Chapter 10
Secret deals and war

War is the ultimate economic example of creative destruction. Expansionist countries and avenging nations will expend vast sums of money, employ their top engineers and look to their brightest scientists to achieve a victory. Losing nations or underdeveloped countries that were in the way will turn to people skills when technological means are lacking in a desperate attempt at survival. World War II touched every corner of the world – from icy arctic coasts to dense tropical jungles, and from advanced laboratories to gigantic assembly lines. For the U.S. aluminum industry, which is sometimes credited with winning the war for the Allies, the war meant protecting bauxite supplies, building huge processing facilities, reallocating electrical power from civilian use to defense purposes, and turning out hundreds of thousands of aircraft that delivered the bombs to the enemy's homeland.

World War I gave a tremendous boost to American industry, but nothing like World War II. Following on the heels of the Great Depression, the U.S. government continued to consolidate economic control, and the power of the military grew to astonishing limits. In 1940, spending by the federal government was about $9.1 billion. By 1944, it had climbed to $95.1 billion – about 45% of the nation's GNP. Alcoa, like many other large U.S. industrial corporations, benefited from all this economic activity, but as the war began it failed to understand the government's need to double U.S. capacity for aluminum production, according to George David Smith's 1988 corporate history of Alcoa. [1] In hindsight, the need to boost output, especially aluminum, seemed so obvious. On June 22, 1945, the Senate Subcommittee of the Committee on Military Affairs issued its report on "The Elimination of German Resources for War" following hearings held before the subcommittee. Henry H. Fowler, director of the Enemy Branch of the Foreign Economic Administration, testified to the importance of aluminum to the war. "There are few Americans today who will question the statement that the ability to wage a modern, large scale war is as dependent upon industrial and economic resources as it is upon military weapons," Fowler said. "An airplane factory is more important than the plane. A sufficient stockpile of bauxite for making aluminum is as important as the stockpile of airplane spare parts. The Germans realized this as a result of their experience during World War I. And when they armed militarily for World War II, they also armed economically and industrially." In 1933, Germany's capacity to produce aluminum was about 40,000 tons per year, but it only produced about 19,000 tons. By the end of the war, its capacity had reached about 250,000 tons. [2]

In 1914, at the outbreak of World War I, Germany was unable to meet its war-time needs for aluminum. Germany had only one smelter, the Rheinfelden smelter on the Rhine River owned by Aluminium-Industrie AG Neuhausen, with a capacity of 1,000 tons per year. During the Great War, five new smelters were built in Germany yielding a total capacity of 35,000 tons per year, and construction of a sixth smelter was started. Four alumina refineries also operated during the war. The ownership of these plants changed following 1920. A major expansion effort took place in 1934-1938 after Hitler came to power in Germany. Primary aluminum production capacity was increased from 40,000 tons per year in 1933 to about 174,000 tons per year in 1938, while production increased from 19,200 tons in 1933 to 160,000 tons in 1938. German alumina capacity in 1938 was estimated at 430,000 tons per year. Following German occupation, Austrian smelting capacity increased about 15 times from about 2,500 tons per year produced at two plants in 1935. With the addition of the second Austrian smelter, German aluminum smelting capacity reached about 341,000 tons per year in 1943 while production reached 282,000 tons. A shortage of electrical power was likely the reason why production did not match capacity. [3]

The cartel build-up to war

During the 1920s and 1930s, while Germany gradually built up its aluminum production capacity, German companies entered into cartel agreements intended to limit French, British and U.S. production, according to the 1945 Senate committee report. Germany increased its purchases of bauxite and alumina from France by ensuring that the French owners of the bauxite and alumina supplies made a larger profit by selling to Germans than by selling to French aluminum producers. By the time World War II started, the U.S., France and Britain found themselves in short supply of aluminum. A similar situation for the U.S. occurred with magnesium as a result of a cartel agreement between the German chemical industrial corporation IG Farben and magnesium producers in the U.S. and Britain. In addition to using magnesium for aluminum alloys, it was used to make Thermite and bombs. [4] "When World War II started, France paid dearly for this arrangement," the report stated. "And when, not long after, the United States was attacked at Pearl Harbor, it found itself with far less aluminum production than it needed. The British went through a similar experience." [5]

In 1931, Alcoa and IG Farben signed the Alted Agreement, which pooled patents through 1939 and beyond. Under the Alted Agreement, Alcoa transferred its technology to Germany. By 1942, Germany was the largest aluminum producing nation in the world. [6] A cartel developed by Alcoa management in 1931 called The Alliance was formed as a Swiss corporation and consisted of one French company, two German, one Swiss, one British and the Canadian company Aluminum Ltd. The members of the

Alliance agreed to set aluminum production quotas and prices. No member of the Alliance was allowed to "buy, borrow, fabricate or sell" aluminum produced by companies which were not members of the Alliance. By March 1938, it became clear to members that The Alliance was no longer of service to them – especially the German companies on the eve of World War II. [7] In 1940, with the fall of France to Germany, the German and German-dominated groups of the Alliance Aluminium Compagnie, the Alliance cartel, controlled 574 shares while the British and Canadian groups controlled 610 shares. In 1941, the Alliance cartel had $1.12 million worth of gold on deposit in the Royal Bank of Canada and assets worth 7 million Swiss francs in the U.S. In May 1941, the cartel's directors, with the exception of the lone Canadian representative, voted to immediately transfer 2 million Swiss francs from the U.S. deposit to Switzerland. The U.S. blocked transfer of the Alliance's assets after that. [8]

Strong aluminum alloys were needed to manufacture modern aircraft, and this required magnesium. Alcoa had purchased the stock of the American Magnesium Co. in 1919 and became the largest magnesium consumer in the U.S. By 1925, IG Farben had joined with Griesheim-Elektron to become the world's largest magnesium producer. The companies' supply and demand interests joined in March 1932 when IG Farben and Alcoa formed a 50-50 joint venture company called the Magnesium Development Corp., or Alig, to develop and utilize processes in the magnesium and electro-metal field. IG Farben was also a 50% owner of an aluminum plant in Germany and had significant technological information that could benefit the Alcoa-Farben joint venture, according to a 2009 account by Mira Williams. Alcoa and IG Farben followed that up in February 1933 when they formed a 50-50 joint venture company called the American Magnesium Co., a processing company that used chemicals produced by the Dow Chemical Co. Between 1930 and 1933, IG Farben joined four important U.S. ventures – and more followed. [9] Between 1933 and 1943, IG Farben invested heavily on research intended to help Germany remain self-sufficient in event of war. The goal was finding substitute materials for various commodities needed for manufacturing defense products. A key example was bauxite. As it fell into short supply, IG Farben looked for ways to substitute magnesium for aluminum to build aircraft. By order of the Luftwaffe, IG Farben made plans to build a large magnesium plant at Aken in 1933. [10]

Germany's goal in securing patents on magnesium technology through the Alig contract was to expand magnesium production in Germany while holding back U.S. production, according to a 2007 account by Pat Choate. The patents were used by the Dow Chemical Co., but as part of the deal with IG Farben, Alcoa agreed to require that Dow limit its magnesium production to 4,000 tons per year. Alcoa threatened Dow with litigation if it produced more than the German-set limit or if it shipped more than 150 tons per year to Great Britain. As World War II approached, Dow was the sole magnesium producer in

the U.S. In 1941, Dow President Willard Dow openly challenged the Alcoa-IG Farben imposed limits, daring them to sue. Dow purchased 1,000 acres of land on the Gulf Coast near Freeport, Texas, and began building a large magnesium production plant that would also produce chemicals for other military uses. Dow assured the U.S. aircraft industry that it could provide them 4,200 tons of magnesium per year. Dow also told the U.S. War Department it could expand its magnesium production by an additional 50,000 tons per year if the U.S. government would purchase the metal at a pre-set low price. The War Department rejected the offer. Dow's Freeport plant produced its first ingot on Jan. 21, 1941. Nine days later, the U.S. Justice Department indicted Dow and charged the company with conspiring with Alcoa and IG Farben to constrict magnesium production based on the Alig contract. But Dow was not a part of the Alig agreement and not at fault for the reduced magnesium production, according to Choate. Dow was exonerated from the charges in March 1944 when the U.S. Senate Select Committee Investigating the National Defense Program, the Truman Committee, issued its findings on the charges. [11]

By 1939, light metal production was a growing part of IG Farben's overall business. It owned a 50% interest in Aluminiumwerk GmbH, which operated aluminum smelters at Aken and Bitterfeld, both in Germany. IG Farben bought all its alumina from Swiss-based Aluminium Industrie Aktiengesellschaft but also operated several aluminum fabrication plants. By the end of World War II, IG Farben produced nearly all the magnesium sheet and magnesium die casts for Germany. Another German company, Metallgesellschaft, owned 50% of the Aken and Bitterfeld smelters. It also handled all the aluminum sales for the Aken and Bitterfeld smelters along with aluminum from the government-owned company Vereinigte Aluminum Werke AG. VAW produced about 70% of Germany's aluminum in 1943 and 76% of aluminum in Greater Germany. Founded during World War I with partial government ownership, VAW invested in aluminum and alumina plants in Austria, Hungary and Yugoslavia. [12]

