IRON AND STEEL AND THE TITANIUM INDUSTRIES IN WARTIME

15 February 1954

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INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. Clark W. King, Executive Vice President and Member of the Board of Directors of Allegheny Ludlum Steel Corporation, was born in Scottsdale, Pennsylvania, and attended the School of Business Administration, New York University. He began his steel career in 1928 with the American Steel and Wire Company. In 1933, when the NRA was established, he was given a leave of absence to serve under the Board of Directors of the American Iron and Steel Institute in the administration of the NRA Steel Code. In 1935 Mr. King joined Bethlehem Steel Corporation's sales development department where he worked until 1941, when he was sent on loan to the War Production Board. He served as special assistant to the director of the Steel Division, remaining at this post under seven different directors. Mr. King joined Allegheny Ludlum Steel Corporation as executive assistant in 1945 and a year later was elected as vice president. He became treasurer and a director in 1949, and in 1950 he was elected Executive Vice President. Mr. King is also President and Member of the Board of Directors of Allegheny Coal and Coke Company, Vice President and Director of Titanium Metals Corporation of America, a Director of Continuous Metalcast Company, Inc., The Arnold Engineering Company, and The Wallingford Steel Company. This is his first lecture at the Industrial College.

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COLONEL DIEHL: Admiral Hague, gentlemen: One of the main industries in our economy is the iron and steel industry. I doubt that you could name any other one industry that has a more profound influence than does this one. Its assets are approximately 10 billion dollars annually and it contributes 4 percent to our gross national product. In addition the iron and steel industry employs some 700,000 people. So just from that you can gain some idea of the magnitude of this industry.

When it comes to war planning, here again we find it is a most important basic segment of our industrial mobilization.

To give us a picture of some of the problems facing the iron and steel industry, we are fortunate in having with us Mr. Clark W. King, Executive Vice President of Allegheny Ludlum Steel Corporation. Mr. King has been associated with the industry for 20 years and has done considerable work in its industrial mobilization planning.

Mr. King will also talk to us at some length on titanium, the so-called "wonder" metal.

It is a pleasure for me to present to you students and faculty and to welcome to this platform Mr. Clark W. King.

MR. KING: Thank you, Colonel Diehl. Admiral Hague and gentlemen: It is a rather unique experience for me here this morning. For a fellow who likes to talk to an assemblage such as this and have a captive audience is rather unique.

But I am very pleased to have this opportunity to meet with you this morning and discuss the ability of the iron and steel industry and the titanium industry to support partial or full mobilization. There has been a long association between the iron and steel industry and the Industrial College and I am aware of the fact that industry representatives have talked to previous classes. This is, I believe, the first class of the college that will have taken special cognizance of the young titanium metal industry.

Since the industries to be discussed are distinctly different in many ways, I propose to explore them with you separately. First, I want to discuss the iron and steel industry.

At first glance the specifications given me for my discussion this morning seemed fairly simple. I have had a close personal and active interest in the problems of steel supply to the military since before the outbreak of World War II. I also had at my disposal a vast array of statistical data concerning the productive capacity of the iron and steel industry.

However, as I began to gather my thoughts in preparation of my presentation, I began to realize that I was groping in the dark. The specifications, I discovered, scarcely indicated the complexity of the problem. And because of its complexity, my personal experience in dealing with problems in military steel supply in World War II was of small help.

I found myself groping due to what we may call a lack of definition. Just what do we mean by partial mobilization or full mobilization?

Are we talking about the raising and equipping of tremendous land forces and naval armadas, backed by necessary supply units, merchant ships, and other essentials we used in World War II? Or are we talking about mobilization for a war whose concept is to destroy quickly before we are destroyed? If it is the latter, how will its requirements differ from the former? Or, if it is a combination of both concepts, what additional production strains can we in industry undertake?

Even that definition is not sufficient. In addition there are questions of conditions under which any mobilization is to be undertaken. Will the steel industry be called upon to support mobilization before the fighting begins or after it is under way? If the latter is the requirement, can we expect to have the safeguards of oceans and allies as has been our good luck in the past? Or shall we expect our plants to become primary strategic targets, thus to have a declining steelmaking capacity?

This morning I am groping in the dark because I simply have no idea what full mobilization entails insofar as steel requirements are concerned. Furthermore, nobody else in the steel industry knows. And where the development of weapons and plans are concerned, that is as it should be. Such information must be kept within the confines of those responsible for their development and execution.

We of the steel industry have neither the right nor the need for such information. But, since we are responsible for manufacturing the steel from which the implements of war must be constructed, we must be informed about the nature of those needs before they can be supplied. So the mobilization requirements, broken down into steel

tonnages by products, should be given to us--but they have not been made available.

And so this morning I find myself in the awkward predicament of experting without knowledge of what I am experting about.

There is one excellent source of information on this subject, the report of the Steel Task Group of 1951. This group, made up of 16 men--all of whom were experienced in the field of steel production, was headed by the chairman of my company's board of directors, Mr. H. G. Batcheller, and I was one of the members of the group. It was named in June 1950, by the then Director of Defense Mobilization, Mr. Charles E. Wilson. Its purpose was to "make a careful study of the industry, to appraise its present and planned capacity to meet military requirements, and to evaluate the supply available for all other uses."

