uses the term in describing all levels of living.

If you took the average, you would have to add about three hundred calories to that in order to get what the average person consumes. But, you see, the answer is there is no average person; so they take the normal person.

The Russians give about the same as we do. This amount is grown in the Russian Zone. We are furnishing a little more than fifty percent of all the food that the Germans are eating today, in our zone. A little more than fifty percent of what they eat is being imported and paid for by the United States, with some help from England.

QUESTION: This question is not on food, Colonel, but you may be able to throw some light on it.

I understand Germany used to have very well managed forests and, considering the acreage of the forests, their yield was very high. Do you know if that management is continuing or is there indiscriminate cutting going on?

COLONEL HESTER: No. The management in our zone and in the British Zone--certainly in our zone--is fully intact. They, in all probability, had the finest forestry practice in the world, prewar. They still have those same foresters. True, some of them have been de-Nazified and kicked out.

We have been overcutting for the past two years. We are cutting now at the rate of about two hundred percent; that means twice the annual growth. The necessity for that is tied up in this matter of coal. Tremendous tonnage of wood is being cut to furnish fuel that was formerly supplied from coal. We have not been able in the past two years to give anything except a couple of briquettes to the people in the cities, like Berlin, for instance, to keep their homes heated through the winter.

As a result, the German forests have had to be overcut. They needed to be overcut somewhat for the simple reason they had acquired, first, an unusual growth; by cutting down other peoples' forests during the war and conserving their own. Second, they just keep their trees too long, anyway. But there is no indiscriminate or foolish cutting, except that which is necessary to keep the people warm until we get the coal production back. In the Russian Zone there is heavier overcutting. There is also some overcutting in the British Zone.

COLONEL THOMAS G. McCULLOCH: I noticed that Mr. Royall, in justifying the request for funds in the bizonal area, indicated the United States might anticipate more of a field of control in, say, economy and politics than the British area. Last night's paper carried an account where the British newspapers had come out in flat refutation of that. Can you say anything about the area of disagreement on that?

COLONEL HESTER: (Discussion off the record.)

MR. JOHN W. SWAREN: You mentioned somthing about the agricultural production of Germany. A number of the farm publications in this country have stated that if American farm agents were sent to Germany they might help improve farm technique and thus increase production. On the other hand, some of the city papers, that have commented on the same suggestion, hold it to be rather an unusual and unnecessary suggestion. Would you care to comment on that?

COLONEL HESTER: Well, of course, agriculture in Germany is considerably different from this country. Regarding the yields in Germany today, even when we are producing actually about 70 percent--I did not mention that in my previous comment--we have gotten back between 65 and 70 percent of its highest prewar production; but even with that 65 or 70 percent, our yields in Germany are much higher than the comparable yields in the United States, per acre.

Nevertheless, there is a good deal to be said in favor of sending over our best technicians, best agriculturists, to Germany. In the first place, the Germans have not been in contact with any scientific information for the last seven or eight years. If we could get fifty to a hundred of our best agriculturists over there to advise them in connection with the improvement of their technique, and bring them up to date on the best and most recent developments in the United States, there is no question about its being helpful. And, incidentally, it would help us to know really how much the Germans are producing because we would have the people there to tell us.

DR. A. J. PETERSON (former member of the Faculty): Some of the Army men who have come back from Germany have indicated they would like to send over some machinery and materials and have them converted into the finished product, stockpiled, or for some other purpose. I wonder if you think that would be feasible?

COLONEL HESTER: Yes, and that is being done. It has to be done to a much greater extent, too.

The same thing is true of cotton. They have their fine textile mills there. They have the know-how and the technical knowledge. If we could give some of this surplus wool of the world--we are getting some from England through Australia--for that purpose now, you could not only give some clothes to the Germans but could pretty well pay for it out of the export of their finished product. We are doing that to a small extent now and are planning to do it to a much greater extent.

That was what I really was meaning by your authority to import raw materials and export your finished product. That is the only way Germany will ever get clothed. She would be able to bring in woolens and cotton and manufacture them and then to help pay for them at least out of the export of additional surpluses from them.

GENERAL McKINLEY: Are private sources of raw materials of that kind, particularly here, offering to do that?

COLONEL HESTER: We are doing it through the Commercial Credit Corporation. You see, there is no way yet--or at least not until within the last few weeks--of explaining to the Germans how to negotiate contracts. That is only very recent. So there will be only a handful for a long time to come. They have no dollar credit.

GENERAL McKINLEY: The Italians enjoyed a different situation from the Germans; that is, they were cobelligerent.

COLONEL HESTER: That's right.

GENERAL McKINLEY: They had a cobelligerent status. Even two years ago, when I was over there, the cotton interests in this country were offering to give them raw cotton and take back the finished product in payment for the raw cotton. So that they would have the cotton goods to the extent of the value which was added by manufacture.

COLONEL HESTER: We are doing the same thing in Germany except we are doing it through the CCC.

The German himself can't do anything in the way of making a contract. Every contract made in Germany has to be signed by the Military Governor, big or little, if it is outside of the internal German economy itself. It makes the actual transaction of business an almost insuperable thing.

Very recently they have permitted the manufacturer to retain a small portion of the money he gets for goods in actual dollars.