Pre-war aluminum deals also were made between the Allies and Japan, according to a 1996 account by Carin Holroyd and Ken S. Coates. In the 1890s, Japan began to import aluminum from Canadian smelters to make army mess kits, buckles and saber clasps. Japan had no bauxite deposits and limited power resources. Japan began to operate aluminum smelters in the mid-1930s when nationalist feelings prompted the Japanese government to support that industry. Until the mid-1930s, Japan relied entirely on imported aluminum, much of it from Canada. The second shipment of aluminum from the new Shawinigan, Quebec, smelter went to Japan, the authors noted. [13] Aluminium Ltd.'s sales of aluminum to Japan escalated from more than 3,500 tons in 1935 to more than 14,000 tons in 1937, on the eve of World War II, and was equal to Japan's domestic production of aluminum in each of those years. The principle Japanese company which

Aluminium Ltd. dealt with was the Sumitomo Corporation, and by 1941 Aluminium Ltd. owned half of Sumitomo's stock. [14] Alcoa also dealt with Japan. Alumina from Alcoa's Mobile, Alabama refinery was sold to the Japanese until the start of World War II. [15]

By 1937, world aluminum production had reached an all-time high, having climbed out of the depths of the Great Depression. Germany alone accounted for 33% of the increase in world consumption. Germany surpassed the U.S. as the largest producer of aluminum in the world each year from 1938 through 1940. Germany produced 211,300 tons of aluminum in 1940, compared to 187,100 tons for the U.S. [16] Meanwhile, aluminum exports to Europe dramatically increased. Alcoa's sales of aluminum to Europe were 900 tons in 1937. That figure increased to 6,350 tons in 1938 and to 9,500 tons in 1939. Alcoa's sales to Europe at this time were unsolicited. Alcoa also sold aluminum to American companies, which in turn shipped aluminum to Europe. For the first six months of 1939, the total amount of aluminum sold to Europe was 12,250 tons. Alcoa took in $49 million in sales in 1939, twice what it had earned in 1938. [17]

Expansion by conquest

Germany also boosted its aluminum industry by conquest. In 1939, the Hungarian aluminum industry consisted of an alumina refinery at Magyarovar with a capacity of 10,000 tons per year, which provided alumina to a smelter on the island of Csepel, and another smelter at Felsogalla that began operating in 1940. Hungary remained neutral during the war, and its aluminum plants were more or less independent of direct German control. The Yugoslavian aluminum industry in 1939 included rich bauxite deposits in Croatia, but strong Partisan activities during the war limited production there – bauxite production in Croatia fell from 400,000 tons per year in 1938 to 70,000 tons by 1941. A new company that was brought in to mine bauxite in Herzegovina had business links with the Reichswerk "Hermann Goering" AG company, according to the 1945 Senate committee report. There were also several small alumina refineries in Yugoslavia, including one owned by several Jews that the Germans seized after the war started. [18]

In 1940, the Germans occupied Denmark, leaving the Allies concerned about the status of the valuable cryolite mine at Ivigtut, Greenland, a Danish territory. A Canadian ship with Royal Canadian Mounted Police was sent to survey the situation in Greenland. The St. Roch left Vancouver, British Columbia, under the guise of an exploration of the Northwest Passage and traveled through the Arctic Ocean to Greenland. Following the attack on Pearl Harbor and the U.S. declaration of war, Greenland was temporarily made a U.S. protectorate. The only actual German incursion in Greenland was the establishment of a weather station with 17 men that was taken down shortly after

discovery. Instead of relying on Greenland cryolite, the Germans chose to manufacture synthetic cryolite in a plant next to the Nordische Aluminium Co. aluminum smelter in Heroya, Norway. A successful Allied bombing raid, however, prevented full-scale production of synthetic cryolite there. One hundred and eighty B-17 bombers were dispatched to Heroya on July 24, 1943, and all but one returned – the Georgia Rebel safely landed in neutral Sweden. [19]

Germany invaded Norway on April 9, 1940, and marched straight into Oslo. The king and his government fled to the United Kingdom. While Norwegian partisans continued a guerilla war against the Germans around mountainous rural parts of Norway, some members of the aluminum industry cooperated with the Germans on the basis of commercial and competitive interests, according Hans Otto Froland, an historian at the Norwegian University of Science and Technology. "This is a case where Norwegian companies worked for the Germans as collaborators, without ideologically having a Nazi orientation," Froland said. The Germans recognized that the war needed to be won in the air, which required aluminum to make aircraft, Froland said. However, while Norway had plenty of hydroelectric power, it lacked bauxite. [20]

By May 1940, the provisional government in Norway had a plan in place to construct a new aluminum plant in a cooperative effort between Norsk Hydro and the Norwegian Aluminum Co. (NACO). Both companies decided to cooperate with the Germans – NACO in order to maintain its position, and Norsk Hydro to gain a foothold in the industry, Froland said. "There were no Nazis in the management of these companies," Froland said. "This was pure economic strategy. Both wanted to position themselves for the future. They didn't know how long the war would last, and it was quite possible that it would result in a new Europe, with Germany in the driver's seat once the war ended." But as Germany's war effort began to face defeats and bog down, NACO and Norsk Hydro had difficulties obtaining bauxite, and the companies never produced any aluminum during the war. Froland noted that many companies across Europe faced the same decision – cooperate with Germany or go bankrupt. "Norwegian businessmen chose to make use of the opportunity to position themselves commercially," Froland said. "Maybe they hadn't given the matter full consideration, but they were drawn into a situation where they were aiding the enemy." [21]

Following the invasion and occupation in 1941, the Oslo Consortium invested in the development of Norway's aluminum industry. The consortium included Thomas Fearnley, Orkla, Fred Olsen, Storebrand, Jens. P. Heyerdahl, Klaveness & Co., and Christopher Kahrs Kielland. This collaboration with the Nazis never resulted in any company employees later being convicted for collaboration with the enemy after the war. [22] In 1941, Germany took over the Norwegian aluminum industry and founded

Nordische Aluminiumgesellschaft, which included two companies, Nordisk Lettmetall and A/S Nordag. The two companies were set up to operate the Norwegian aluminum plants in accordance to a German master plan called the Koppenberg Plan. [23] The German plan called for increasing aluminum production six-fold by 1944, beginning with construction at Ardal and expanding plants at Glomfjord, Eitrheim, Sauda and Mar/Heroya. Plans called for building a 50,000 ton-per-year alumina refinery and a 24,000 ton-per-year aluminum smelter at Ardal, because hydroelectric capacity at Ardal was already partially developed. In 1941, Norsk Hydro sold the Tyin falls above Ardal to A/S Nordag. The number of construction workers increased to 4,000, but progress was slower than expected. By 1943, the Germans were using Russian, Ukrainian and French forced laborers. Then in October 1944, officials in Berlin ordered all work in occupied countries to stop unless the work could be completed before April 1, 1945. A light-metals plant on the Heroya peninsula near Porsgrunn was heavily bombed by Allies in 1944 before it could start production. Construction at Ardal continued, but at an even slower pace. By the time the war ended, three of the five hydroelectric generators had been set in place, and furnaces for the aluminum plant were in place. A/S Nordag was transferred to the newly established Directorate for Enemy Property, which soon called for completion of the Ardal project. [24]

Germany's alumina capacity increased during the war to about 600,000 tons per year. Germany needed to import bauxite for its alumina refineries, and beginning in 1925 it took steps to ensure supplies through a Swiss holding company called Bauxit-Trust AG that was involved in bauxite mining in Hungary, Romania, Yugoslavia and Italy, according to the 1945 Senate committee report. Hungary was Germany's most important source of bauxite before the war, supplying 30% to 50% of Germany's demand. Yugoslavia was second in importance. Germany took all of both countries' bauxite exports and began to take bauxite from Greece beginning in 1935. German imports of bauxite were in excess of its alumina production, and by the start of the war, a stockpile of 1.5 million tons of bauxite had been accumulated. German conquests did not lead to unlimited or uninterrupted supplies of bauxite, however. Bauxite deliveries were held up by transport problems and actions by popular resistance movements. [25]

Germany's grand plan before the war was to build an integrated aluminum industry in Central Europe or Eastern Europe, where considerable bauxite and hydro power existed. But other than a large smelter in Austria, the plan did not develop. Neither did their plans for aluminum production in Norway, according to the 1945 Senate committee report. "The record of the Germans on the whole offers no convincing proof of their purported organizational genius," the report said. "They have been able to loot properties, to take over existing facilities and to construct new ones, and to impress labor to work under their direction. But except where they have found collaborators in

the financial and industrial leadership of national companies and in puppet governments, they have been unable to achieve any marked success. One reason for their failure may be their inability to mobilize the working people of Europe willingly to fulfill German orders." [26]