The group held numerous meetings with steel industry representatives, other steel experts, steel consumers, and government officials before arriving at its conclusions. These conclusions, coupled with certain recommendations, were presented to the Defense Mobilizer 31 July 1951, in a classified report known as the "Survey of Steel Requirements."

Although the conclusions and recommendations remain classified, certain aspects were released to the public. I think we can draw sufficiently from that report--backed by what has occurred since--to state the position of the steel industry for partial mobilization according to the only official information at the industry's disposal.

It should be understood, as the report is reviewed, that the Steel Task Group reached its conclusions and made its recommendations in the light of conditions as they existed in the early part of 1951--when we were in partial mobilization for the fighting in Korea and when Russia's mastery of the atom was a conjecture and not an accepted fact. Furthermore, requirements for partial mobilization only--under the concepts of that day--were all the group had to use as a basis.

The group calculated at that time that steel capacity would be expanded from the 104,230,000 ingot tons annually existing on 1 January 1951 to an estimated 120,300,000 ingot tons as of 1 January 1954. Regarding this calculated expansion, the group concluded: "We have expressed our opinion that the expansion program of the industry, as now planned, will provide steel capacity on an over-all basis sufficient to meet military requirements as presently defined, with a substantial surplus available for other purposes."

Actually, on 1 January 1954 rated capacity of the industry, as reported to the American Iron and Steel Institute, amounted to 124,300,000 ingot tons annually. But the expansion program is not yet complete. The industry will spend 775 million dollars in 1954 to further expand its facilities.

Among the projects for 1954 are more new furnaces; stainless steel rolling-mill equipment; a wire rod mill; plate mill facilities; expansion of wide-flange beams and other structural steel capacity; a new tandem cold rolling mill; and much other work. About 800 coke ovens may be constructed or rebuilt.

Also under consideration is the expansion of facilities for producing electrolytic tin plate, electrical sheets, and other facilities. A number of new sintering plants may be constructed. Technological advances and competition inside and outside the industry are constantly creating the needs for new and improved facilities of all types.

I think it appropriate to state that the group qualified its conclusion that planned capacity in 1954 would be adequate under the conditions and circumstances then known. I will pass up those qualifications now in order to move on to recommendations made in conjunction with attaining and supporting that capacity. In so doing, I believe I will demonstrate the sincerity of the industry in carrying out its national defense assignments.

One section of the recommendations dealt with the problem of basic metallics. It stated: "If planned facilities are to produce from 118,000,000 to 120,000,000 ingot tons of steel, an adequate supply of raw materials is obviously essential." The report then included in its recommendations: "In order to supplement the diminishing supply of domestic high-grade ore, action should be taken to encourage and aid in every way possible programs now under way designed to beneficiate low-grade ore (taconite and other low grades) in order that they may be utilized economically."

I understand that several of the steel or ore mining companies are well past the development stages of beneficiation programs. Huge investments in beneficiation equipment have already been made and some of the beneficiated ore is already arriving at the blast furnaces.

Since some of you may not be familiar with the beneficiation process, I will describe it briefly. Low-grade ore, such as taconite, which is magnetic, is first crushed through a series of operations into a fine powder. It is then passed through a system of electromagnets which attract the iron oxide from foreign matter. This oxide is then pelletized and sintered before use in the blast furnaces.

It is too early in the game to work out a set of statistics on the economics of beneficiation, but some people in the industry have voiced the opinion that this beneficiated ore, in the blast furnace, may compete in cost with the more naturally rich ores from Mesabi and elsewhere. Beneficiated taconite has an iron content of the order of 61 percent, compared with an iron content of from 49 to 51 percent of Mesabi ores. If beneficiation proves economical in the light of actual experience, the domestic ore problem will be well on the way to solution.

However, in addition to recommending development of beneficiation, the group also urged encouragement in the seeking out of new ore fields. Progress along this line has been nothing short of sensational, although the new fields discovered and under development are outside the country.

The unbelievably rich fields of Cerro Bolivar and El Pao in Venezuela are in production and we are already using some of their ores with up to 58 percent iron in our blast furnaces. We are also receiving ore shipments from the newly opened fields of Liberia. And shipments from the bountiful fields of Labrador are scheduled to begin this year. Indications are that the ores from both Liberia and Labrador are richer than the ore of Mesabi.

It appears obvious that where ore is concerned, the industry--like in its increase in steelmaking capacity--is doing its job.

Now, with respect to alloying materials--in addition to the basic raw materials, there are many others including the large number of alloying materials. Most of these materials come from outside our boundaries and for them we are dependent upon open sea lanes and friendly governments.

In recent years we have obtained most of our chromium from Turkey, Rhodesia, and New Caledonia. Tungsten has been coming to us from Portugal, Australia, Thailand, Bolivia, Korea, and Japan. The Belgian Congo is our largest source of cobalt. The Belgian Congo is also a major source of columbium, with Nigeria, Brazil, and Mozambique. India, Africa, and Cuba have been our main sources of zirconium; vanadium has come principally from Peru; and Bolivia and Indonesia have supplied us with tin. Canada has been practically our only source of nickel, although that material is available and is now coming in increasing quantities from Cuba, with a dribble from New Caledonia. One other important alloying material, molybdenum, can be considered in plentiful domestic supply.

The Task Group pointed out a danger in counting too heavily upon foreign sources, as conditions stood in 1951. It stated: "It must

be emphasized that interference in the delivery of these increasingly important foreign tonnages, as occurred in the last war (World War II) could vitally affect the maximum production of steel in this country. Protective measures are obviously the responsibility of the military."

As you know, practically all of these alloying materials have been in critically short supply at one time or another in recent years and most of them have been stockpiled by the Government. It is my understanding that the Government now considers many of its stockpile objectives fulfilled, one notable exception being nickel. The portion of the current nickel supply stockpiled by the Government is being increased in 1954, according to advice we have received from our principal supplier, International Nickel Company, and it predicts that supplies for use in steel production will be curtailed. This may have the immediate effect of reducing our production of such products as nickel-bearing stainless steel, not for the military, but for the civilian economy.

Regarding scrap, the report recommended:

> ". . . continued effort to increase the supply of scrap necessary for sustaining steel production by historical pattern, and also a complete study to more accurately determine the availability of scrap for this purpose, and to provide for any possible deficiency by supplementing presently recognized sources of metallics by every means possible."

Everyone is aware of the critical scrap shortage of World War II, a shortage which, incidentally, remained chronic until the end of the fighting in Korea.

Since the end of the Korean campaign, our mills have been running at less than capacity and scrap for the moment is in plentiful supply. Those of us in the steel industry know that this situation will change almost immediately when steel production picks up, and this important raw material will again be in short supply.

Those of us who remember the scrap drives of World War II, when we had to call upon the patriotism of the Nation's housewives in order to get them to give up their spare skillets and bedsteads, know how serious the scrap problem can be. Furthermore, since those drives had to be repeated during the Korean action, we know that our scrap supply must be watched at all times.

A large part of the blame for the scrap shortage in the first place has been attributed to the pre-World War II policy of shipping this valuable raw material abroad. We in the steel industry are apprehensive, to say the least, to see scrap again being shipped out of the country.

I could continue with the citation of recommendations from the Steel Task Group report and relate how we of the industry have done our part in meeting those recommendations. But I believe the report is available to you, so we will pass to some other considerations for the moment. Let's take a look at present-day steel production.

World steel production for 1953, according to "Iron Age" magazine, has been estimated at slightly more than 254 million ingot tons. This is an increase over 1952 of approximately 11 percent.

The free world in 1953 produced nearly 200 million ingot tons while the Iron Curtain nations turned out a bit more than 54 million ingot tons. This would indicate that free-world steel production in 1953 amounted to almost four times that of the mills beyond the Iron Curtain. Red output increased during the year at a comparatively faster rate than that of the free world. Free-world output increased over 1952 by 10 percent while red production went up by about 14 percent.

Let's analyze free-world production--and remember the figures I give you represent production in 1953 and not capacity to produce.

Australia produced 2.2 million ingot tons; Austria, 1.4 million; Belgium, 4.9 million; Brazil, 1 million; Canada, 4.1 million; France, 11 million; and West Germany, 17 million. India produced 1.6 million; Italy, 8.8 million; Japan, 7.6 million; Luxembourg, 2.9 million; Mexico, .6 million; The Netherlands, .9 million; the Saar Basin, 3 million; Yugoslavia, .6 million; the United Kingdom, 19.7 million. The United States, with a record production, melted 111.6 million ingot tons. And all others of the free world together produced 1.5 million. This totals 199,987,000 ingot tons.

Now let us see what happened behind the Iron Curtain, at least according to the best estimates obtainable by "Iron Age."

First the satellites--Czechoslovakia's steel output is estimated for 1953 to have been 4.1 million tons; East Germany, 2.3 million; Hungary, 1.6 million; Poland, 3.7 million; Rumania, .8 million tons. And this gives us an estimated total of 12,490,000 ingot tons for all the satellites--just slightly more than France turned out alone.

To the satellites we must add Russia's output, which is estimated at 41.9 million tons. This gave the Communist countries an estimated 54,390,000 tons of ingots to support their program in 1953.

The figures I have given you may tend to make our civilian population complacent. They should not engender complacency, however, because in this period of military buildup there is no direct relationship between the tons of steel produced and the tonnage used for

military purposes. Your sources of information concerning the amount of Iron Curtain steel going to military applications are certainly more accurate than mine. I therefore will not attempt to make any assumptions along those lines.

Fortunately, because of such problems as location of raw materials, power, and distribution of end products, the steel industry in the United States, at least to some degree, is decentralized.

Insofar as rated capacity is concerned, and I am not now speaking of 1953 production, we have a picture like this.

1. The Eastern District, including the New England States, New York, New Jersey, Delaware, Maryland, and all but the southwestern portion of Pennsylvania, can produce 25 million ingot tons per year.

2. The Pittsburgh-Youngstown area includes southwestern Pennsylvania, all but the northernmost counties of Ohio, and West Virginia and Kentucky. This district can produce 44.3 million tons. It is concentrated around Pittsburgh and Youngstown, with other important tonnages coming from Wheeling and Weirton, West Virginia.

3. The Cleveland-Detroit district includes Michigan and the northernmost counties of Ohio. It can make 12.8 million tons, concentrated around Cleveland and Detroit.

4. The Chicago District includes Indiana, Illinois, Iowa, Missouri, Minnesota, and Wisconsin. Its capacity is 27.4 million tons, largely concentrated in the Chicago-Gary area.

5. The Southern District includes the entire South, and Texas and Oklahoma. Its rated capacity is 6.9 million tons. The main mill concentration is in northern Alabama.

6. The Western District takes in the balance of the Nation. This district has a rated capacity of 7 million tons, most of it in California, Utah, and Colorado.

As of 1 January 1954, these districts had a combined rated capacity to produce 124.3 million tons, compared with 117.5 million tons on 1 January 1953. When the Japanese attacked Pearl Harbor 7 December 1941, our capacity was rated at 88.5 million and on V-J Day our capacity was 95.5 million tons.

I have broken our capacity down into districts to indicate how it is distributed throughout the Nation. With nuclear warfare a possibility, it is frightening to contemplate that the amount of 72

million tons of our capacity is concentrated in six highly populated industrial centers. The implication is obvious.

When I first mentioned the report of the Steel Task Group, I read the following quotation: "The expansion program of the industry, as now planned, will provide steel capacity on an over-all basis sufficient to meet military programs, as presently defined, with a substantial surplus available for other purposes."

In conjunction with that statement, I told you that the group has made some qualifications to its opinion. The major qualification concerned ". . . the possibility of serious delay in the production of one or more of the weapons of war, in case there is an unexpected military requirement for any individual steel product."

The report continued:

> "The pattern of finishing facilities as now scheduled is largely the result of judgment on the part of the managements of the various producers. We strongly recommend that these finishing facilities be reviewed to establish their relationship to military programs, and we further recommend that the industry be kept currently informed during the development of long-term military programs, in order that appropriate adjustments in finishing facilities, if required, may be met in time to meet actual production needs. It is particularly important that steel requirements be defined in terms of mill products."

Once again I want to stress an important fact to you. It is this: We of the steel industry do not need to know what the military is planning in terms of guns, planes, tanks, bombs, and so on down the list. But if we are to give you adequate service, it is vitally necessary that we know what you are planning in terms of types, grades, and sizes of products.

We do not produce war materiel. We do produce different grades and types and sizes of the basic metal from which materiel is fabricated. I wish I could tell you that we didn't have any growing pains in our control system during World War II, but in truth we had a lot of troubles, too.

We suffered because we didn't know the size of the problem. We didn't get enough alloy steel in the early days of the war because when the war began we had no measure of the size of the need of the aircraft industry and other consumers for alloy steel. The shipbuilding program needed unprecedented quantities of plates, so it was promptly decided to roll plates on hot sheet-strip mills. Actually it turned

out that we needed to add to our overall steel-melting capacity during the war days, and we didn't get that done as soon as we might have, because we didn't know when the war started that we needed it.

The conversion of the steel industry to war production isn't as tough as converting an automobile plant to bomber production. When we change over we keep right on mining ore, and making pig iron, and making steel in our openhearths and electric furnaces. We are lucky that there is much flexibility in the very nature of our regular finishing facilities. Within certain limits, it is easy to shift from one product to another in our mills.

However, if taken by surprise, it is possible for us to be far out of line, as we were on plates at one time in World War II.

Our major problems in World War II were not those of production, but of production control and distribution. The first systems we used to ration steel broke down. Among other causes, we know that there were too many people crying too loudly for steel and too many priority tickets were issued. It wasn't until we had a system that balanced all the needs against the industry's capacity that we really began to get maximum usefulness out of the industry.

When it came to building new basic steelmaking facilities during the emergency, we learned all over again that it takes time--and steel--to build steel mills. During World War II, one plant was an outstanding example. It took 26 months to put it into operation. That mill--now owned by U. S. Steel and operated as Columbia-Geneva Steel Division, at Geneva, Utah--was designed and built by the company that has more experience in mill creating than any other company in the world. It was built to large, but fairly standard, specifications and it incorporated few time-consuming innovations. Twenty-six months may span into eternity when measured in terms of nuclear war.

Gentlemen, I understand that, although our present steel capacity is at the moment operating at around 75 percent of capacity, there are the beginnings of rumblings in Washington that we do not have enough capacity to meet full mobilization needs. I think I would be remiss in my duty if I did not speak up on this matter as plainly as I know how.

Nobody in the steel industry can seriously claim that its present capacity is adequate to support full mobilization and also take care of the essential civilian needs. We can't, for the obvious and often-repeated reason that we have not been permitted to learn what the job entails. All we can and do say is that, as far as our information has gone, we have made the preparations we set out to make--preparations

which were deemed adequate in the light of information given to us. Our past actions should make it manifestly clear that if we are not now able to support the kind of mobilization which you are comtemplating, we will strive to make ourselves adequate.

However, when the military, or any Government official, out of the blue, starts decrying our inability to support mobilization, they will be injuring the steel industry and indeed all industry.

When and if mobilization comes, it will not be for self-preservation, for we could preserve our own lives simply by bowing to Moscow rule. No, it will be for something more important than self-preservation. It will be for the preservation of the liberties and freedoms which we inherited from the battle-scarred hands of our forefathers. One of the important freedoms is our system of enterprise and industry.

The production of steel is not a Government function, but a function of free enterprise; a function of the American investor, manager, production worker.

So we ask that you consult with us. Give us your projected needs, not in the form of secret weapons, but your needs in steel structurals, plates, sheets, strip, wire, pipe, and so on. If we can't meet them with what we have, more production facilities will be installed.

With your permission, I will now discuss the titanium metal industry, with the request that you hold any questions on iron and steel for another few moments.