I think it might be interesting to this group to know that for the first time--the first time in history I know of--we have a country over there that deals internally and also externally, yet the medium of exchange they use inside has absolutely no relationship to the medium of exchange used outside. There is no relationship whatsoever between the German mark and any other currency in the world. When we ship food into Germany, the German consumer pays for that food in German marks. It has no relationship to what it costs the United States to send it over there.

The money that is paid by the German for the food is put into a blocked account. When we make a contract for the Leica Company to ship out a thousand cameras and sell them for, say, $400,000, the German manufacturer does not send a dime of that. They turn back to this blocked account that the Germans paid in for this imported food and dig out a few marks and pay him for his cameras and put whatever the amount is into a joint foreign exchange agency.

So, you see, the two things are just as separate as night and day. There is no relationship between them. Until we can break that down there is going to be a very cumbersome method of engaging in foreign trade.

GENERAL McKINLEY: I've been through the same thing.

QUESTION: Could you tell us, Colonel, something about the productivity of the agricultural region in the northwest of Germany as compared to that in the eastern part of Germany, occupied by Russia? It seems to me that that part in the lowlands next to Holland should be fairly productive.

COLONEL HESTER: I was not trying to say that the Russian Zone could afford a higher caloric level than we can in the British and United States Zones. What I was trying to say was that the population is much more dense. There is not anything like the same number of acres available for agricultural production.

You will find some of the finest production in the world up there in that area alongside the Ruhr. Some of their yields are fantastically high. But because of the large industrial population and the density of the overall population the actual amount of food we get out of the British and United States Zones is small. Of course, in the United States Zone we have largely scenery; the British got all the industry; the Russians got all the food; the French have the wine.

But you are correct in saying some of the finest productive soil is in that area.

QUESTIONER: I did not know anything about the Ruhr. I was up in the other part and it seemed to me it was more productive than the agricultural land in this country.

COLONEL HESTER: They are producing right now--they are only 65 to 70 percent of their highest prewar production--twice, in many cases two and a half times, as much per acre as we produce here in the United States. But don't forget the fact that there are seven Germans on one acre and there are three acres for one man in this country. That is the difference.

QUESTION: To what extent can the German industry, when it becomes revived, be complementary to the industries of the countries bordering on it, like Denmark, Holland, Belgium, and so on?

COLONEL HESTIR: I can answer that best by citing what happened every day I was in Germany. They were trying to sell us food in order to buy machines. This was true in Holland, Denmark, Sweden, Belgium, Norway, Italy, Yugoslavia, and the whole crowd of them. If we could have exchanged industrial goods for food, we could have brought in many hundreds of thousands of tons of food. There were tremendous quantities of food in Holland. That was the biggest market for food, prewar. Their economy is agricultural, based pretty largely on their sales of vegetables, and things of that kind, to Germany. But we could not take them because there were no calories in the vegetables and it cost more money than we had. Our funds were appropriated by the Parliament of the United Kingdom and the Congress of the United States. In order to keep those people alive, we had to put calories in them. So that is one of the things I was referring to when I spoke of these man-made problems.

If we could wash out all the barriers to trade in Europe, we could build a real cornerstone under the Marshall plan. But, you see, one of the principal difficulties is you have no common currency. If you travel today in Europe, you have to carry a half-dozen different currencies in order to get food, lodging, and gasoline. In many instances it is just impossible for one country really to do business with the other. It is almost entirely impossible to do business with Germany since it has been divided into four states.

There is no question about their economies complementing one another. That is why we feel it is most important not to build Germany back up as a potential threat to the peace of the world, but build it back up to a level by which she can import the things she needs and export the things the people around her need. That is what we are trying to do.

I do not think there was a week, in the two years I was over there, that somebody from one of those countries did not come to us trying to sell us food in order to buy something they needed from German industrial production.

QUESTION: I remember a German telling me how he could go to Bavaria and get food and carry it back up into the northern part. Now Bavaria was supposed to give a certain amount of food to those in the northern territory. As I recall the situation, the Military Government finally had to go into Bavaria and forcibly take away some of their cattle. That was the problem as I recall it. Has that been, in any way, straightened out?

COLONEL HESTER: We have corrected a lot of their failure to turn it in, but we have not corrected their indisposition to do so--and we never will.

But under this bizonal organization we have set up down at Frankfurt, you have a minister with his staff. The present member from the British Zone has on his staff an inspectorate; he has all of the statistical information about what the production is, and what the imports are. Here is the way it works, under an agreement we got signed by Generals Clay and Robertson last summer. We determine, actually by thrashings and diggings, what the production is on a random number of farms--the old Gallup poll idea--so we can turn up with an actual overall production figure for a state. We will take, as an illustration, potatoes. Bavaria produces considerably more potatoes than it needs for the official ration as established for the combined areas. It will have to ship out about a million tons of potatoes, or a little more, this year. Well, Bavaria isn't self-sufficient for twelve months in grain or in fats. So, if she doesn't ship out a million tons of potatoes she doesn't get the corresponding amount of imports she would normally be entitled to when you add both up and divide them. So we think we have that pretty well licked.

Now I would not for one moment want to leave anybody here the impression that we have eliminated the black-market in Germany. I do think we have it under a little better control in a good many of the countries surrounding it; but it is not eliminated. We will admit three hundred calories are being distributed outside of the ration, but it comes from indigenous production.

The controls on imports are pretty well foolproof. But if a state does not live up to its obligations to move food out of its area into a less surplus area, we simply refuse to move imports into that area. If they do not ship out potatoes, they do not get their grain or fats or dried skim milk, and so forth and so on. Bavaria has practically no sugar. So we take the thing they are shortest in and refuse to ship it to them unless they meet their interzonal commitments.

There is a little improvement since you were there.

GENERAL McKINLEY: There has been a big change since I was in Italy. For one thing, their transportation seems to be pretty well organized again. When I was over there, we were cursed with the fact that we would have lots of food in one area and couldn't move it up to the areas where there was a scarcity. There was no way that we could move it.

COLONEL HESTER: I know. Transportation was simply shot to pieces. Actually, I suppose the biggest problem we have in Germany today is transportation. We are not moving the coal that is being produced out of the Ruhr. However, we think we can lick that because coal is eventually going to help us to make more cars.

If you can ever get a decent winter and a decent summer, combined, over there, we will have some chance. But last winter every canal and river in Germany was frozen over solid and food and other commodities had to be moved by rail, which was at that time shot to pieces.

GENERAL McKINLEY: Colonel, you have been very generous with your time and patience. I want to assure you we have all enjoyed this talk very much. We are deeply indebted to you.

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RESEARCH AND DEVELOPMENT IN METALLURGY

12 December 1947

CAPTAIN ROWLEY: To bring our series of Technological Progress lectures to a close, we are going to hear this afternoon about research and development in the field of metallurgy. This is a field in which great advances have been made, especially in the last generation. It is also a field in which industry, the Armed Services, and other agencies are working very hard toward new developments.

Our speaker is Dr. Frederick Seitz, Jr., whose career has been spent considerably in the field of education. He, until this July, has headed the school conducted at Oak Ridge for the instruction of newly arrived physicists and engineers. His regular academic duty, you might say, is as head of the Department of Physics at the Carnegie Institute of Technology at Pittsburgh.

I take great pleasure in presenting Dr. Frederick Seitz, Jr.

DR. SEITZ: I assure you that it is a great pleasure to address this group.

What I would like to do in the rather short time I have at my disposal is give you a brief picture of the status of the study of metals at the present time and of the various fields that are attached to it.

If you examine the various fields of technology from the standpoint of their history and background, you find that they fall into two major groups. One of these groups is very easy to understand. These fields of technology are those which have sprung directly out of science. There are certain fields, a prime example of which is electrical engineering, in which the field of technology would not exist if it were not for the fact that at a definite point in the natural development of science certain discoveries were made. In the case of the field of electrical engineering, it is true we occasionally run into electrical phenomena in every day living, such as when we pick up a static charge while walking along a corridor and obtain a shock upon touching a door handle. But in the main, electrical phenomena are rather submerged in the world about us, although we know they play a very important role. What has happened in the course of the development of electrical engineering is that scientists, going out of their way to investigate unusual things, uncovered the laws of electricity and magnetism, and other men put it to use.

In a field such as this, there is an underlying theory which is sound and which can always be used whenever anything new is designed, whether it is a motor, a transformer, an antenna, or a radar device. In the whole profession there is a high regard for the theoretical principles and understanding. There is a close bond between the scientists and the engineers.

The field of atomic engineering is in exactly the same situation. The phenomenon of fission, which opened up the field of atomic engineering, was discovered in the course of scientific research. The first men to do work in the field of atomic engineering were very close to the fields of science. Again you find the situation that is met in electrical engineering a very high standard of appreciation of fundamental principles.

There are other fields of technology that fall in a different category. These are the fields of technology which were developed through necessity in a period before the underlying theory was available. One example is mechanical engineering. Civil engineering is another.

The need for the practice of mechanical and civil engineering goes back into prehistory. People had to build bridges, dams, and similar devices long before they knew the basic laws of mechanics. In about 1700 these basic laws were discovered and it then became possible to put the fields of mechanical and civil engineering on what we might call a scientific basis. Previously the practical methods of mechanical and civil engineering resembled those of a field of art, as a result of the centuries of growth on a purely empirical foundation. The people had rules of thumb that had been developed purely by trial-and-error methods for doing the things that had to be done technologically.

When the science was developed, it first made very little impression. In the first place, there was the traditional art-like development which had many successes to its credit. The individuals who were trained in mechanical and civil engineering tended to resist the more intellectual growth. They did not see any need for it. And the truth is that in the early days, the development of the laws of statics and dynamics on the part of the scientists of the day did not have a great deal to contribute to mechanical and civil engineering.

Exactly the same situation existed in ordnance. Gunpowder had been invented many years before Newton and Galileo, and guns were used. One did not have, however, anything resembling an exact theory of the operation of the ordinary weapons of ordnance. It is true that the discovery of the laws of mechanics made it possible to do something more, but it was not obvious that these new theoretical principles would be of any great help. And you find in 1700 that the effects of the development of mechanics on the subject of ordnance were on the whole relatively small. In fact, in the field of ordnance, as in the field of mechanical and civil engineering, it took about a century before the effects began to be felt. We find that ballistic science really did not develop to a high degree until the time of the Napoleonic wars. The great French ballisticians had their incentive a century after Newton and Galileo.