The Allied aluminum effort

Preparations for war by the Allies followed Germany's. In 1937, England signaled Aluminium Ltd. of Canada to increase aluminum production for the rapidly expanding Royal Air Force facing Germany's rising air power. [27] Following the November 1938 Munich Conference, President Franklin Roosevelt began U.S. preparations for war despite its neutrality by ordering an air force of 10,000 planes. Starting in 1939, both the Army Air Corps and the Navy began to expand its air force. Congress appropriated $300 million in 1939 for the procurement of 6,000 new planes by the Army Air Corps and an increase in personnel to 3,200 officers and 45,000 enlisted men. Many of the new aircraft were exported. On March 25, 1940, the U.S. industry was authorized to sell freely with friendly nations, and British and French orders that year totaled more than orders for the U.S. military. The Lend Lease Act in March 1941 led to even more exports. [28]

On Sept. 3, 1939, Britain declared war on Germany, starting World War II. At that moment, a large proportion of the German merchant fleet was at sea, and about a third of the ships sought shelter in neutral harbors, including Spain, Mexico, South America, the U.S., Portuguese East Africa and Japan. As a result, 28 German ships carrying bauxite ended up in Trieste, Italy. At least 19 German ships were scuttled by their own crews by the end of 1939. The British felt optimistic about its naval blockade in early 1940, but many neighboring neutral nations continued to trade with Germany. In the case of Sweden, it openly sold iron ore to Germany. In other cases, trade was conducted secretly. About a third of Dutchmen were estimated to be deriving their livelihood from German trade, and Norway's rising imports did not match its domestic needs and were believed to be passing on to Germany. U.S. companies were prevented from arms trading with Germany under the Neutrality Acts, but there were no restrictions on raw materials. During the last four months of 1939, U.S. exports to 13 nations capable of serving as middlemen for Germany increased by about 50%. [29]

In 1939, about 90% of aluminum production in France was directly or indirectly controlled by Cie. De Produits Chimiques et Electrometallurgiques Alais Froges et Camarque, also known as Pechiney, with the rest controlled by Ste. d'Electrochimie, d'Electrometallurgie et des Acieries Electriques d'Ugine, also known as Ugine, according to the 1945 Senate committee report. Pechiney had entered into cartel agreements

with IG Farben in 1927. Pechiney produced aluminum and magnesium metal as well as aluminum products. It also mined bauxite and coal near the Mediterranean coast of France, where it operated two of its three large alumina refineries. Utilizing abundant hydropower in the Alpine region, that area became the center of aluminum smelting. Lesser smelting took place near the Pyrenees. Fluorspar, pyrites and a small amount of bauxite was mined in the central plateau region of France. Most of France's aluminum production was located in the south of France, which was not occupied by Germany until November 1942. But Germany controlled the French aluminum industry directly and indirectly by investments – capitalization of Pechiney tripled from 1940 to 1941, and administrative and management personnel at Pechiney were pro-German, according to the 1945 Senate committee report. Germany's expansion plans for France's aluminum industry were successful as it had a strong demand for aluminum for the German aircraft-manufacturing industry. French aluminum output increased from 35,000 tons per year in 1936 to 70,000 by 1943, and Germany took about 70% of that output. [30]

Following the fall of France, the Germans looted the country, hauling everything back to Germany on French trains that remained in German hands. Not only did Germany take French military and manufactured goods, they also took over France's industry and raw materials, including considerable bauxite reserves to be turned into aluminum for aircraft. At the greatest extent of its European occupation, Germany not only had abundant metal, coal and other resources but also two-thirds of Europe's industrial capacity. Allied bombing, however, began to shut down transportation of those raw materials, and all that industrial capacity ended up at reduced production levels or closed down altogether. The Allies also targeted the Balkans. Yugoslavia, Romania and Bulgaria exported large quantities of their surplus oil, chromium, bauxite, pyrites and agricultural commodities to Germany, and Germany was almost entirely dependent on Hungary and Yugoslavia for bauxite. In an attempt to stop bauxite shipments to German smelters, British undercover agents were dispatched to blast the Iron Gate, a narrow gorge where the Danube River passes through the Carpathian Mountains, by sailing a fleet of dynamite barges down the river. The plan was prevented by Romanian police acting on a tip from the pro-German Iron Guard. The Balkan nations were officially neutral but surrounded by the Germans to the north, Italy to the west and Russia to the east. They also feared that if they didn't supply the Germans, they'd end up like Poland. [31]

The Allies needed to take steps to protect their bauxite supplies, especially in South America. British Guiana was a major bauxite source during World War II – about two-thirds of all Allied aircraft manufactured during the war used aluminum that began as bauxite from British Guiana. Demand for British Guianese bauxite climbed from 476,000

tons in 1939 to 1.9 million tons in 1943. The monetary worth of these exports climbed from $2.9 million in the early 1940s to $6.7 million is 1947. Part of this growth depended on the Demerara Bauxite Co. opening two new mines at Mackenzie. The growth in bauxite exports not only helped local employment but left a surplus of $6 million in the Guianese Treasury at the end of the war. In September 1940, while still neutral, the U.S. provided fifty World War I-era destroyers to Britain in exchange for leased sites from Newfoundland to British Guiana for use as military bases. The U.S. began to build the Atkinson Field airstrip in British Guiana before December 1941 at Hyde Park on the east bank of the Demerara River. The U.S. 44th Reconnaissance Squadron was stationed there to patrol the seas between Panama and British Guiana, and a U.S. blimp flew along the coast on the lookout for U-boats. [32]

On Nov. 23, 1941, thirteen days before the Japanese attack on Pearl Harbor, U.S. troops raised the U.S. flag in Dutch Guiana. The next day, the White House announced that it had sent the troops to occupy Suriname, in cooperation with the exiled government of The Netherlands in London, to protect bauxite mines. The government of Brazil agreed to protect Dutch Guiana's southern border and possibly the southern border of French Guiana. The move was seen as a way to protect the Western Hemisphere from an Axis invasion from the bulge of West Africa. "I think we shall have to take over Martinique (the French West Indies island) and French Guiana also if Vichy continues to succumb to Nazi influence," Senate Foreign Relations Committee Chairman Tom Connally said. In its announcement, the White House said 60% of the bauxite required by the U.S. aluminum industry came from Dutch Guiana, which was vital to the defense of the U.S. and the Western Hemisphere. The White House said The Netherlands would have used its own troops under normal circumstances, and that Brazil "has indicated its whole-hearted approval of the emergency measure." A source in Rio de Janeiro said about 2,000 troops would be sent to Dutch Guiana. [33] The U.S. State Department issued a report on the importance of protecting bauxite mines in Dutch Guiana on Nov. 29, 1941. Dutch Guiana produced about 60% of the bauxite used in U.S. aluminum smelters. The U.S. and the exiled government of The Netherlands entered into consultation and agreed that U.S. troops would be sent to Dutch Guiana to guard the mines, the State Department said. [34]

By 1939, Alcoa continued to dominate the U.S. aluminum industry, producing and selling all the aluminum it had the capacity to make, using processes that had been standard for five decades and unpatented three decades. Alcoa sold aluminum ingot at 20 cents per pound, about twice what it cost the company to produce. Its net profit on sales was nearly 20% on invested capital. Between 1900 and 1940, the average price for ingot aluminum ranged from 20 cents to 27 cents per pound, while average costs ranged from 10 to 14 cents per pound. In 1940, when competition by Reynolds Metals Co. smelters in Alabama and Washington appeared for the first time, the metal price dropped to 15

cents per pound. When Alcoa operated under a monopoly, it made sense for the company to reduce costs in order to lower prices and increase sales volume, or to increase profits on existing sales volume. [35] U.S. production and consumption of aluminum in 1939 broke all previous records as the nation prepared for war, according to Patricia Plunkert at the U.S. Geological Survey. The aviation industry in 1939 alone consumed twice the amount of aluminum produced in 1937, the previous peak year. In 1940, the government set the aluminum price at 15 cents a pound, which lasted the duration of the war. [36]

The U.S. aluminum shortage

As the war spread through Europe and American lend-lease arrangements expanded, Alcoa management believed the company's production capacity was sufficient to meet the U.S. government's needs, according to Smith. It was Alcoa's shortage of capacity, however, that eventually broke the company's monopoly hold over aluminum production in the U.S., as the government turned to building new plants that eventually became surplus and were sold to new aluminum competitors at the end of the war. [37] The federal government initially relied on agencies it had created to deal with the Great Depression to build defense industries. The Reconstruction Finance Corporation was created on Jan. 22, 1932, as an independent agency to boost the country's confidence and help banks return to their daily functions during the economic crisis. RFC's powers were expanded during the war to comprise eight new corporations, including the Metals Reserve Co. and the Defense Plant Corporation. From 1941 through 1945, RFC authorized more than $2 billion in loans and investments each year, peaking at $6 billion in 1943. [38] In January 1941, as the number of economic agencies preparing for World War II proliferated, with frequent organizational changes and overlapping jurisdictional claims, and as the size of the federal government quadrupled, President Roosevelt established the Office of Production Management to centralize the direction of federal procurement programs. The Office of Production Management was superseded by the War Production Board in January 1942 under Executive Order 9040. [39] Most lending to wartime subsidiaries ended in 1945 and completely ceased by 1948. The Reconstruction Finance Corporation was abolished as an independent agency by Congress in 1953 and totally disbanded in 1957. It was eventually replaced by the Small Business Administration. [40]

The Defense Plant Corporation was created in August 1940 as an RFC subsidiary to finance the building of industrial plants for war-time needs. By the end of World War II, the agency had invested about $633 million in aluminum plants across the nation, accounting for more than half of aluminum smelting capacity – more than Alcoa itself. The Defense Plant Corporation had about $100 million invested in alumina refineries,

including about $15 million in experimental non-bauxitic refineries. It also owned nine smelters costing about $174 million, two large rolling mills in Chicago and Spokane that cost about $50 million apiece, an extrusion and fabricating plant in Phoenix, Ariz., that cost more than $32 million, and various other facilities across the nation, according to a 1945 account by Nathanael Engle. [41] As was the case with defense industries during World War I, plant management was left up to private enterprise, but output was dictated by the War Production Board, which specified production schedules, the price of bauxite, the allocation of alumina output and the price of aluminum, according to Smith. Because of Alcoa's expertise, the company built and operated nearly all the new Defense Plant Corporation aluminum plants. Alcoa insisted the government retain 85% of the profits from Defense Plant Corporation plants as well as any losses. [42]

Between 1920 and 1940, the U.S. aluminum industry, essentially Alcoa, had increased production by a factor of eight. Nevertheless, the U.S. found itself facing serious aluminum shortages on the eve of World War II, according to a 1954 account by Carleton Green. In June 1940, the Office of Production Management requested that production of aluminum in the U.S. be increased by two-thirds within one year to 300,000 tons per year – half of that new production earmarked for military and half for civilian. Before that goal could be achieved, however, the military had absorbed all the increase and needed more. In February 1941, the federal government admitted the severity of the aluminum shortage and called for an expansion of production to 423,000 tons per year, with very little allowance for civilian consumption, according to Green. In May 1941, with the 420,000 tons per year of capacity already in place, the goal was expanded once again to 700,000 tons per year. Estimates for war needs included 450,000 tons per year for aircraft alone and another 150,000 tons per year for other military needs. In May 1941, the Truman Committee described the aluminum production capabilities of the nation's potential enemies: Germany and the territory it held were capable of producing 457,000 tons per year, and plans were in place to increase that amount by 235,000 tons per year by 1943. Japan was planning to increase its production capacity by 100,000 tons per year, and fears were expressed that Russian aluminum capacity could fall into German hands. [43]

On July 15, 1946, Charles M. Wiltse of the War Production Board completed a 348-page report on "Aluminum Policies of the War Production Board and Predecessor Agencies, May 1940 to November 1945," which provided an in-depth history of the U.S. government's support for expanding the U.S. aluminum industry immediately prior to and during World War II. The report described government recognition of aluminum shortages prior to the war, priority control by the Office for Production Management, problems with scrap and secondary production, problems with assessing requirements for wartime, success of the first and second expansion programs, war-time production

problems, allocation decisions, cutbacks and reconversions, scarcity and abundance, and labor problems. [44]

Wiltse's report began on May 29, 1940, when President Franklin Roosevelt asked Congress in a well-publicized speech to provide the funding and ability for the U.S. to produce 50,000 aircraft per year for national defense purposes. Roosevelt appointed an Advisory Commission for the Council of National Defense (NDAC), and talks began between NDAC and both Alcoa and Aluminium Ltd. of Canada. The amount of aluminum that would be needed was to be determined by the Army and Navy departments. Earlier on Aug. 7, 1939, the Army and Navy Munitions Board had issued an optimistic report about the U.S. aluminum industry. "Normal stocks of metal on hand and metal producing capacity are sufficient to guarantee the United States self-sufficiency in aluminum in an emergency," the Munitions Board report said. "Bauxite supplies from the Guianas should be maintained in an emergency, but should this prove to be unfeasible, domestic mines, although limited in their reserves of ore, could supply the entire bauxite requirement during an emergency of at least three years." [45]

Following Roosevelt's speech, NDAC talked to Alcoa and military officials to determine needs and capacity. According to Wiltse, "The Aluminum Company (Alcoa) did not profess to know how much aluminum went into an airplane, but the Army Air Corps knew even less, and the aircraft manufacturers were equally ill-informed." Alcoa's aluminum production capacity in June 1940 was about 200,000 tons per year, but Germany's quick conquest of Norway, Poland, the Low Countries and France had added to Germany's 500,000 ton-per-year capacity. The U.S. was still predominately isolationist in 1940, so "the argument that the Nazis could be beaten only by producing more planes and more aluminum than Germany could produce fell on deaf ears," Wiltse said. Around this time, Reynolds Metals Co. president Richard S. Reynolds met with Sen. Lister Hill, a member of the Senate Military Affairs Committee, and expressed concern that U.S. production capacity was dangerously small compared to Germany's. Reynolds then talked to Alcoa Chairman Arthur Vining Davis, telling him "that he should lay the true situation before the administration and ask for government funds to build his production up to (500,000 tons) at the earliest date practicable," but Davis reportedly thought Reynolds was "unduly alarmed" and rejected the suggestion, Wiltse said. [46]

On Aug. 12, 1940, Walter L. Rice, special assistant to the U.S. Attorney General, called aluminum production the "bottleneck" in the nation's defense program. Rice noted that if it took 16,000 pounds of aluminum for the Glenn L. Martin Co. to make a medium-range bomber, then the U.S. needed 400,000 tons to make 50,000 aircraft, but Alcoa only planned to produce 187,500 tons. Rice's conclusion was challenged by NDAC, but not very well, Wiltse said. Complaints by aircraft manufacturers about aluminum supply

shortages had become “general” by November 1940, and by December 1940 “it was clear that aluminum required more attention than it had received,” Wiltse said. On Jan. 2, 1941, the Priorities Board received a report from its committee that “unless the fabrication capacity of the Aluminum Company plants is increased, a shortage of certain forms of high-tensile strength aluminum alloys will become serious.” On Jan. 7, 1941, Marion B. Folsom, the former treasurer at Eastman Kodak Co., who had been appointed to NDAC’s aluminum oversight program in June 1940, called U.S. aluminum production “satisfactory,” but that very same day the Office of Production Management took over NDAC’s role. The next day, Folsom and Frank B. Cliff, the former assistant controller of General Electric Co., met with Richard S. Reynolds and Steven J. Simmons, Alcoa’s vice president of marketing, to discuss matters. Reynolds complained of aluminum shortages, and by Jan. 14, 1941, Alcoa responded by promising more production. Alcoa presented major expansion plans four days later. [47]

War-time expansion plans also conflicted with long-term plans for the development of hydropower and transmission in the Pacific Northwest, according to Wiltse’s 1946 report. In February 1941, Interior Secretary Harold L. Ickes expressed concern that Alcoa held contracts for more than four-fifths of the Bonneville Power Administration’s hydroelectric capacity. Ickes said he was reluctant to grant Alcoa more BPA power because it would concentrate power output at one end of the system, rather than distribute BPA power across the Pacific Northwest, but Ickes also objected to Alcoa itself. “It is, of course, apparent that by increasing its sales of power to the Aluminum Company, the Bonneville Power Administration necessarily would increase that company’s monopolistic control of the aluminum industry, as well as give it a virtual monopoly of Bonneville’s power facilities,” Ickes said. Three weeks after making those statements and refusing to grant Alcoa more BPA power, Ickes announced that the BPA had signed a 20-year power contract with Reynolds for an aluminum smelter at Longview, Wash. The very next day, Reconstruction Finance Corporation Administrator Jesse H. Jones announced it had approved a loan to Reynolds for the 30,000 ton-per-year smelter. [48]

Concerns expressed about NDAC’s low requirements estimates and their approval by the Armed Services, along with an over-reliance on Alcoa for aluminum production, “became grounds for calling into question both the competence and the independence from private monopoly influence of the government officials involved,” Wiltse said. The Senate’s Special Committee Investigating the National Defense Program, headed up by Sen. Harry Truman, began to look into the U.S. aluminum industry with a hearing held on May 12, 1941. The initial question was why aluminum shortages existed six months after NDAC had said supplies were adequate. The Truman Committee met again on June 16, 1941, where Interior Secretary Ickes blamed Alcoa and the Office of Production

Management for the aluminum shortages. Ickes claimed Alcoa deliberately sought to "put off the horrible day when the monopoly would have to experience some competition," and that Alcoa "would prevent the necessary expansion of our aluminum manufacturing facilities, regardless of the cost to the country or to the world, in order to get them all within its own domination and control." I.W. Wilson, Alcoa's vice president of production, followed Ickes at the hearing, but he was unable to answer the committee's questions about costs and earnings by Alcoa. Other witnesses said Alcoa, the Tennessee Valley Authority and the BPA had been waiting for six weeks for the Office of Production Management to finally announce an aluminum expansion program. Members of the committee held the same concerns, according to Wiltse. [49]

Plans for the U.S. aluminum industry's first expansion program for an additional 300,000 tons per year was completed by July 15, 1941, about the same time that the Office of Production Management was reorganized, according to Wiltse. The plan was sent to the War Department, and the Defense Plant Corporation was assigned to build the new plants, which included seven new smelters in Washington, Oregon, California, New York, Alabama and Arkansas. More delays followed. On June 4, 1941, Arthur H. Bunker, an electrical engineer with a strong metallurgical background who had been an executive vice president at the Lehman Corporation investment company in New York, was placed in charge of the federal aluminum program. Bunker spoke to the Washington Post on Aug. 31, 1941, and complained about the Office for Production Management. "The OPM admits that while haggling over prices may save the government some money, there is not exactly a millennium at the government's disposal," Bunker said. "Banker caution is a good idea, but right now a better idea is a lot of aluminum and magnesium in a hurry." [50]

The Truman Committee and reaction

Oversight for this enormous war build-up emerged from a grassroots effort in the U.S. Senate. In January 1941, Sen. Truman and his investigating committee, the Senate Select Committee Investigating the National Defense Program, began their self-assigned task by looking at documented waste and mismanagement during construction of Army camps. They soon discovered a shortage of aluminum, copper, zinc and rubber as the world seemed to be heading for war. They found that Alcoa held a near monopoly over aluminum production in the U.S. while the company also claimed it could meet both domestic and military needs. But the committee didn't think the numbers added up. The committee also discovered that a shortage of magnesium existed as a result of the cartel agreement between Alcoa and IG Farben. [51] Truman came up with the idea of the investigating committee after driving around the U.S. to look at military facilities. He

reported on problems he'd seen to the Senate and to attorneys at the Reconstruction Finance Corporation and the Defense Plant Corporation. [52]

In March 1941, Congress established the Senate Special Committee to Investigate the National Defense Program as a bi-partisan committee tasked with looking into waste, inefficiency and war profiteering. In hindsight, the committee is considered one of the most successful investigative efforts ever mounted by the U.S. government and is believed to have indirectly helped Truman later become president. From 1941 through 1948, the committee held 432 public hearings, listened to 1,798 witnesses and published nearly 2,000 pages of reports. Each report was unanimous with bipartisan support. Military leaders were apprehensive of Truman's plan for an investigative committee, but its establishment was made by unanimous vote (but only 16 of 96 senators were present to vote). The committee's first target was construction of military housing, which the Army agreed to hand over to the Army Corps of Engineers. The committee next focused on the "alphabet soup" of government organizations established to oversee the national defense build-up. A committee report on the Office of Production Management was very critical, but Roosevelt was able to disband the office before the report came out. By the time the Japanese attacked Pearl Harbor on Dec. 7, 1941, President Roosevelt had come to recognize the value of the Truman Committee. Truman's efforts through the committee were recognized by Time magazine when it put him on the cover in March 1943. [53]

The Truman Committee estimated in January 1941 that existing aluminum inventory and production capacity were adequate to meet defense needs through October. By February, aluminum was placed on a priority list, with virtually all production going to defense needs. By July, authorities in Washington, D.C. recognized the scope of a coming air war and approved the first government-sponsored aluminum program. The program involved three major steps: 1) expand private industry, which meant mostly Alcoa but also newcomer Reynolds with its refinery and smelter plants in Listerhill, Ala.; 2) use Defense Plant Corporation financing to construct new aluminum smelting plants in practical locations near inexpensive electrical power so the plants could be utilized for commercial purposes after the war ended; and 3) construct emergency smelting plants using power from large industrial areas that would be uneconomical to operate once the war ended. The first phase began in October 1941, and the second began in February 1942. [54]

In early 1941, the Truman Committee heard testimony from Office of Production Management officials which admitted "our sights haven't been high enough." The committee criticized the Office of Production Management for relying on "Alcoa as a source of information as to the availability of aluminum" and felt that Alcoa had

manipulated its information “to avoid the possibility that anyone else would go into the field,” according to Smith. As the spring and summer of 1941 rolled by, more government officials became concerned about possible aluminum shortages, and some senators believed the problem could be addressed if the federal government sponsored other companies or built its own plants. During a Truman Committee hearing, Interior Secretary Ickes suggested the government might build new plants “upon terms that won’t make it possible for the Aluminum Company to put on any financial or other screws at the end of the emergency.” The reality was that Alcoa lacked sufficient money to build enough capacity to suit the government’s demands, according to Smith. Instead, the government was forced to rely on Alcoa’s engineering department to build 20 new plants between 1941 and 1943. [55]

President Roosevelt established the War Production Board on Jan. 16, 1942 under Executive Order 9024 to replace the Office of Production Management and the Supply Priorities and Allocation Board to supervise war production efforts. The War Production Board directed the conversion of many peacetime facilities to war needs, allocated scarce resources and materials such as aluminum, established priorities for the distribution of services and materials, and prohibited nonessential production. Operating nationwide with 12 regional offices and 120 field offices, the board rationed commodities such as rubber, gasoline, heating oil and metals. Between 1942 and 1945, the War Production Board supervised the production of $183 billion worth of weapons and supplies – about 40% of the munitions output in the world. Production of military aircraft increased from about 6,000 in 1940 to about 85,000 in 1943. The War Production Board was dissolved on Nov. 3, 1945, and its remaining functions were handed off to the Civilian Production Administration. [56]

The story of the Reynolds Metals Co.’s move into aluminum production has gained mythic proportions. In 1937, Reynolds President R.S. Reynolds traveled to Europe where he was witness to the German military buildup. When he returned to the U.S., he met with Arthur Vining Davis and urged Alcoa to triple capacity of aluminum production for use in making aircraft, but Alcoa was slow to act. The federal government believed the shortage of aluminum was because of Alcoa’s monopoly, and Alcoa received negative publicity over this, but Alcoa quickly rose to the war challenge. In three years, Alcoa built more than 20 aluminum plants, including eight smelters, 11 fabricating plants and four alumina refineries and operated them for the U.S. government. Total investments in the aluminum industry during World War II rose to $672 million, of which $474 million came from Alcoa. Employment in the aluminum industry increased from 26,179 workers in 1939 to 95,044 by 1944. When the war ended, the U.S. canceled Alcoa’s plant leases, and most of the aluminum plants were sold to Kaiser or Reynolds at or below the cost to build them. Alcoa also was required to license the technology needed

to run the war-surplus plants. The only World War II plant that Alcoa was allowed to keep was the Cressona extrusion plant in Pennsylvania. [57]

In 1941, the Office of Production Management asked Alcoa to come up with a plan to produce an additional 150,000 tons of aluminum per year. Alcoa responded to the request in May with a comprehensive nationwide program including: 1) Alcoa would enlarge operations at its smelters in Alcoa, Tenn., and Massena, N.Y., at its own expense in order to produce an additional 50,000 tons per year, with the government providing additional electric power; 2) Alcoa would build and operate for the government a smelter in the Pacific Northwest with a capacity of 100,000 tons per year, using electrical power from the Bonneville Power Administration pursuant to a 20-year contract; 3) Alcoa would use government loans to build, operate and eventually own alumina-refining facilities in the Arkansas bauxite district sufficient to supply the new smelters; and 4) Alcoa would increase its fabrication facilities using government loans. [58]

The offer was not sufficient, and a different plan soon emerged. On Aug. 19, 1941, Alcoa and the Defense Plant Corporation entered into a contract to build facilities capable of producing 200,000 tons of alumina and 170,000 tons of aluminum. In the agreement, Alcoa was responsible for choosing sites, acquiring land and building the plants. Funds would be provided by the Defense Plant Corporation, which would hold the title and lease the plants to Alcoa upon completion. Soon afterwards, the Truman Committee criticized the plan, stating that the plan "contained few, if any, safeguards to the Government, and was entirely too favorable to Alcoa." In response to this criticism, a new agreement was entered into on Dec. 12, 1941, that increased the capacity of the plants to 500,000 tons of alumina per year and 256,000 tons of aluminum per year. The new agreement also amended certain provisions and removed the necessity for the Defense Plant Corporation to obtain Alcoa's consent in furnishing bauxite and distributing alumina. Alcoa proceeded to build and operate the plants and later was hailed for its efficiency and reliability. [59]

The World War II build-up

President Roosevelt signed the first War Powers Act on Dec. 18, 1941, less than two weeks after the Japanese attacked Pearl Harbor. Similar to the Departmental Reorganization Act of 1917, signed as the U.S. went into the First World War, the new act enabled Roosevelt to reorganize the executive branch, independent government agencies and government corporations to enable the U.S. to execute World War II in an efficient manner. Language in the act stated that the act and all changes made through its power were to remain intact for six months after the conclusion of the war. The second War Powers Act, passed by Congress on March 27, 1942, further strengthened

the executive branch so it could execute the war. It allowed the federal government to acquire land, under condemnation if necessary, for military and naval purposes. It also established new procedures for war-related production contracting. [60]

As war broke out and was fought overseas, defense industries directly consumed about one-third of all U.S. industrial output, but despite rationing, consumer output also expanded. By 1944, as a result of wage increases and overtime pay, real weekly wages before taxes in manufacturing were 50% higher than in 1939. For a time, the U.S. government purchased one-half of all the goods produced in the U.S. President Roosevelt realized that the U.S. government could not produce all the planes, ships and tanks it needed, so he turned to mobilizing proprietors of mines, factories and industrial shops. Through the Reconstruction Finance Corporation, the U.S. government was able to advance funds needed to expand factories, in some cases building new factories and leasing them to industry. [61] From 1939 to 1945, aluminum production worldwide tripled, from 687,000 tons per year to 2.2 million tons. [62]

Shortly after the attack on Pearl Harbor, War Production Board Chairman Donald M. Nelson asked Arthur Vining Davis to implement a 3-shift, 24-hour per day production schedule at the company's Arkansas mines. Davis brought in miners from across the U.S. to meet the request. By 1943, annual production had increased to 5.4 million tons. Production began to slow down as the war drew to a close, but the population and infrastructure of the town of Bauxite, Ark., had grown significantly. [63] Alcoa invested a total of $300 million of its own money in expanding its own aluminum production facilities during the war. Alcoa also built for the government, without fee or profit, $450 million worth of government-owned aluminum producing facilities, according to Charles C. Carr's 1952 book on Alcoa. Alcoa managed 22 government-owned plants, including eight smelters, 10 fabricating plants, two alumina refineries and two processing plants for low-grade bauxite. Total aluminum production in the U.S. grew from about 164,000 tons per year in 1939 to about 1.25 million tons at the peak of the war-time effort. [64]

Alcoa built and operated smelters for the government at Burlington N.J.; Jones Mills, Ark.; Los Angeles, Calif.; Meade, near Spokane, Wash.; Queens, N.Y.; Riverbank, Calif.; Troutdale, Ore.; and St. Lawrence, near Massena, N.Y. Alcoa operated all but one of these smelters under a government contract that gave the government 85% of the profits, according to Carr. Alcoa operated aluminum fabricating plants for the government, including the McCook sheet mill in Chicago; the Trentwood sheet mill at Spokane; a rod and bar mill in Newark, Ohio; a cast cylinder-head plant in Kansas City, Mo.; an extrusion plant in Cressona, Pa.; an extrusion and tubing plant in Phoenix, Ariz.; a forging plant in Monroe, Mich.; a forging plant in Newcastle, Pa.; a forging plant in Canonsburg, Pa.; and an aluminum powder plant in Glassmere, Pa. Alcoa also operated

alumina refineries for the government at Hurricane Creek, Ark. and near Baton Rouge, La. Alcoa operated Alcoa Combination Process alumina refineries for low-grade bauxite at Hurricane Creek and in East St. Louis, Ill. [65]

Only two other companies ran aluminum smelters in the U.S. during World War II – the Reynolds Metals Co. and the Olin Corporation. Reynolds Metals entered the smelting industry before hostilities broke out, but the impetus was impending war. Richard Samuel Reynolds had founded the U.S. Foil Co. in Louisville, Ky., in 1919 to provide lead and tin foil for his uncle R.J. Reynolds' tobacco business. In 1926, the U.S. Foil Co. began rolling aluminum foil and promoting aluminum foil for food and cigarette packaging. Reynolds Metals was formed in 1928. The company continued to grow through the Great Depression, and the company prospered with the development of rotogravure printing on aluminum foil in 1935. [66] With European nations preparing for war in the late 1930s, Reynolds Metals found it difficult to find an adequate source of metal for producing foil, and R.S. Reynolds went abroad in 1937 to find new sources of aluminum. While in Germany, he discovered a vast amount of aluminum was being purchased for what appeared to be a future war – a war involving airplanes. When he returned to the U.S., he tried to convince the government of the need to expand aluminum production to meet this foreign threat, but months of meeting and corresponding with government officials proved fruitless. [67]

On May 10, 1940, the Germans rolled into Belgium and Holland and occupied the two countries. In a radio address six days later, President Roosevelt promised that the U.S. would soon produce 50,000 airplanes per year. Reynolds recognized that in order to achieve Roosevelt's goal, the U.S. would need to increase aluminum production to 400,000 tons per year. Reynolds had a plan of action in mind when he approached Sen. Lister Hill of Alabama about the aluminum problem. Hill reportedly was impressed by Reynolds' plea and helped arrange two meetings with Secretary of War Harry H. Woodring. Reynolds also met with government and industry officials. He urged the government to furnish funds to enable the U.S. aluminum industry to expand by 500,000 tons per year. Finding no support for his proposals, Reynolds decided to act on his own. [68] Reynolds mortgaged all his existing company's plants and all plants to be built on borrowed funds and took out a $15.8 million loan from the U.S. government. Within six months, Reynolds Metals was pouring aluminum at its new smelter in Listerhill, Ala. [69]

By Nov. 20, 1940, construction crews had moved onto a one-square-mile tract of farmland outside of Sheffield, Ala. Five months and 28 days later, the first aluminum ingot was poured at the Listerhill smelter. Two months later, in July 1941, the first aluminum sheet was produced at an adjacent alloys plant. After World War II ended,

President Truman awarded Reynolds with a certificate of merit. [70] Reynolds later claimed that he urged Arthur Vining Davis to triple Alcoa's production of aluminum but Davis failed to grasp the significance of the German war effort because of advice he was receiving from the U.S. War and Navy departments. Seeing an opportunity to enter the aluminum industry, according to this version, Reynolds approached the National Defense Advisory Commission for aid without success because the government was only listening to Alcoa. Then, with help from Sen. Hill, Reynolds was put in touch with the Reconstruction Finance Corporation and an arrangement was made. By mortgaging its 18 plants, Reynolds Metals secured a loan to build a smelter in Longview, Wash., and a smelter and sheet mill at the brand new unincorporated town of Listerhill, Ala. [71]

Using a 20-year power contract with the Bonneville Power Administration, the Longview smelter began producing aluminum in September 1941 on the Columbia River about 40 miles downstream from the one-year-old Alcoa smelter in Vancouver, Wash. [72] The 31,000 ton-per-year Longview smelter cost about $6.5 million, financed with a loan from the Reconstruction Finance Corporation. Reynolds Metals completed construction and began operating the 100,000 ton-per-year alumina refinery and the 50,000 ton-per-year aluminum smelter at Listerhill in May 1941 for a combined cost of $15.8 million. Power for the Listerhill facilities was supplied by the Tennessee Valley Authority. The Listerhill alumina refinery sat idle, however, from the time it was built until 1949 because Reynolds Metals was obligated to produce all its alumina at the Hurricane Creek refinery that it leased from the government. As a result, according to R.S. Reynolds, the Listerhill refinery was "about to fall apart from rust" in 1949. [73] Additional Reynolds facilities were contracted in 1940, including rolling mills and sheet plants in Louisville, Ky., and bauxite mining operations in Arkansas. During World War II, Reynolds Metals delivered nearly 10,000 tons of aircraft parts and nearly 500,000 tons of other aluminum products, including bombs, radar equipment and military packaging. [74]

One other company got into the U.S. aluminum industry during World War II. The Olin Corporation traced its roots back to 1892 as the Equitable Powder Co., founded by Franklin Olin, which made blasting powder for coal mines. Through the years, Olin founded the Western Cartridge Co. to sell ammunition and to produce brass during World War I. The company bought the bankrupt Winchester Repeating Arms Co. in 1931, produced 15 billion rounds of ammunition during World War II, introduced the M1 rifle, and was reorganized as Olin Industries in 1944. [75] In 1942, the Olin Corporation built a 20,000 ton-per-year aluminum reduction plant in Tacoma, Wash., for the Defense Plant Corporation. The weapons manufacturer, headed by 84-year-old F.W. Olin, also operated the Tacoma plant. In 1943, in order to address the need for a more secure domestic supply of bauxite during war-time, Olin acquired Kalunite Inc. of Salt Lake City, Utah, a company that was developing new ways to make alumina from alunite instead

of bauxite. Olin used nearly $5 million of Defense Plant Corporation funding to build a processing plant near Salt Lake City capable of producing 26,000 tons of alumina per year. The plant was completed in 1943 and was expected to begin operation by 1944. At the end of World War II, Olin was given an option to purchase the plant as war surplus, the first such offer by the government at war's end, according to Engle. [76]

The aluminum war machine

In 1900, U.S. production of primary aluminum was 2,500 tons. Production rose to 163,500 tons by 1939 and then peaked at 920,000 tons during World War II. [77] The U.S. produced 148,000 tons of aluminum per year in 1939, compared to 200,000 tons in Germany. By 1943, U.S. production had climbed to 835,000 tons, more than three times German production of 250,000 tons. Production in Canada climbed from 75,000 tons in 1939 to 450,000 tons in 1943, adding to the Allied war effort. Overall production during the five years of the war was 4 million tons for the U.S. and Canada together, compared to 1.4 million tons in Germany. The increased production in the U.S. was accomplished with financing by the U.S. government for four alumina refineries, eight aluminum smelters and 10 large aluminum fabricating plants. The government-financed plants produced twice the amount of aluminum produced by Alcoa plants. [78] As demand soared, U.S. production of aluminum in 1942 passed the production level of lead for the first time, leaving aluminum in fourth place behind steel, copper and zinc. Aluminum production passed zinc in 1943 and copper in 1952. Uses for aluminum numbered about 1,500 in 1940, increasing to 3,500 by 1945 and reaching more than 4,000 by 1948. [79]

All that energy-intensive production had an impact on other national resources, according to Engle. In 1940 the U.S. aluminum industry consumed more than 4.5 million megawatt-hours of electrical power, making it the largest consumer of electrical power in the nation. It was estimated that by 1943, during the height of war-time production, the U.S. aluminum industry consumed about 22 million megawatt-hours. An estimate of the average annual consumption of raw materials for the refining of alumina in 1943 for the aluminum industry of just the Pacific Northwest included 1.2 million tons of bauxite, 36,000 to 54,000 tons of quicklime, 42,000 to 60,000 tons of soda ash, and 4,800 billion to 6,000 billion BTUs of coal, oil, gas or electricity. An estimate of the average annual consumption of raw materials for smelting in the Pacific Northwest included 600,000 tons of alumina, 121,800 to 136,500 tons of petroleum coke, 52,200 to 58,500 tons of pitch, 14,000 to 16,000 tons of natural cryolite, and 8,000 to 10,000 tons of synthetic aluminum fluoride. [80]

According to the Truman Committee Report of March 1944, Alcoa's plants produced 414,000 tons of aluminum per year, government-owned plants leased to Alcoa during

the war produced 646,500 tons, and the combined plants operated by Reynolds and Olin produced 101,000 tons. The industry-wide grand total came to 1.1 million tons per year. [81] Nearly 100% of all that aluminum went into aircraft manufacturing. What little else that remained went into other military and naval equipment. [82] As the U.S. aluminum industry shifted from consumer markets to strategic needs, the kitchen utensil business was shut down and the focus moved to aluminum for aircraft. Over the next 5 1/2 years, the U.S. aluminum industry produced about 1.75 million tons of hard alloy aluminum to build 304,000 military aircraft. [83] In 1930, Alcoa offered a new aluminum alloy for the aircraft industry called 24S-T to replace an older alloy 17S-T. The new alloy had a tensile strength of 68,000 pounds per square inch and was difficult to produce. During World War II, other new alloys were developed, including 14S for aircraft structural fittings and 17S for propeller blades. One new alloy, called 75S, was ready in the final years of the war. Alloy 75S was used for the wings of Boeing B-29 bombers and had a tensile strength of 82,000 pounds per square inch. [84]

The U.S. military had 3,000 planes in 1939 when President Roosevelt asked Congress for $300 million to build additional airplanes for the Army Air Corps, which at the time had only 1,700 aircraft. Congress agreed to pay for 3,251 aircraft. [85] In May 1940, Roosevelt asked the U.S. aircraft industry to produce at least 50,000 planes per year, which would double monthly production. Government assistance to the industry began with the Emergency Plant Facilities program and then the Defense Plant Corporation. Automobile manufacturers and related industries made up most of the expanding aircraft industry, but assembly line methods were not well suited for aircraft. Planes needed large open-bay factory layouts, and aircraft construction was much more complex and required more precision – there was a standardization problem, and the need for large production volume necessitated design changes. [86]

Over time, U.S. aircraft production largely succeeded in shifting from job shops to assembly line type production. The Ford Willow Run plant near Detroit, Mich., was the largest and most successful example, turning out 5,476 of the model B-24 bombers in 1944-1945. The plant turned out 46,000 tons of airframe weight in 1944 – more than half of Germany's total annual production and nearly equal to Japan's annual total. Beginning in spring 1942, U.S. aircraft factories began to run 24 hours a day, six to seven days a week. Production efficiency also improved – a B-17 bomber required 55,000 individual work-hours to produce in 1941, but that figure fell to 19,000 by 1944. The number of planes the U.S. aircraft industry produced doubled from 1939 to 1940 and then doubled again in 1941 and doubled again in 1942. By the end of 1943, there were 83 aircraft production plants in the U.S. and five more in Canada. Total factory space grew to 175 million square feet. Total workforce peaked at the end of 1943 at more than 2 million workers. In the peak production month of March 1944, more than 9,000

aircraft came off the assembly lines. By the spring of 1944, more aircraft were being produced than could be used, so production was curtailed. The value of the U.S. aircraft industry's output rose from about $225 million in 1939 to about $16 billion in 1944. [87]

By the end of World War II, the U.S. had produced nearly 300,000 planes. During that time, aircraft manufacturing went from 41st place among U.S. industries to first. Manufacturer for manufacturer, factory for factory, or worker for worker, the U.S. out produced its enemies. By 1944, U.S. workers were out producing German workers by two to one and Japanese workers by four to one. Many of the airplanes made before the U.S. entered the war went to Britain and France. The 1939 Neutrality Act permitted nations at war to acquire armaments from U.S. manufacturers if they paid in cash and used their own transportation. By 1940, Britain had ordered $1.2 billion worth of aircraft. By the end of the war, the British Empire received 38,811 planes, the Soviet Union received 14,717 planes and other nations received 6,126 planes. [88] In 1941, Soviet leader Joseph Stalin wrote to President Roosevelt about the significance of aluminum and aircraft, saying, "Give me 30,000 tons of aluminum and I will win the war." [89] As the U.S. aircraft industry began to expand in 1939, factories moved from single shifts to double and triple shifts to meet demand. Aircraft designed by one company were sometimes built by other companies. Aircraft production in the U.S. increased from 3,611 in 1940 to a high of 96,270 in 1944 before scaling back when the war concluded in 1945. [90]

U-boats and saboteurs

Keeping the U.S. aluminum industry supplied required reliable shipping to get South American bauxite to U.S. alumina refineries. But by 1936, the U.S. merchant fleet was becoming obsolete and declining in numbers, partly a result of the Great Depression. Between 1922 and 1937, only two ocean-going dry cargo freighters had been built in the U.S. By 1936, only 10 shipyards in the U.S. were capable of building a ship more than 400 feet long, with a total of 46 shipways in the U.S. A large number of ships had been built at the start of World War I, but by 1936 many of them were two decades old. To address that need, President Roosevelt signed the Merchant Marine Act on June 30, 1936, creating the U.S. Maritime Commission. The independent agency was tasked with establishing new shipyards capable of building over a 10-year period a fleet of 500 modern and fast merchant cargo ships that could be sold, chartered or leased to American companies for overseas shipping. The ships would also act as a reserve U.S. Naval auxiliary fleet in event of war. The act also called for training both shipyard workers and merchant marine personnel. [91]

Once war broke out in Europe, Alcoa lost access to foreign-flag ships to transport bauxite from South America to the U.S. In 1939, the U.S. War Shipping Administration provided Alcoa with 14 World War I vintage cargo ships to keep the flow of bauxite going. The ships were prone to German U-boat attack, and four of the 14 ships were sunk. In 1940, Alcoa consolidated the three bauxite-shipping companies operating in the Gulf of Mexico into the Alcoa Steamship Co. Several ships operated by the company also sank during the war, including the City of Birmingham and the Robert E. Lee. In 1941, Alcoa ordered three ships from the Moore Dry Dock Co. in Oakland, Calif. – the Alcoa Courier, Alcoa Corsair and Alcoa Cruiser. The ships were intended to carry both bauxite and up to 102 passengers with luxury first-class accommodations – a swimming pool, beach, sports and sun decks, glass-enclosed promenades, a cocktail lounge, a library and staterooms with private baths and showers. The company wanted revenue from passengers to assist with the cost of shipping bauxite. The ships would also carry 313,000 cubic feet of cargo, including a refrigerated hold. But after the Japanese attacked Pearl Harbor, none of the ships were delivered to Alcoa. Instead, the three ships were reconfigured for the U.S. Navy for use as medical facilities and troop transport. The Alcoa Courier was renamed the USS Tryon after a former Naval Surgeon General. [92]

The Germans were well aware of the Caribbean bauxite-shipping routes. German submarines threatened shipments of bauxite from the Caribbean as early as summer 1941, and by the end of the war scores of bauxite carriers had been sunk, according to Smith. [93] As enemy submarines scored hits, production at bauxite mines in Arkansas rapidly increased. In 1943, more than 6 million tons of bauxite was mined in Arkansas. [94] Germany's submarine campaign reached its height by April 1942. According to post-war records, 35 U.S. merchant marine ships were sunk by U-boats in March 1942, with 42 more in April and 52 more in May. [95] During the war, Alcoa lost eight of its own ships and 13 leased bauxite carriers to German U-boats. Sixty-seven sailors lost their lives. [96]

On May 6, 1942, the SS Alcoa Puritan, a cargo ship owned by the Alcoa Steamship Co., was sunk by a German U-boat while transporting bauxite from a transfer station at Trinidad to Alcoa's alumina refinery in Mobile, Ala. The U-507, commanded by 34-year-old Kapitanleutnant Harro Schacht, attacked the SS Alcoa Puritan just before noon, first with a torpedo that passed the cargo ship astern. The U-507 then surfaced about two nautical miles away and began to shell the cargo ship, which was alone and unarmed. The first shot landed in the water ahead of the SS Alcoa Puritan and was considered a warning shot. Capt. Yngvar A. Krantz tried to outrun the submarine with a zigzag pattern. The sub fired several more shells that missed and then refined its targeting and made about 70 hits over the next 25 minutes. The hits laid open the cargo ship's superstructure, perforated the exhaust stack, broke all the windows and instrument

faces, set fire to interior areas, and then disabled the steering mechanism. With his ship going around in circles, Krantz ordered the engines stopped and the crew to abandon ship. The U-507 approached the crew in their lifeboats, and Schacht shouted that he was sorry and hoped the survivors would "make it in all right." He waved good-bye, and the sub submerged. About an hour later, a U.S. Navy patrol aircraft alerted earlier by the cargo ship's radio distress call spotted the survivors, and several hours later they were rescued by a U.S. Coast Guard cutter. The U-507 was sunk by U.S. Navy aircraft off Brazil on Jan. 13, 1943. The submerged wreck of the SS Alcoa Puritan was discovered by an oil exploration company in 2002 about 45 nautical miles south-southeast of the entrance to the Mississippi River. [97]

By spring 1942, losses of bauxite shipments caused by German submarines in the Caribbean were creating a hardship. The U.S. at the time lacked available shipping to fill the replacement needs. Other solutions were available, however, according to Wiltse. One was to use the lime-soda sinter alumina-refining process, which would allow the U.S. to produce more alumina from the same amount of bauxite shipments and allow U.S. alumina refineries to process bauxite with a high 15% silica content. The U.S. could also order the chemical and abrasives industries to use lower quality bauxite, leaving the higher quality bauxite available for aluminum smelters. Bauxite mining in Arkansas was increased as part of the overall plan, and Alcoa even began to develop a new source of bauxite in Jamaica, which was closer to the U.S. Federal officials also promoted the production of more synthetic cryolite as submarine attacks in the North Atlantic threatened shipments of natural cryolite from Greenland. [98]

Aluminum plants were attractive targets to bombers and commando operations alike. In 1944, the alumina refinery at Gardanne, near Marseilles, was sabotaged by the French Resistance. [99] The war was brought to the U.S. homeland in 1942 when government agents captured German saboteurs holding instructions to destroy Alcoa plants in Tennessee, New York and East St. Louis. [100] The Nazis were concerned about the growing threat of Allied bombers and believed a major setback to U.S. aluminum production would slow down the bombing. [101] On June 12, 1942, the German submarine U-102 landed at Amagansett, on Long Island about 115 miles east of New York City, and dropped off four saboteurs – Ernst Burger, an American citizen, and George Dasch, Richard Quirin and Heinrich Heinck, German citizens who had lived and worked in the U.S. in the past. Another submarine, the U-584, landed at Ponte Vedra Beach, south of Jacksonville, Fla., four days later and dropped off Herbert Haupt, an American citizen, and Edward Kerling, Hermann Neubauer and Werner Thiel, all German citizens who also had lived and worked in the U.S. [102]

The two teams were on a mission called Operation Pastorius that was headed by Admiral Wilhelm Canaris, chief of the German Abwehr secret service. They were to meet on July 4, 1942, in Cincinnati to coordinate their sabotage activities. The mission's goal was to sabotage Alcoa plants in Illinois, Tennessee and New York; a cryolite plant in Philadelphia; hydroelectric plants at Niagara Falls; locks on the Ohio River; crucial railroad equipment in and near Altoona, Pa.; and the Pennsylvania Station in Newark, N.J. The agents were also instructed to spread a wave of terror by setting explosives on bridges, railroad stations, water facilities, Jewish-owned businesses and public places. The agents were provided with counterfeit birth certificates, Social Security cards, draft deferment cards, driver's licenses and nearly $175,000 in U.S. money. [103]

Shortly after the first submarine landed, an unarmed U.S. Coast Guardsman discovered Dasch in the dunes on the Long Island beach. Dasch seized the guardsman by the collar, threatened him and stuffed $260 into his hands. The four Germans then took a train into Manhattan, N.Y., and checked into a hotel. As a massive manhunt ensued, Dasch told Burger in the hotel that he actually hated the Nazis and had no intention to carry out the mission. Burger had spent 17 months in a Nazi concentration camp and also was not a Nazi supporter. He agreed with Dasch to defect. Dasch tried to turn himself in to the FBI, but he was rebuffed on the phone in Manhattan and even had trouble convincing the FBI when he showed up at their offices in Washington, D.C. He finally convinced the FBI by dumping $84,000 in cash on an assistant director's desk. The other seven German agents were arrested over the next two weeks. President Roosevelt issued an executive proclamation to create a military tribunal to prosecute the German agents. They were found guilty and sentenced to death on Aug. 3, 1942. Roosevelt commuted Burger's sentence to life in prison and Dasch's sentence to 30 years. The other six were executed by electric chair on Aug. 8, 1942. Afterward, Hitler rebuked Admiral Canaris, and no more sabotage attempts were made by the Germans in the U.S. Dasch and Burger were granted executive clemency by President Harry Truman in 1948 but were regarded as traitors when they returned to Germany. [104]

End of war revelations

As with many other industrial companies, the war was good for Alcoa's pocketbook, according to Smith. By 1943, Alcoa's annual payroll was $251.2 million, up from $44.5 million in 1939, and Alcoa's workforce included 95,044 employees, up from 26,179 in 1939. With so many workers being drafted into the military, and with so many technically-trained Americans being drafted into the nation's war-time industrial effort, Alcoa was forced to constantly train new workers, from potmen to scientists. Alcoa's success at integrating these new workers showed the maturity of the industry. Among the new workers were women and older men. In some Defense Plant Corporation

plants, more than half the workforce was over 65 years old. [105] During World War II and the preparation time prior to the war, the U.S. produced 1.75 million tons of aluminum to build 304,000 airplanes for the military. During the time between May 1940 and V-J Day, Alcoa produced 5.7 million tons of alumina and 2.75 million tons of ingot aluminum, as well as fabricating 1.35 million tons of aluminum sheet, 250,000 tons of forgings, 200 million tons of castings and 225,000 tons of extruded shapes. Alcoa's net profit for this time period was $199 million. [106]

By the end of the war, the government earned nearly $30 million from the smelter plants and $20 million from government-owned fabrication plants run by Alcoa. At no time during the war did a shortage of aluminum for military purposes occur. There were criticisms and charges of shortages during the war, but the Truman Committee held two investigations that ended with praise for Alcoa. There were also unsupported charges by Interior Secretary Ickes, along with comments in the media by columnists and reporters. Alcoa's record during the war was upheld by the Truman Committee's Third Annual Report, which stated "that Alcoa should be commended for the prompt and effective manner in which it expanded at its own expense" and "with which it constructed the government-owned aluminum and alumina facilities." [107]

End of the war investigations were also held overseas by the victorious Allies. One investigation looked at who held shares of Aluminium-Industrie AG Chippis, which operated aluminum smelters in Germany, Austria and Switzerland. According to the 1945 Senate committee report, shareholders included British Aluminium Ltd. at 15.5%, the Canadian company Aluminium Ltd. at 28.5%, the French company Ugine at 21%, the German company Vereinigte Aluminum Werke AG at 20%, and various Swiss private interests at 15.5%. Several companies from Allied nations held stock in a company that provided aluminum to Germany during the war. The Aluminium-Industrie AG smelters faced hydropower and alumina shortages during the war, but the company's fabrication plants stayed busy, and deliveries from fabrication plants to Germany increased during the war. [108]

Another investigation looked into IG Farben. According to a November 1945 investigative report for the U.S. occupational military government in Germany, mostly based on IG Farben's own records, "IG Farben, nominally a private business enterprise, has been and is, in fact, a colossal empire serving the German State as one of the principal industrial cores around which successive German drives for world conquest have been organized." The company was composed of at least 380 domestic firms, and it owned factories, power plants, and coal, magnesite, gypsum and salt mines across Germany. The company also owned or was suspected of owning more than 500 foreign firms and had cartel agreements with more than 2,000 companies – including Alcoa,

Standard Oil of New Jersey, E.I. DuPont de Nemours, Ethyl Export Corp., Imperial Chemical Industries of Great Britain, Dow Chemical Co., Rohm and Hass Etablissments Kuhlmann of France, and Mitsui Interests of Japan. [109]

The report claimed that IG Farben used these cartel agreements to obtain knowledge about key processes as well as to obtain critical materials, the post-war investigation found. IG Farben also served the Nazi government as a principal agency for military and economic espionage around the world, as well as psychological and economic warfare through propaganda. The report explained in great detail that Farben was aware of the Nazi government's plans for world domination and its use of chemicals to kill people. All the company's plans fell apart as the end of World War II drew near. "In anticipation of Allied victory, thousands of Farben's secrets went underground along with other German resources to lay the foundation for World War III; and thousands of its important files were, according to the testimony of its responsible officials, destroyed just prior to the advent of the Allied troops," the report stated. [110]

The German defeat also opened doors to new manufacturing technologies. During the war, German aircraft manufacturing companies built four extremely large presses for forming entire aircraft subassemblies out of aluminum, thus reducing the number of aircraft parts, simplifying the assembly process, and increasing structural strength. In 1948, two of the presses were shipped to the U.S. by the Air Force, where they were installed at plants operated by Alcoa and Bridgeport Brass. The other two presses were shipped to the Soviet Union. In 1950, the U.S. Air Force commissioned the building of even larger presses, which were operated by Wyman Gorden, