RESTRICTED

ALUMINUM PRODUCTION

11 March 1948

CONTENTS

Page

SPEAKER- Mr. Frank L. Magee, Vice President and General Production Manager of Aluminum Company of America 1

Publication Number L48-109

THE INDUSTRIAL COLLEGE OF THE ARMED FORCES

WASHINGTON, D. C.

RESTRICTED

ALUMINUM PRODUCTION

11 March 1948

COLONEL GODARD: It has been my privilege for the past several weeks to introduce to you leaders from various fields of American industry. I am sure you must have all been impressed by the fact that the more important a man was and the bigger job he had, the better prepared he was. I have noticed that our best speakers have invariably brought along people who could answer questions that might puzzle those speakers—and I say that in no critical sense. The speaker this morning, Mr. Frank L. Magee, has brought along the Chief of Production Planning from the Aluminum Company; also the Chief of Metal Production, the man responsible, to use the term Mr. Magee used in talking to me, for the "pigs." I know what he means and I am sure you do too.

I would guess that this is the first time in Mr. Magee's long period of business experience that he has stepped before an audience like this; and I presume that he is thinking back a long while to the days when he wore stripes on his arm as a sergeant in the First World War. I feel sure, Mr. Magee, that this is the first chance you have ever had to keep so much "brass" quiet for so long.

Mr. Magee is going to talk to us this morning on the production of aluminum, its manufacture, and the problems that surround it. He has spent 30 years in this business, starting as an apprentice, and he is now Vice President and General Production Manager. I do not think I need to tell you any more. A man who has spent that amount of time in the business certainly must know it.

It is my privilege to present him to you now. Mr. Magee.

MR. MAGEE: Thank you, Colonel Godard. I can assure you that as a sergeant in the Signal Corps in the First World War I was very much impressed with "brass". I am still quite impressed with "brass". I am impressed with this audience. I am delighted to get a chance to come down here and talk to you.

I brought with me two of my associates, a couple of veterans, like myself, of the civilian front of World War II. Hugo Wilder was in Washington—many of you probably know him—as our liaison man with WPB. Fred King and I were sort of stuck behind the lines, so to speak, reinforcing Hugo in Washington by trying to get the stuff out. We were in Washington a great deal and met many of you fellows. I thought it was only right that you should get a crack at those of us who were mixed up with the production end in this late war. When the right time comes, you may raise questions and we will do our darndest to answer them. We will not be able to take care of all of them, I am afraid, but we will do our best.

During World War II, many of you had the opportunity to become familiar with problems peculiar to the production of aluminum and with the applications of this light metal for both civilian and military uses. This has already been emphasized for me by way of your preliminary list of questions submitted for this afternoon's seminar on aluminum production. During the 45 minutes now allotted to me, I must necessarily beg patience of the aluminum experts in the College while I attempt to present the following three phases:

1. A brief description of aluminum, its forms, and the properties which make it useful.

2. A short history of the metal, with emphasis on the progress of the industry during the past decade.

3. Some of aluminum's important civilian and military applications.

It will be my purpose, in presenting this picture of the aluminum industry, to high-light the outstanding problems encountered in the production of aluminum. At the same time I hope it will enable you to obtain an evaluation of the industry's capabilities as well as an idea of some of the mutual problems we must solve in the event of another war.

ALUMINUM--ITS FORMS AND PROPERTIES

Some of this is really quite elementary. I am sure most of you studied this in your high-school days. But I think it is worth while to recall occasionally these facts. Such a review is a reminder of the fundamental reasons for building a business around such a particular element as aluminum.

Aluminum is considered the third most abundant element in the world, exceeded only by oxygen and silicon. What is more significant is that aluminum is the most plentiful of all the metals found in the earth's crust. Geologists estimate that about 8 percent of the surface layer of the earth is aluminum. Unlike many other metals, however, such as copper or gold, aluminum is never found in metallic form, but rather in chemical combination with other elements. That is very important to us. Aluminum was first isolated as an element by a Dane in 1825, but only since 1888, just 60 years ago, has the metal been produced on a commercial basis.

Aluminum has an atomic weight of 27 and a specific gravity of 2.7, which is about one-fourth to one-third that of the other widely used structural metals. A cubic inch of aluminum weighs only one-tenth of a pound, while a cubic foot weighs 168 pounds. Aluminum has a melting point of 660° C., or 1220°F.

or may be made by forcing molten metal into a steel die under pressure. The various basic forms, or mill products, are fabricated into finished parts and structures by drawing, stamping, spinning, hammering, machining, welding, brazing, riveting, and for some purposes, soldering. This may be a little trite, but I include it to emphasize that aluminum can be handled by these various methods to a greater extent than any other common metal. About everything that can be done with every other metal can be done with aluminum; and some things that cannot be done with other metals can be done with aluminum. The metal can also be given a wide variety of finishes designed to enhance appearance, to increase resistance to corrosion, or to protect the surface from abrasion.

HISTORY AND PROGRESS OF THE ALUMINUM INDUSTRY

The history and progress of aluminum in the world of metals is a story of one of the great industrial developments of modern times. The life of this industry is measured in terms of decades, while most other metals are hundreds and even thousands of years old. Despite the late entry of aluminum into the metal world, its production today is greater volumetrically than that of any other nonferrous metal and is second to that of steel and iron.

Of note for this audience, man's first real interest in aluminum stemmed from a desire to use it for military purposes. In the middle of the nineteenth century Napoleon III, emperor of the French, and a nephew of the great Napoleon, summoned to his court a chemist named Sainte-Claire Deville, who had been able to make aluminum by heating a mixture of aluminum chloride and sodium. The metal was then selling for $545 a pound. Deville was commissioned by the Emperor to find a way of making aluminum cheaply and in large quantities for breast-plates, helmets, and cartridges to lighten the equipment of his soldiers and thereby increase the mobility of his army. France was about to face Russia in the Crimea and Napoleon III wanted to show Nicholas that he was more than just a "parade ground" general. Unfortunately, his dream never materialized. Sainte-Claire Deville was unable to produce the metal in large enough quantities and at a price which would permit such an extensive application. But the Frenchman's work was not in vain. From $545 a pound in 1852, he succeeded in bringing the price down to $34 by 1856 and to $17 in 1859. His work made possible the first commercial use of the metal, even though it was confined mostly to ornamental and jewelry type items. His work also made the metal available for scientific research and the scientists of the world were made aluminum conscious for the first time.

For more than 25 years aluminum continued to be made by chemical processes. In 1886, Charles Martin Hall, a young American just out of

During the course of the next 15 years the production of aluminum increased rapidly. In 1905 almost 11 million pounds were produced and by 1910 production was more than three times as great. Five years later, in 1915, (I am leading up to the First World War) output amounted to more than 90 million pounds, eighteen times as much as that at the turn of the century. The markets responsible for this notable increase in production were primarily the automobile, electrical conductors, and cooking utensils. During this period aluminum also began to make its appearance in the reciprocating parts of machinery, in electrical apparatus, and in vats and tanks used in the processing of various products and chemicals.

I have been talking so far about primary aluminum and will continue to do so, except as noted later. By "primary" aluminum I mean the aluminum pig and ingot made in the electrolytic cells or pots, as distinguished from "secondary" aluminum, which is aluminum that has been processed and recovered on the market in the form of scrap.

The demand for aluminum during the First World War boosted production from 115 million pounds in 1916 to a peak war production in 1917 of almost 130 million pounds. In other words, war increased our production by 15 million pounds, or a little over 10%. Output declined slightly in 1918 to 125 million pounds. Perhaps the outstanding use for aluminum during World War I was in the Liberty aircraft engine. Approximately 40 separate parts, including pistons and crankcases, were made of aluminum. These parts accounted for about one-third of the weight of the engine. Aluminum was also used in the Fuselage, aileron frames, cowling, wing ribs, instruments, and other small parts in World War I aircraft. Large quantities of aluminum were also used in the construction of trucks, busses, and oil-burning engines for submarines and destroyers. Other uses for the metal included machine-gun radiators(they were extruded, and it was quite a job at the time, as I remember. I was an apprentice), time fuses for shrapnel, aluminum powder for explosives, wire in bullets, equipment for field kitchens, canteens, and mess kits. Because of the Allied blockade and the scarcity of other metals the use of aluminum was highly stimulated in Germany in World War I. That is significant in our industry and, of course, in your business. We will refer to that later in talking about aircraft and the preparedness of Germany for the use of aluminum and magnesium in aircraft. For the first time, therefore, in World War I, aluminum was regarded as an important war material. I might add that even though the production of aluminum did not increase too much, to only 130 million pounds, in the First World War, there was a definite restriction on civilian uses and much of the production was going into war and essential civilian materials. There was a considerable amount of substitution of aluminum for war uses.

Stimulated by the purchases of the French and British, most of you know what transpired in the next few years in Aircraft production. From 6,000 planes in 1939 the figure mounted rapidly to a peak of about 86,000 in 1943. The size, and consequently the weight, of planes grew apace in these same years. The average aircraft of 1943, exclusive of engine, propeller, and landing gear, weighed about three times as much as the average plane of 1939. And three-fourths of the average weight of wartime aircraft was Aluminum. The resulting load placed on the Aluminum industry was staggering. No major basic industry was required to expand for purposes of war as was Aluminum. While steel was expanding 10 percent over its 1939 capacity, and copper 50 percent, aluminum expanded 600 percent.

In September 1938 Alcoa took a chance and launched an expansion program, largely based on what we got from the upper echelons here in Washington and what we obtained from our aircraft customers and from contact with the French and British Commissions in the United States. This expansion program, upon completion some five years later, resulted in a capital expenditure of approximately 300 million dollars of its own money. And that 300 million dollars was not hay, gentlemen. I know how our treasurer sweated over borrowing it. At the start of this program its productive capacity was about 293 million pounds of metal a year. This capacity had mounted to 355 million pounds by the end of 1939, to 500 million by the end of 1940, to 686 million by the end of 1941, and to 828 million pounds by the end of 1942. That was all under our own steam in private industry. The significance of Alcoa's expansion program becomes apparent when it is realized that its works furnished the Aluminum for Aircraft during the critical year of 1942. Alcoa's expansion in metal production consisted of increasing existing facilities at four reduction plants (i.e., the electrolytic reduction plants which make aluminum from alumina, or aluminum oxide) as well as the construction of a new plant at Vancouver, Washington, which went into operation, 23 September 1940.

Considerable expansion also took place at the Alumina works at East St. Louis, Illinois. We built a new plant at Mobile, Alabama, which was put into operation in 1938. That was built to use the bauxite which came from Dutch Guiana. Being on the seaboard, Mobile was a desirable place to put the plant. Alcoa's fabricating capacity was likewise greatly expanded to meet wartime demands. Sheet capacity was expanded six and one-half times over prewar, castings 7 times, extrusions 10 times, wire--rod and bar 12 times, tubing 13 times, and forgings 45 times.

The Government wartime aluminum expansion program resulted in the building of 58 works required a total investiment of almost 682 million dollars, all Government money. It started in August 1941, when the defense plant corporation let the first contracts. The first program was designed to add 512 million pounds to the Nation's annual aluminum capacity. This original program was supplemented in February 1942, by an additional construction program designed to increase the Nation's annual capacity by some 640 million pounds.

Aluminum was the first basic material placed under priority rulings, the industry so completely met the terrific demands placed upon it that the metal also became the first important material to be freed of priority control. Cutbacks began at certain high-cost plants as early as December 1943 and continued through 1944 and 1945 so that it was never necessary to operate the system at capacity. That is the reason 1943 was the peak.

Getting into peacetime, total primary aluminum production in 1946, the first full peacetime year, was 819 million pounds. A decline from the 990 million pounds produced in 1945 but still some 80 million pounds greater than the combined output for the years 1939 and 1940. Including the scrapping of military aircraft, secondary production decreased from 597 million pounds in 1945 to 556 million pounds in 1946, quite a significant figure, and largely contributed to by scrapped aircraft cut up in the fields and put back in the furnaces.

During 1947 Aluminum production topped its previous 1946 peacetime record by almost 40 percent. Recently published bureau of Mines' figures show that 1,143,500,000 pounds of primary Aluminum were made last year. This is four times 1939 production and the demands of the trade are currently unsatisfied. This can be attributed, to a large extent, to shortages of other materials such as tin, Zinc, Lead, Steel, and galvanized iron. Copper is now getting a little more plentiful. On the other hand, there are a number of reasons supporting the belief that Aluminum will hold onto a substantial portion of its markets, even when other materials become more plentiful. For one thing, the basic price of Aluminum ingot has decreased a full 25 percent since 1939, during which time we have had a 75 percent increase in labor rates. Ingot today sells for 15 cents a pound compared with 20 cents in 1939. Furthermore, as a result of war contracts, there exists today a much greater know-how among manufacturers and workers in handling the metal. Wartime research and development also resulted in new alloys and improved techniques which are available for civilian applications. In addition, the war served as a proving ground for many applications that are now adaptable to peacetime use. And finally, industry and the public in general are interested in the metal because of its excellent record on the home-front in civilian applications during the war years when maintenance was at a minimum.

The aluminum industry that has emerged from World War II bears little resemblance to its prewar counterpart. Its character, its size, and its importance to our peacetime economy have undergone a radical change. Ten years ago, on the occasion of the fiftieth anniversary of the founding of the industry, aluminum, directly or indirectly, gave employment to about 200,000 persons in the United States. Today, close to a million people earn their livelihoods either through the manufacture of aluminum, or by making products in which the metal plays an essential part. Over the same span of years, the list of known commercial uses for aluminum has grown from around 2,000 to approximately 4,000. In 1938 there was just one primary producer of aluminum. Today there are three large and important producers with facilities capable of making four times as much metal.

Aluminum storage drums were used to transport high octane aviation gasoline by plane over the Burma "Hump" to the beleaguered China front. These CBI-55 gallon drums weighed only 21 pounds as compared with 52 pounds for the regulation steel drum, thus enabling thousands of additional gallons of vitally needed fuel to be shipped each month. Tens of thousands of these drums, developed jointly by Alcoa and the Air Transport Command, were made at our New Kensington works.

Another development was the Aluminum landing mat, which weighed only one-half as much as the steel mat. These light weight mats could be airborne if necessary, or carried by small cargo vessels into places that were inaccessible to heavy equipment. Aluminum landing mats made possible speedier construction of aircraft landing fields so vital to the swift advance of U. S. forces in the Pacific. Millions of pounds of aluminum were used for this purpose.

Aluminum also had important wartime packaging uses. Practically all the powdered coffee, fruit juices, etc., were shipped in small aluminum foil envelopes, coated with plastic and heat sealed. Penicillin was shipped in small glass bottles protected by aluminum seals and cover caps. Blood donor and recipient sets were packaged in aluminum to keep them sterile. Ball bearings and other small equipment likely to rust were packaged in aluminum foil.

Aluminum squad huts and barracks were developed in the latter days of the war to provide shelter for troops stationed on the south Pacific Islands. This program was just getting under way when the war ended; approximately 25 million pounds of aluminum were used for this application. Aluminum was also used for similar buildings for Arctic housing.

Other important wartime uses for aluminum were machine gun tripods; searchlight reflectors, housings and bases; flame thrower tanks; gasoline truck transport tanks; 500 and 1,000 barrel portable gasoline storage tanks; fuse caps, powder containers, and detonators of shells; canteens, mess kits and cooking utensils; portable field kitchens; smoke bomb shells; signal flare parts; foil for "Radar Interference"; outboard motors; submarine detectors; trestles; small assault boats; cases and antennae of walkie talkies; gun sights; bazooka "barrels"; powder for explosives; as well as pistons and other engine parts in jeeps, command cars, tanks, trucks, weapon carriers, and tank destroyers. Aluminum parts were also used in the atomic bomb.

Before passing to some of aluminum's peacetime applications I want to mention two other wartime uses which are particularly interesting. One concerns the use of the metal for body armor. Up to VJ-day more than 2.5 million pounds of aluminum had been used in armored nylon vests worn by pilots, bombardiers and navigators. This armor proved so successful

land, air, and water transportation. Building construction, on the other hand, consumed only 8 percent. Since VJ-day, however, building construction has forged into the lead as the number one consumer of aluminum for the first time in history. Some idea of how aluminum is used by various industries is indicated by Alcoa's own shipments for 1947. These shipments, broken down into eight broad categories, show that 19 percent went into building construction; 15 into transportation; 9 into cooking utensils; 7 into household appliances; 6 into general and electrical machinery; 6 into power transmission; 14 into miscellaneous applications; and 25 percent was shipped to fabricators for further processing. While this breakdown does not recognize the final disposition of the material shipped for further processing, the 25 percent figure is significant because it points out the fact that there are now many more fabricators using aluminum. Prior to the war only 4 percent went into this category.

From a tonnage standpoint, the outstanding use of aluminum since the war has been for roofing and siding, particularly in rural areas. One of our products, Alcoa roofing sheet, has already been applied to approximately 500,000 farm building throughout the nation. Aluminum windows have become especially popular since the war. Residential windows, in particular, serve to illustrate the rapid increase in the use of aluminum in building construction. Prior to the war, only about 25,000 such windows have been made. But in 1946, more than 500,000 of these windows were fabricated, and estimates for last year place this figure well above the two million mark, representing approximately 25 million pounds of aluminum. There is an accelerated demand for aluminum for home and building heating and ventilating ducts and fittings. Hundreds of sheet metal contractors are using aluminum for this purpose, and more than 100,000 homes are now equipped with aluminum ducts and fittings. Other rapidly growing building uses for aluminum include shingles, gutters and downspouts, nails, screens, thresholds, venetian blinds, awnings, garage doors, and prefabricated house panels. In 1947 more aluminum was also used in the production of shop-fabricated houses and for metal-clad buildings. In large office and industrial building projects, aluminum wall facing, including cast spandrels, gives considerable promise of becoming a large market.

We are building a new aluminum-sheet mill at Davenport, Iowa. It will be our biggest and most expensive mill and will be constructed almost entirely with aluminum materials. The roofs, sidings, window sashes, conduits, electrical conductors--everything we could possibly hang on to that building will be made of aluminum. So far as I know, we have not had to use a mason on the job. It is a living example of why we think we have a great market in the commercial factory type of buildings.

The use of aluminum for commercial vehicles, such as truck, bus and trailer units has grown rapidly, and there is a strong trend toward aluminum in the passenger car field. Not only is the metal being employed for body construction in buses, but it is also being used for bumpers, heaters, seats,

Collapsible tubes are currently packaging more than seventy diversified products, ranging all the way from toothpaste to zinc oxide ointment. This field is fast swinging over to the use of aluminum, primarily on account of the tin shortage. It may be noted that shortages of certain metals and the difficulty and cost of getting such metals as zinc, lead, tin, copper, etc., out of the ground have been influential in bringing about an increased demand for aluminum for many uses. Aluminum drums, barrels and carboys are also being widely used by the brewery, food product, and chemical industries.

Other growing applications for the metal include: household appliances and office machines; furniture and all sorts of home furnishings and accessories; hardware, tools and instruments; paint; machinery and equipment for the processing and chemical industries; toys and sporting equipment; irrigation pipe; license plates; musical instruments; tanks and structures; metallic fabrics; and literally thousands of other items.

This resume of present-day applications has of necessity been brief, but I hope it has been sufficient to illustrate the broadening scope and growing importance of aluminum in our peacetime economy. It might well be that we shall lose many of these markets when other metals become more plentiful. I feel, however, that we shall retain a great many of them even then.

Mutual Problems In The Event of Another War

I would hope that, from the foregoing recital, you have obtained some measure of confidence in our industry's capabilities. It is not and, for 60 years, has not been a static industry. It is a highly competitive industry which continues to build on its original foundation of research and technical development so that it can maintain its position with respect to markets for competing materials and continue to create new uses for aluminum. Even to one closely associated with the production of this metal, it is inspiring to review the research and development work in progress in all phases of the business. I am sorry there is not the time to tell you more about this.

The aluminum industry is modestly willing to match its preparedness and performance record in World War II against that of any other basic industry. In so doing we take away no credit from any individual industry or from U. S. industry as a whole. True, there were delays, unbalances, and misunderstandings but mistakes were of commission and not ommission.

In the next war the preparation time will be nil. If I have convinced you that our industry is strong, virile, and patriotic and that we have an active army of trained and skilled personnel, then I believe you will be willing to agree that these two forces combine for you the best preparedness stock pile we can conceive as the answer to what is obviously our number one mutual problem in the event of another war. Gentlemen, I cannot stress

Substantial quantities of high-grade bauxite are provided for in the stockpiling program of the Army and Navy Munitions Board.

In addition there is now no question that large domestic deposits of low-grade bauxite and high-alumina clays can be used in another national emergency. During World War II the Bayer combination (sometimes called the lime-soda sinter) process using low grade bauxite, was developed by ALCOA and provides an excellent means for the production of high-quality alumina by utilizing existing alumina plants.

Lime.--There is no reason to anticipate any real problems in the supply of this raw material needed for the process of refining alumina from bauxite.

Coal and Gas.--Substantial quantities required for fuel and steam, especially in alumina process. This problem is obviously not peculiar to the aluminum industry.

Soda Ash.--The use of soda ash increases directly as the silica content of bauxite. Therefore the use of lower grades of bauxite or clays increases the soda ash requirements. When the bauxite requirements and grades are established, there should be no difficulty in determining and providing for the soda ash supply within the borders of the United States.

Natural Cryolite.--Refined natural cryolite (trade name is kryolith) has usually been preferred for starting new electrolytic reduction cells or pots. It is imported from Greenland which is a good reason to have a limited supply on hand for a national emergency. This material is not absolutely essential, however, and could be replaced by synthetic cryolite if necessity prevails.

Synthetic Cryolite and Aluminum Fluoride.--Synthetic cryolite and aluminum fluoride are essential in the electrolytic reduction of aluminum. Raw materials required to produce these two compounds are sulphuric acid, soda ash, alumina, and fluorspar. It is believed the supply of all of the foregoing raw materials in the United States can be assured in the event of war.

Petroleum Coke.--Substantial quantities of high-grade coke and tar and pitch binders are needed for the electrodes of the aluminum electrolytic cell. Coke of the proper quality can be obtained in the United States.

Electric Power.--The reduction of alumina to aluminum requires large quantities of electrical energy and the location of aluminum pig and ingot producing plants is usually determined by power availability. In peacetime, low-cost power is essential. In the late war aluminum reduction plants were installed adjacent to large blocks of power. Construction time was from six to nine months.