The gradual welding together of the empirical technology and the theoretical principles which began in the eighteenth century continued well into the present century. In certain new fields, such as aerodynamics, where the benefit of using theoretical principles could be felt almost at once, it is found that the traditions based on theoretical understanding came in much faster, in fact, than in some of the more conventional fields, such as mechanical engineering.

Now, metallurgy as a whole, regarded as a branch of technology, resembles the fields of mechanical and civil engineering and ballistics rather than the field of electrical engineering. Archeologists have good evidence to show that the metallurgists (who have been with civilization almost from its dawn) were among the first artisans to have a preferred position in society and, because of their special art, were among the first people to rank with the administrators and the early clergy in being freed from the burden of tilling the soil. It is easy to imagine that in the prehistoric era the metallurgists, the men who made copper and steel and shaped them into useful tools, took advantage of this position and were quite willing to play on the somewhat mystic aspects of their knowledge.

Metallurgical science did not develop, in fact, until the end of the last century--and for very good reasons. In order to have a well-developed metallurgical science, it is necessary to have an underlying knowledge of the behavior of atomic systems, a knowledge of the constituents of matter. This knowledge did not come to us until after developments which extended well on into this century. As a matter of fact, the underlying knowledge was not really available, let us say, until 1930 or thereabouts, after the development of what is now known as quantum mechanics.

The result of this situation is that the field of metallurgy still exhibits very strongly today the effects of two different traditions. One is the historical tradition, in which metallurgy is regarded to some extent as an art, trial-and-error methods being used to make progress. The other is the scientific tradition, based on the desire to reduce our understanding and knowledge of metals to fundamental principles similar to the fundamental principles that operate in other fields, such as electrical engineering.

The science of metals is young. The fusion of these two channels is not yet complete. In fields such as electrical engineering, in contrast, one finds ready acceptance of the people who delve into theoretical ideas. There is acceptance of this approach in certain regions of the field of metallurgical practice; in other regions there is not. I think that at the present time we are about at the half-way point in the course of this development. It will take fully another generation before the fusion is complete, that is before metallurgical education and practice resemble in their entirety the type of education which exists in fields such as electrical engineering and atomic engineering.

In order to indicate perhaps more sharply this difference in viewpoint between the man who is interested in metallurgical practice in the traditional sense and the man who is interested in the fundamental science of metals, I might attempt to outline the general fields of interest in the two cases and indicate how the difference in viewpoint is being reduced.

I would estimate that at least ninety percent of all the metals which are made and used are produced because of the unique mechanical properties metals can possess: high strength coupled with ductility, a certain absence of brittleness; the capability of being brought, by proper heat treatment, to great hardness; and so forth.

The next great field of interest centers about electrical properties. Of the ten percent of metals not used for mechanical purposes, the great majority are used for electrical purposes: for their ferromagnetic properties, as in the case of transformer steel and for their high conductivity, as in the case of copper.

Although mechanical and electrical properties cover almost the whole field, there are a few exceptional cases, which are becoming to be more and more important as time goes on. In the first place, there are metals that are used because of their excellent high temperature properties. One very good example of this type of metal is the tungsten, which is used in the filament lamp. Tungsten is of interest in this application because it has a very low vapor pressure at very high temperatures. Similarly, there are the metals that are being used in gas turbine engines and in jet engines. As a matter of fact, the development of special metals and alloys for high temperature service is probably one of the most important fields for the immediate future. We need not look very far to find metals that are used for other special purposes, for example because of a high degree of resistance to corrosion.

Now, the practical metallurgist, having certain immediate goals, naturally limits his attention when possible to the things at hand. His first great interest is in composition. He knows that unless he has control over composition, he cannot match reproduceably any property that he wants; thus, process metallurgy ranks very high in the fields of conventional technology, trial-and-error methods having been used for control in the past.

Since metals are used so predominantly for their mechanical properties, the second predominant interest is in mechanical testing. Here again there is a very long and well-developed history. There are the certain conventionalized tests, such as the straightforward tensile test in which a specimen, properly machined, is placed in tension and the flow and rupture studied. Or the specimen may be tested in bending. The metallurgist may study metals in rapid deformation or slow deformation, depending on the ultimate use.

A third field of interest to the every day metallurgist is the field of reaction rates. Steel, for example, is particularly useful because it is possible to control its hardness and ductility by subjecting it to tempering reactions in which time and temperature play a role. The standard procedure involves heating the metal to an elevated temperature so that the carbon which it contains goes into solution. It is then cooled, during which process, the carbon comes out of solution. The metallurgist has found that if he heats and cools the metal at certain definite rates, he can control its characteristics in a way that depends upon composition. For this reason, the problems centering about reaction rates interest him.

About fifty years ago it was found that there is a strong correlation between the observed practical properties of metals and their appearance under the microscope. For this reason microscopic techniques, that is, techniques in which metals are polished, etched, and then studied under the microscope, now play a very important role in the conventional study of metals. Fifty years ago the use of the microscope was regarded as an innovation; and the great metallurgists of the past, men such as Howe, Sauveur and Tammam, who introduced the microscope, were considered somewhat radical during this period.

If the conventional, practical metallurgist could get along with only the tools I have mentioned, I think he would do so--and for very good, practical reasons. After all, his success depends on putting out certain products which behave in a certain, regular way. The case of the introduction of the use of the microscope, however, indicates that if he is to be successful, it is essential that he introduce new methods. That is why the subject of the science of metals is so important from a practical viewpoint. In the development of a science one arbitrarily studies all aspects of a subject not with any immediate practical use in mind, but in order to ascertain behaviors in a general way. Experience shows that if one follows such a procedure consistently, then in a certain percentage of cases one turns up something that is exceedingly new and of great practical importance.

From the standpoint of the science of metals, the general ordering of metals goes about as follows: The person who is concerned with the fundamental properties of metals is interested, first, in the gross structure of the metal. Such things as the size of the crystals present in a given specimen interest him.

Second, he is interested in the atomic arrangement. Since 1913, with the development of X-ray techniques, it has proved to be possible to determine the detailed arrangement of atoms in solids. The practical development of this subject and its use in the study of metals began in about 1920, just after World War I. In this country a great deal of the pioneering work was done at the General Electric Company by scientists such as A. W. Hull, who first started a systematic classification of metals on the basis of their atomic structures.

In more recent times, since about 1930, there has been interest not only in atomic structure, but in electronic structure. Metals are made up of atoms, which, in turn, are made up of electrons. Since the development of the atomic theories, it has been possible, using suitable techniques, to determine how the electrons as well as the atoms in metals are behaving.

From the standpoint of metal science, any knowledge that can be accumulated concerning these two characteristics is regarded as important.

The third fundamental field of broad, general interest centers about the thermodynamical properties of metals; in other words, those characteristicts which are also of great interest to the chemist studying reaction rates and equilibrium phenomena in connection with chemical reactions. Phase diagrams, which show the equilibrium relationships between the crystallographic structures which occur in metal systems, are regarded as fundamental knowledge from the standpoint of those interested in the science of metals.

The broad fields concerned with atomic and electronic structures and with the thermodynamical studies of bulk materials, rank first in the order of interest from the scientific standpoint.

A systematic study of the characteristic properties of metals, soon shows that it is impossible to understand all their properties if it is assumed that they are perfect. If one could obtain a perfect metal, say a perfect single crystal of iron, one would find that it would not behave anything like the way ordinary iron does. In the first place, it would not be ductile, that is, it would not flow plastically. It would be very strong and would break brittlely at a value of tensile stress perhaps five to ten times greater than the tensil strength of any of the known forms of iron.

It is known now, as a result of research in the last twenty years, that metals, and solids in general, owe a large number of their interesting and important characteristics to the fact that they contain imperfections. A person concerned with the science of metals will attempt to make a systematic study of the type of imperfections which can occur in metals and other solids in order to obtain a better understanding of them.

There are several kinds of imperfections. In the first place, there are what might be called point imperfections, that is, imperfections occurring at a definite point in the crystal lattice and which affect a small area of atomic dimensions about that point. The alloying agents such as carbon which are commonly added to iron to make steel, have their effect in a small region about the position in the lattice where they lie. In fact many of the effects of alloying agents in general can be correlated with the influence which they exert at the points where they are situated.

It is known that diffusion would not take place in many metal systems if it were not for the existence of certain kinds of point imperfections. Alloys can be made from the pure metals by mixing the powders, for example, and heating them in a furnance so as to allow interdiffusion of the two constituents. This interdiffusion process would not take place with anything like the speed it does if it were not for the fact that metals contain imperfections which help diffusion.

There are other kinds of imperfections. For example, there are imperfections that are sometimes called line imperfections because they extend as lines through long distances in the lattice. It is believed that line imperfections play an important role in determining the plastic properties of metals, so important for their mechanical behavior.

Similarly, there are imperfections which occur over planes. The simplest of these are the imperfections which occur between two crystal boundaries. Most of the materials that are used in crystals contain many crystals, and the surfaces of contact are regions that merit particular study. In addition, there are planar imperfections which occur on a finer scale. If you took a single metal crystal, you would find that it is composed of small mosaic blocks, which are tilted or rotated relative to one another. The planes between these mosaic blocks represent important regions in the sense that metals would have very different properties if they did not occur.

I believe that it is safe to say that a large fraction of the knowledge that is accumulated in this systematic scientific study of metals will eventually find its use somewhere in practice. I would say that the great problem today in developing metallurgical engineering is in making certain that the people who work in practical, everyday metallurgical technology and those who work in metal science meet around the same table and find a common ground of understanding, so that they can transfer work and knowledge from one portion of the field to the other. The study of metals by X-ray techniques was more or less of an academic thing twenty-five years ago. Today every metallurgical laboratory has good X-ray equipment, just as fifty years ago it was novel for every good metallurgical laboratory to have a microscope. It is found that techniques such as electronic diffraction and microscopy, which ten years ago were studied only in a few specialized laboratories, are becoming available today in many metallurgical laboratories where practical work is being done.

As stated previously, I believe that the problem of joining metallurgical practice with science has been solved to about half of the extent possible, that is, I believe we are about half-way along the road. It seems to me that within a generation the educational techniques that are used in metallurgy in general will resemble those which operate at the present time in other fields of engineering, such as electrical engineering and aerodynamics.

There is no better way to illustrate the manner in which this interplay of practical technology and metallurgical science takes place than by selecting examples from wartime experience.

In discussing wartime developments, I believe I can divide them, at least for the purposes at hand, into three major groups. Consider first the run-of-the-mill metallurgical problems, the problems which were met in the early days of the war in an ordnance laboratory or an ordnance producing plant. One finds that, for the most part, the advent of war brought very few problems of a basic nature. Particularly in the early days of the war, the great problems centered not about innovations in the sense that new ideas had to be used but about the adaptation of the production machinery and the supplies available to production demands.

Take a typical and, perhaps, very prosaic example. A certain steel company in Philadelphia is asked to produce class "A" armor, which it had not produced since World War I. The main problem here is to clean out the mill in which class "A" armor had been made and in which manufacture had stopped in about 1918 and to put it back into operation. The next problem is to find men to operate it. Fortunately, there are men available who worked in the same plant during World War I and they are able to do the job. Since the naval armor being made has a high priority, these men get the nickel and chromium they need for the manufacture. Nothing very new is needed except the activity involved in stimulating production to the figure required.

On the other hand, the person who is making light armor, small-arms projectiles, or small-arms weapons finds himself in a different situation. He has guided all his thinking on the assumption that he can get nickel and chromium if he needs them for his manufacture. He assumes that he can get all of the brass that he wants to make cartridge cases. Suddenly he finds there are shortages; the person making naval armor or naval projectiles has priority on the nickel and chromium, and he must do without them. His basic problems, then, are: First, to get along without the use of the alloying agents which he had expected he would obtain, and second, to get large production. Instead of using nickel and chormium, he finds he has to use manganese and silicon. He proceeds following rather conventional lines and finds in the course of six months of development that he can make fairly good materials in spite of the shortages. In the course of another year, by careful control, his production is high, his quality is good.

This is the story in the great majority of the fields of conventional metallurgical development. The problems that are met are not very different from the peacetime problems. There are certain specialized situations that arise from time to time and require the surmounting of hurdles.

Perhaps the production difficulties of the type I mentioned were even greater in European metallurgical practice. In our own country we never had to forego the use of brass for small-arms cartridge cases. In a country such as Germany, where copper and zinc were at a very high premium, these metals could be used only for special things. There it became necessary to develop steel cases. We recognized this as a possible problem, and could have solved it had it actually arisen. Fortunately, it did not.

In the broad, conventional field of metallurgy, one finds cases where innovations were introduced to cut corners that were not of the variety I mentioned. For example, the field of powder metallurgy developed very rapidly because of needs for quick methods of making certain parts that would be very difficult to machine. Pressings of powders could be made to the desired shape and time could be saved. There were large developments in this field.

There are two other fields in which the impact of wartime experience brought about great changes and which are perhaps better illustrations of the need for wider understanding of fundamental principles. First, there is the problem of high temperature alloys. Two aspects of this subject are of interest. First, there is the development of alloys for, let us say, turbine systems. It was found that the metals which could be shaped and formed easily by conventional machining methods were on the whole not good for turbine blades that would operate at the high temperatures, that are of interest in a gas turbine for an airplane supercharger. It was necessary to do something quite new and radical. One of the developments which made progress possible was that of the "lost wax" method. It was found that parts for high temperature gas turbines could be made by exactly the same technique that the dentist uses in making an inlay.

Here was a specialized problem that was solved by using rather radical, new ideas. In this case the only contribution from the fundamental science of metals lay in the fact that the systematic study of the thermodynamic properties of metals had shown in which directions one might hope to find good alloys for this new type of casting technique.

Another problem, which arose toward the end of the war, was that concerned with liners for jet engines and related devices. There is a very close correlation between this problem and that of blades for high temperature gas turbines. In both cases the thermal characteristics of the materials set the limit. The development in the field of jet engine liners is still in its infancy.

One cannot mention any field of wartime development without sooner or later running into the activities of the Manhattan District. I think that there is no field of activity which illustrates better the way in which fundamental knowledge contributes to the speed of technological development. Consider just one material which played a basic role, namely, uranium.

In the early years of the war uranium, as a metal, was practically unobtainable. A few specimens of rather poor metal had been made as a matter of casual interest. In the past people wanted to know the melting point and similar characteristics of uranium and made small quantities of pan material. In 1941, the technology of manufacturing high quality metallic uranium was almost nonexistent.

Then, suddenly, a great interest in uranium in all its compounds came into being. The investigators who were doing the preliminary work in the Manhattan District found that the only form in which they could get uranium in any large quantity was as an oxide. They wanted other forms for general study and they wanted them rapidly. This represents a typical wartime situation to provide a test of a nation's background.

I cannot describe all of the details here, but I believe it safe to say that by 1945, four years after the interest in metallic uranium started, There was as much knowledge available on the metallurgy of uranium as had been developed in the whole field of steel metallurgy since the dawn of civilization.

The reason those studies were successful is that there were available men who had training of a very broad type. The problems which arise in preparing metallic uranium are very different from those which arise in preparing metallic iron or one of the alloys of iron. It is necessary to have a great degree of flexibility in approach. An examination shows that in this development the investigators who played a key role were chemists and physicists. They were willing to look upon the problems at hand as typical research problems and had at their disposal many of the techniques which had never before been used in metallurgy.

If one could talk with complete freedom about the wartime developments in the Manhattan District, I think it would be easy to provide ample evidence to show that our country was able to handle this development in the way it did because we had a very large group of men trained broadly in all of the fundamental sciences which lead into the field of metallurgy. Many of the men who made important discoveries had not previously done any work with metals as such. I don't want to leave you with the impression that the conventional metallurgist made no contribution for that would be far from a proper picture. The additional supplementary background, however, was at least as important as the conventional one.

To repeat, I believe that the great problem we face at present is that of speeding up as rapidly as we can this fusion of the traditional background of metallurgy and the development which is based upon fundamental science.

Fortunately, there are a number of good institutions that are doing this well. Before the war there were about three institutions in the country which had training programs in the field of metallurgy which took proper account of the balance between practical interest and scientific interest. Since the war there have been several additions, one very important one at the University of Chicago in the form of the Institute for the Study of Metals.

I believe that the support of such institutions will do as much as anything else to further the cause of practical metallurgy in this country by making a wider and wider group of men concerned with practical metallurgical problems familiar with the fields of science that tie in with metallurgy. In this connection I might say that government aid is doing a great deal to help matters.

Before the war metallurgical science in this country was sponsored almost entirely by private organizations (if we can include state-supported universities among private organizations, and for the purposes at hand I shall consider them as such). The largest amount of metallurgical research was being carried out in American industry, for obvious reasons. A certain amount of fundamental work was being done in academic institutions, with grants either from private sources or from state governments. On the whole the amount of money which was being spent on fundamental metallurgical research was far from adequate. The best illustration of this is the fact that when the pinch came—and it came very strongly within the work of the Manhattan District—it was necessary to use in the laboratories where the most important work was being done men who never before had had much to do with metals. There were not enough men in the country who had a background of understanding of metallurgical problems from the broad, scientific point of view.

At the present time the situation has changed, at least temporarily, a great deal. I would say that at least half of the fundamental metallurgical work in the country now is being supported explicitly by governmental sources. The Office of Naval Research is probably carrying half of this burden through contracts which it is letting with agencies that range from the Bureau of Standards on through to private industry. The academic institutions are receiving an appreciable share. It is very likely that in the near future other branches of the Government, perhaps the Atomic Energy Commission, will contribute to fundamental metallurgy by supporting fundamental work in all of the places where it is done.

I believe that the way in which metallurgy, both practical and fundamental metallurgy, can be furthered most is by continuing this support. I say this not to solicit your support in the program because of the benefits it might give to the institution where I happen to be working, but because I believe all of the experience which we have had to date shows that when a national emergency arises, the scientific information we have on any field of technology proves its value.

QUESTION: There appears to be very little information about the steel industry until 1860, which is about the beginning of the Age of Steel. My question is, when was steel first used by man and for what purpose?

DR. SEITZ: I am sure it goes very far back into prehistoric periods. There were steel columns in some of the Greek temples. I don't know to what extent archeological findings have turned up weapons, but I am quite certain that steel tools were found in the Sumerian diggings. I think a safe guess would be at least five thousand years; probably longer.

CAPTAIN ROWLEY: How was steel made in the old days? Does anybody know?

DR. SEITZ: Yes. One of the standard techniques was to make a mixture of iron oxide and charcoal and heat it. The charcoal would reduce the iron oxide, and you would control the mixture so that you wouldn't get too much carbon.

QUESTION: Along that same line, every now and then we read, generally in the Sunday supplement, about some piece of bronze or steel being found that has properties which cannot be duplicated by our metallurgists of today. Is that so?

DR. SEITZ: There were found, say in the 1890's, specimens of copper which were quite hard. The archeologists at that time said that modern (modern for 1890) metallurgical techniques had not developed anything of a comparable type. Actually, I believe that the foundations of the science of hardening copper developed in our civilization about 1909. Today there are big industries founded on this; for example, those concerned with the beryllium harding of copper and the copper hardening of aluminum (duraluminum). I would say that at the present time there is nothing I know of in the way of metallurgical development which the ancient peoples had which we don't have. But what you refer to very likely was true sixty years ago.

QUESTION: Dr. Seitz, we have been told and we have read that there is a great shortage of scientists in research and development. What is the situation in the field of metallurgy on this particular problem? Are there enough metallurgists being graduated from our technical schools to satisfy the field; if not, what steps are being taken to induce men to go into the field?

DR. SEITZ: I would say, just from the number of letters which come across my desk asking for men to be hired, that we are not training men at a sufficiently rapid rate. What the need is, what the ratio of supply to demand is, I don't know. I would guess that at the present moment there would be jobs for ten times as many men as are being turned out. At least, there are ten times as many letters as there are men.

These things have a way of catching up rather quickly. I would say that the productivity of men could easily be doubled without saturating the field. You must remember that men were not trained all during the war. The great peak in educational load at the present time is in the junior year. It will be another eighteen months before this class graduates.

Exactly the same situation is true in graduate work, incidentally. The men who returned from graduate study in 1945 won't, in general, get their doctor's degrees until 1949. Most of them want to take more time, rather than less, to finish.

So I would say that the field will not start being saturated until about 1949. How long after that it will take before the students come around asking you to get jobs for them, I don't know.

QUESTION: Does there seem to be more interest shown in the field of metallurgy in schools than there was before the war?

DR. SEITZ: Yes. I would say that there is greater interest in all fields of science and engineering. You find that in all of the schools the sciences are getting many good men. For instance, in our physics department, we now have 120 undergraduates, whereas before the war we had only thirty. I think this is typical of all fields.

CAPTAIN ROWLEY: Is that partially due to the influx of ex-GI students?

DR. SEITZ: Yes. I think the average veteran, in taking up his rights under the Veterans Administration, thinks in terms of getting a technical education. Or, let's say, a much larger fraction of them want a technical education, if compared with the students going to college before the war.

QUESTION: Can you give us some idea as to the development of isotopes and their application to metallurgy and other fields?

DR. SEITZ: Yes. At the present time the principal interest in isotopes for metallurgical research lies in using them as tracers to study, for example, what processes go on in a blast furnace or in an open-hearth furnace, how rapidly metals interdiffuse, how rapidly zinc diffuses in copper, and things of that kind. I would say that the isotopes are furnishing a very useful tool for this kind of study. I think that isotopes will be commonplace as a tool in another five years.

There are other interests in isotope problems, of course, in metallurgy. As a matter of fact, in a sense, the problem of making the atomic bomb was largely one of isotope separation and is intimately connected with all the metallurgical problems going with that. I would say that this is one of the fields that is here to stay, so far as both scientific and practical interest go.

QUESTION: Were undergraduate science students used at the Manhattan District? I have reference to students who were of draft age and were deferred. If they were used, were they efficient? Did you get much good out of them?

DR. SEITZ: Undergraduates were not used, so far as I know; but there were many graduate students who were. I'll give you a typical example.

I had a student at Carnegie Tech who, in 1942, was starting his graduate work. He decided he would join the service and did. He ended up being transferred to Chicago to work in the Manhattan District. Since I went there to do some work in a special field, I succeeded in having him work with me. He was one of the most useful members of our group. He worked very hard. He was subject to military discipline during the entire procedure and was very glad that he could combine his period of service with this opportunity to do something which, so far as he was concerned, was highly educational. He is now getting a Ph.D. in physics at Chicago. His wartime work was not only useful to us but useful to him, in a very broad way.

CAPTAIN ROWLEY: Doctor, according to an earlier lecture in the course concerning the number of years' supply of certain minerals, both ferrous and nonferrous, left in this country and other countries, they are in pretty short supply when the present rate of consumption is considered. Is there a considerable portion of research being devoted to the development of substitutes for some of them?

DR. SEITZ: Yes. That was a very big field for research during the war, of course, and I think a large amount of exploratory ground has been covered.

I think that the situation which develops is this: When you use up the good deposits, you find that you have a much larger number of poorer deposits. Very soon you learn to work those deposits. Perhaps the cost of production goes up, but even then I think in general the situation somehow manages to take care of itself, at least on this continent.

I believe the situation at present is that almost all of our very fine, rich iron ore has been used and we are now going into lower-grade deposits. But I believe it is safe to say that the cost of steel will not be affected very much by that. When the time comes, a great deal of imagination is thrown into the problem; and one just finds that new techniques are developed which can be used economically.

This subject is surveyed constantly in the metallurgical journals. As I understand the situation with regard to iron, for example, we are well off and will continue to be so for a number of centuries at our present rate.

QUESTION: Is the same thing true with respect to copper?

DR. SEITZ: Yes. As a matter of fact, the most recent edition of the journal which surveys that subject tells us that in Montana there has been discovered almost an entire butte composed of copper ore, which can be mined and handled at relatively low cost and apparently gives us an almost indefinite supply. It is now believed there are similar buttes in other parts of the country.

Lead may be short; zinc may be short. But I think that metals which are used in great tonnage will be ample for our needs, although the cost may rise.

QUESTION: You spoke of the study of atomic structures of metals. Have you been able to relate that to definite physical properties of a metal? If so, have you arrived at any point or are you nearing a point where you can work a certain atomic structure into a metal and know what properties it will have?

DR. SEITZ: Nature, or the laws of thermodynamics, seem to decide what structures you will get. But you can study the structures and classify them, as you classify butterflies. You find there is a very important correlation between the underlying atomic structure and the properties of the metal.

I will give you a typical example. I believe it is safe to predict, on the basis of what we know of structures, that chromium should be a very ductile metal if made sufficiently pure. This was suspected in the early days of the war, since we had knowledge of the structure then. People who had special interests in metals that would withstand high temperatures undertook the problem of making pure chomium. By the end of the war, they had succeeded in making it only in small quantities. However, those small quantities actually showed the metal to be ductile.

You can predict things of that kind at this time. The knowledge you have may not tell you how to solve the problem at hand completely, but it will give you some very important leads.

CAPTAIN ROWLEY: Doctor, I want to thank you very much for a highly informative lecture. We all appreciate it.

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