Titanium metal was drafted into the military service practically the day it was born. Only a few pounds of this new middleweight champion of metals have ever been permitted to get into civilian service.

The ability of titanium metal, then, to support partial or total mobilization is almost wholly dependent upon the passing of time. For increasing production capacity is not as simple as the mere construction of more and larger facilities. Its production is held back by the development of an entirely new branch of metallurgy, including techniques for reducing the material from ore to sponge; formulas for the development of complex alloy compositions; processes for reclaiming scrap; procedures for rolling, forming, and annealing; and an entirely new field of technical data on physical and mechanical properties.

Despite those difficulties, considerable progress was made in 1953. The 12 months were marked by an outpouring of basic research data which for the first time accurately sketched in the general outlines of alloy behavior. The producers of jet engines and airframes,

bedeviled as they are by the formidable stresses and thermal attack of transsonic flight, courageously phased prototype titanium structures into production schedules.

As for the primary producers, output in 1953 was pushed upwards to over double the 1952 level, although production did not meet target levels due to technological difficulties which slowed down both production and the planned rate of facility expansion.

Domestic, and for that matter world, reduction of titanium ores to win pure titanium sponge, the starting material for titanium ingots, was in 1953, as in the past, confined to two centers. They are the Henderson, Nevada, plant of Titanium Metals Corporation of America (TMCA), a company owned jointly by National Lead Company and Allegheny Ludlum Steel Corporation, and the Newport, Delaware, plant of E. I. du Pont de Nemours & Company, Inc. The former is the world's only fully integrated plant, designed to recycle all byproducts of reaction. A Bureau of Mines facility, at Boulder City, Nevada, contributed 115 tons or so to the year's basic output, and the Japanese sent to this country a modest amount of sponge metal of fairly high quality, probably about 20 or 30 tons. All together, 1953 sponge production is estimated in the area of 2,250 tons, which compares with each of the past six years as follows: 1948--3 tons; 1949--8 tons; 1950--50 tons; 1951--500 tons; 1952--1,057 tons; 1953--2,253 tons.

ODM has certified to the need for an absolute minimum of 22,000 tons of usable capacity in 1955, whereas other studies insist on a figure almost twice as great, if American air supremacy is to be maintained. The new requirement announced by ODM last week is 37,500 tons capacity by 1956. As near as I can see at this time, the requirements for titanium--and I don't mean sponge or ingots but titanium products--are completely unresolved. Mr. Charles S. Thomas, Assistant Secretary of Defense, testified on 1 February 1954, before the subcommittee of the Committee on Interior and Insular Affairs as follows:

> "Mr. Chairman, I think our particular function in this matter, that of the Defense Department, is to develop the requirements of the Services. And as I think you know, some years ago that was done as to titanium requirements, and they came up with a total requirement of 20,000 tons, and the Defense Department at that time, I think, recommended 35,000 tons, and it was eventually reduced to 22,000 tons. That was before my time and before Dr. Flemming's and Mr. Mansure's time. Now, those are not realistic requirements, in view of what has transpired and in view of the new types of airplanes that are on the design boards today. So we have requested that an additional study be made, and that the Services give us

additional requirements now based on a five-year program (which carries through 1958). That will be available within about sixty days or thereabouts."

The pressures of the titanium industry to expand are not to be denied. Technicians may grumble that advancement in basic arts such as metallurgy have never been rapid. Metallurgists may complain that it took the aluminum industry 10 years to bring about a bare 20 percent improvement in aluminum base alloy strength, whereas far stronger titanium alloys have been adapted to advanced jet engine design in a matter of one or two years. And the titanium industry may have demonstrated that no metal has equaled titanium in its jump from laboratory bench to full-scale production facilities with only a passing nod to pilot units.

All this is given only passing academic sympathy by the aircraft industry, caught up as it is in its own frenetic design problems of thrusting operational aircraft to Mach 1.5 and of mastering the mysteries of intercontinental guided missiles hurtling at the speed of meteorites.

In World War II, 450 mph was a respectable speed for fighter aircraft. Today, the possibility of tripling that speed is commonplace. You know the story of the Douglas Skyrocket which has flown at 1,239 mph. Today jet engines of 10,000-pound thrust occupy the center of the stage, but engines of 20,000-pound thrust are not far off in the wings. Such are the advanced designs by which an Air Force remains supreme, and only thus can meaning be given to President Eisenhower's statement that "no real security rests in a second best Air Force." But the designer of such devices must combat all the problems of external heat from skin friction and the internal heat from jet engines; he must have a corrosion-resistant metal of light weight and very high strength, capable of maintaining that strength at high temperature. Only titanium alloys offer these attractive characteristics to the designer, and the speed with which such advanced aircraft moves into production is dependent on expanding titanium production.

In a further effort to bolster the quantity of available metal, the Defense Material Production Authority in mid-1953 contracted with Cramet, Inc., for a 6000-ton per year facility costing some 25 million dollars. This wholly owned subsidiary of the Crane Company, Chicago, has announced a plant location near TVA power at Chattanooga, Tennessee, and full production is expected by 1956. These 6,000 tons per year, together with 3,600 tons available by mid-1954 from the Titanium Metals Corporation of America, and 3,600 tons from du Pont by the end of 1954, assure only a total of some 13,200 tons in 1956. This falls far short

of the ODM target of 37,500 tons, and it is expected that additional companies may enter the field or TMCA or du Pont will decide to expand capacities now under construction.

As a matter of fact, the GSA has already awarded a new design contract to du Pont. This 600,000 dollar contract covers the designing of a plant to be located in the TVA area which will be capable of producing 7,000 to 8,000 tons of sponge annually. In the event du Pont decides to undertake construction of the plant, GSA funds already awarded will be applied against such construction. Otherwise, du Pont will turn over the plant as it develops to the Government and GSA will seek another contractor. The total cost of such a plant is estimated at 25 million dollars.

It has been aptly said that titanium metal is like an infant prodigy. It is strange, and wonderful, but its future development is hard to predict. As you know, practically all titanium sponge is now produced by various modifications of the original Kroll process. If this process is the ultimate in winning the metal from titanium oxides, then future progress of the development can be fairly accurately forecast. However, a better method may be found at any moment and this would tend to throw present calculations completely out of kilter. A number of alternate processes are now in varying stages of development. These include processes being developed by such organizations as Monsanto, Electromet, and Titanium Horizons.

The recent Malone hearings have placed many difficulties encountered in titanium metal expansion before public view. Rex R. Lloyd, Director of U. S. Bureau of Mines at Boulder City, Nevada, pointed out that about 4 billion kilowatt-hours of electricity would be required to refine 100,000 tons of titanium sponge. The tremendous power requirements involved in the present process have made it necessary to locate sponge plants in such places as Henderson, Nevada, and the TVA area, where power is available.

Another prime difficulty in titanium production was pointed out by F. S. Wartman, Chief of the Titanium Research Section of U. S. Bureau of Mines at Boulder City. In testifying about the Government's requirement of experience by a company in operating pilot production before being awarded contracts to construct and operate commercial plants, Mr. Wartman declared:

> "That requirement, I think, is the result of bitter experience. The fundamental difficulty in making titanium is that it dissolves its own oxide; that in doing so its mechanical properties are changed. It becomes useless and there is no way of getting the oxide out once it has been dissolved.

"So, if you turn millions of dollars over to a company that hasn't gone through that with at least a few key men, it means they are going to be experimenting on a ten-million-dollar scale instead of a one-hundred-thousand-dollar scale.

"Undoubtedly this pilot-plant requirement delays things, but experience has shown that there must be some intermediate step or a company will waste a lot of money learning."

The Malone hearings also brought out information regarding the self-sufficiency of America in titanium raw materials. Rollin P. Smith, manager of the Henderson, Nevada, plant of Titanium Metals Corporation of America, testified that "Most of our raw material so far has come from Australia. We have got some from our operation in Florida, probably about five per cent."

Mr. Smith went on to say that it is probable that future titanium oxide requirements will be supplied by domestic ilmenite ore. This is a combination of iron oxide and titanium oxide which is found domestically in abundant quantities. TMCA and other companies have developed programs aimed at treating ilmenite for the manufacture of an intermediate product from which titanium-tetrachloride can be made. If these programs are successful, raw materials will be no problem.

The best key to actual needs of titanium metal by the military was revealed during the hearings by General Kern B. Metzger of the U. S. Air Force Materiel Command. He testified that military aircraft requirements in 1954 would be some 9,800 tons; and in 1955, 19,000 tons. He added: "For 1956 it becomes more difficult to plan, but I would say 35,000 tons. This is only for planes. The Army and Navy have stated that due to limited supply it was to the best advantage of the country to withhold their planning in favor of aircraft."

Elsewhere in the world a belated interest in titanium is encouraging modest production plans. The British Ministry of Supply has contracted with Imperial Chemical Industries for 1,500 tons of sponge yearly to supplement current importations of American titanium for their jet engines. These 1,500 tons are not expected to be available for at least two years. East of the Iron Curtain there is known to be considerable activity in titanium, although Russian technical periodicals continue to confine their attention to physical metallurgy rather than production or fabrication.

Prices for titanium products are already declining. Only last week, TMCA announced price decreases averaging about 12 percent. It is expected that as production continues to climb the combination of

more efficient processing schedules and accumulated know-how will permit producers to pass along additional savings to their customers. The conquering of the many technical problems involved in scrap reprocessing also should contribute to the overall titanium development. A technique for remelting titanium scrap was announced in 1953 by TMCA and during the year a significant volume of remelt metal was produced to regular commercial specifications. There is every expectation that this flow will be multiplied as facilities for TMCA at the Watervliet plant of Allegheny Ludlum are expanded to handle all mill-return scrap and absorb offerings from outside sources.

If I have been too long in making my presentation, I apologize. I appreciate your attention and I now invite your questions.

COLONEL DIEHL: Gentlemen, Mr. King is ready for questions.

QUESTION: Mr. King, a previous speaker on steel made amongst other recommendations that integrated steel companies should be prepared to produce in the event of an A-bomb attack a secondary mill product which they don't normally produce. Would you comment on the feasibility and practicality of such a scheme?

MR. KING: Here's my concept of a steel company under conditions of mobilization. You don't normally have to put in a lot of new facilities to convert from one product to another. I think all modern sheet strip mills have runouts where a plate may be pulled off rather than running the material on through the finishing stands to produce sheet. The same facilities used to produce wire for highway guard cable would produce armored cable for military needs. The same kind of stainless steel used in the pilot's seat armor in an aircraft is used to make hub caps for automobiles. I do not believe that conversion from one product to another represents a very difficult problem. The problem basically is whether the industry has enough facilities of all kinds to produce for mobilization and also take care of civilian needs. For instance, is there enough capacity to produce military requirements for plates, using all the universal mills and the sheet strip mills, or do we need more facilities? Until there is a better concept of what is needed in the way of mill products, in my judgment, the problem will not be answered.

QUESTION: We have a stockpiling program designed to compensate for the critical shortages of alloying materials. Is there any move afoot by the steel industry and the Government to encourage free enterprise stockpiling by having the individual plants increase their inventories of these materials? In addition to Government stockpiling and a terrific potential, should industries do a certain amount of stockpiling during peacetime?

MR. KING: I think the point you make is very good. Unfortunately the matter of cash to run a business is involved. If provision is made for the financing of those stockpiles, that would be one way of handling it. I think, however, there is a more appropriate approach to the problem and that is the method that is being followed of developing materials which use less of these critical alloys.

A good example is the introduction of what we call chrome-manganese steel. It is an iron-base material alloyed with about 16 percent chromium, 14 percent manganese, and 1 percent nickel. This material is a good substitute for 18 percent chromium-8 percent nickel. It is not a new material but was produced in Europe where there has always been a nickel shortage. Should the nickel in this material be increased up to 2 percent to 4 percent instead of 1 percent I think it could serve for many military requirements now calling for 18-8. As for stockpiling of strategic materials, until somebody devises a means for enabling a steel company to carry large stocks of these expensive materials, I do not see how it could be done.

QUESTION: I understand that manganese was a critical area. What has been done on the recovering of manganese from its slag?

MR. KING: From what I gather from hearsay and from conversation with men like Howard Young I think that while the manganese situation has been desperately critical at times, it is one on which a great deal of effort is being expended. If you travel through the West today and go out between Henderson and Boulder City, Nevada, you will find subsidized operations for the recovery of manganese.

I think those operations are springing up around the country. They will bear fruit and will be important to us in case our offshore supplies are cut back. The reports I hear with respect to recovery of manganese from slag piles are encouraging. However, since we do not have to look upon manganese in the case of stainless and high alloy steels the way the carbon steel producer does, I am not as familiar with the problem as I might be.

QUESTION: Mr. King, you emphasize the need for knowing the military department's requirements as a basis for your planning. In your opinion would it be practical to concurrently, or at an earlier stage, replace that procedure and have the iron and steel industry give the ODM and military departments their projected estimate of steel capacity subdivided into the 23 forms and shapes to serve as a basis for the military department to develop in its requirements only what it would take under that limited capacity?

MR. KING: That is very practical and can be done at any time and in varying ways. Basic statistics are already available in the "Annual Statistical Report" published by the American Iron and Steel Institute. Finishing capacity would normally be broken down on the basis of a so-called balanced production.

However, that balanced capacity could be changed in favor of practically any type of product required. You must bear in mind that ingot capacity of the industry does not represent finished capacity. For instance, when a company puts in a plate mill or any other type of facility, its capacity if used 21 turns a week would be far in excess of the company's requirements. So finishing capacity of the industry is far in excess of melting capacity. While the industry could not quickly increase its melting capacity, by stressing one group of products at the expense of others great variations are possible. As an example, a fairly small percentage of the total ingots in 1953 were converted into plates. Yet by using maximum plate capacity, production of this product could be increased perhaps tenfold--of course at the expense of other flat rolled or other products. Earlier I referred to a presentation of the Steel Task Group. This group did exactly as you suggested. They showed all-out production of plates, bars, structurals, and so on, possible in the industry by sacrificing production of products whose demand would not be as great under the conditions of limited mobilization. A similar study could be made in light of capacity as it stands today.

QUESTION: You described the expansion and capacity of our steel industry in the last number of years. Looking forward another 5 or 10 years, about how much expansion do you anticipate as voluntary expansion by the industry and in what fields do you expect it to be concentrated?

MR. KING: Such expansion has not been defined. However, if you want to refer to some of the forecasts of the Brookings Institution or the survey that was made several years ago by the Pauley Committee, you can get the figures. I don't think a steel man is going to disagree too much with them. The steel industry has never objected to expanding. But it runs into different sets of circumstances, depending upon economic conditions.

You will remember I am sure, when TNEC held hearings before the Second World War at which the steel industry was accused of overexpansion. After World War II, under a different set of economic conditions, the industry was accused of holding back. I think the demonstration that has been made by the steel industry since 1940 is one that should be encouraging to all of us. The industry is willing to expand as rapidly as the demand permits. If there is no military demand, I think future expansion will be mainly in capacity to produce flat rolled products.

It is clear that flat rolled products are finding increasing application in the present-day economy.

QUESTION: Mr. King, you mentioned 124 million tons capacity and the expansion is still going on. How much of that capacity is represented by facilities that are becoming obsolete, or are already obsolete, or will be obsolete in the near future?

MR. KING: Facilities represented by the 124 million tons of capacity are for the most part modern. After World War II steel companies set about not only to expand but to modernize existing facilities. As for future expansion, it is largely in additional facilities and not those to replace obsolescence. The facilities I mentioned that were scheduled for installation in 1954--new rod mills, new terne plate mills, new cold rolled tandem facilities, and so on--are for the most part covered in whole or part by Certificates of Necessity. I don't think you would get a certificate, even in very small percentage of value, if it covered out-and-out replacement of obsolete equipment. However, you may find some replacement of obsolete facilities in the case of coke ovens. But mainly 1954 expansion is being undertaken to expand and broaden the base of companies that have ingot capacity and now want to be in a position to sell more widely with new products and increased quantities of products they are now producing.

QUESTION: Has your company done any advanced planning on the steps you would take in the event of bomb damage to keep the production line going?

MR. KING: Yes, we have with the encouragement of Government agencies. I am not sure exactly what those plans are. I haven't checked into them lately. But I know plans have been made to take care of the problem of our employees and the problem of our facilities. I don't think there has been any instance where plans cover alternate facilities in case of bomb damage but basically, taking the cue from what we know of damaged steel plants during World War II in Germany, it is rather difficult with the type of implements of war available then to knock out a steel plant. I have been in the plants of Witten, Cologne, and Dusseldorf and have heard the Germans recount that only by incessant bombings were those plants shut down. It required a dead-center hit to knock out a steel plant. Practically the only really vulnerable part of a steel plant, or bottleneck of a steel plant, is its blooming mill.

QUESTION: Does the steel industry look upon the advent of the plastic industry, the growth of plastics, as a competitor? I am thinking about the use of plastics, particularly its application to auto bodies.

MR. KING: We in the stainless steel industry look upon plastic as a competitor in the case of polyvinyl pipe. PVC pipe is finding application in the chemical industry. In germany there is a great deal of plastic pipe used in the chemical industry where in this country lead or stainless would be used. I think you can expect that a certain percentage of the tubular requirement for chemical plants will go to plastic as facilities are installed for plastic pipe production. I don't think I am qualified to comment on use of plastics in automobile bodies since my company does not manufacture carbon steel in sheet forms.

QUESTION: You referred in your speech to apprehension over the shortage or possibility of shortage of scrap and that as a consequence the steel industry has resisted scrap export. Since the resistance by the steel industry has a financial effect on the junkies of this country, and the price of scrap has gone down considerably, I was wondering what steps the steel industry might think of which would make it economical for the junkies who engage in this business to remain financially solvent while still not exporting scrap.

MR. KING: The economic status of the scrap dealer is not a steel industry problem. On the other hand, I repeat that the scrap question is serious. I think that the Commerce Department in its appraisal of the situation is taking a calculated risk in granting license for the exporting of scrap. We all hope this does not come back to plague us later.

QUESTION: Do the technical difficulties that are plaguing you in the extraction of titanium sponge continue to bother you during the conversion of the metal into various forms?

MR. KING: I think it is likely that the problem of winning pure titanium from titanium dioxide or trioxide is much more severe than many of you might realize. By modifications of the Kroll process we treat rutile, which is titanium dioxide, with carbon and chlorine and to get a pure titanium tetrachloride is a complicated and difficult problem. Generation of such gases as phosgene represents great difficulty in the purification of titanium tetrachloride. Once pure titanium tetrachloride is available, it is not too difficult through use of molten magnesium to produce pure sponge metal. Throughout the process, however, extreme controls are necessary. Once in ingot form conversion problems are not too difficult, but many problems are encountered nonethe less.

Because we are in the high alloy business, high temperature alloys, stainless steel, and so on, at Allegheny Ludlum, we think our facilities are admirably adapted to converting titanium metal. But we find, as an

example, that it is very easy to pick up hydrogen during the hot work processing of an ingot. There are ways to prevent the picking up of gases and there are ways to purge the flat rolled product if these gases are picked up. If there is a pickup of hydrogen in the rolling of a titanium slab, it can be scourged by annealing under a flood of dry argon. Problems in titanium manufacture go across the board.

QUESTION: I have three questions on titanium. The power requirement versus aluminum; the cost per pound compared with stainless steel; and the ability to weld, talking about a section one-half inch.

MR. KING: I can't speak with authority on aluminum. It is my understanding that aluminum requires about 10 kilowatt-hours per pound. In the case of titanium production, the requirement is approximately 15 kilowatt-hours per pound. The cost of titanium produced under various modifications of the Kroll process is inherently very high.

Without the recycling of magnesium chloride, you can figure on the use of a pound of magnesium for each pound of titanium produced. I can't give you a breakdown of all costs but this titanium business has not been a bed of roses as a lot of people think it has been. They think in terms of a metal that sells for an average of $14 a pound in mill products. They don't know about the high costs involved. We entered the titanium metal business in 1949 and slowly worked up to 1,000 pounds a day output on a pilot unit. Under terms of our GSA contract we were to have 10 tons a day output in September 1952. Even with the talent and know-how we have thrown into this project while we have facilities to meet our goal, we are even today working very hard to produce 4.5 to 5 tons per day. Anything that could be looked upon as profit is still ahead of us because there has been a tremendous investment made, at least by TMCA, in forwarding this titanium project. The operating deficit last year which has been built up over the years we have been trying to get this thing going would be appalling to all of you.

On the weldability there is no question in my mind that we will have titanium alloys that will weld satisfactorily. It is mainly a question of hard work and endeavor. I think that actually we should get weldable alloys this year. At least that is my feeling.

COLONEL DIEHL: Mr. King, on behalf of the Industrial College I thank you for a most informative lecture and a stimulating discussion period following it. Thank you very much, Mr. King.

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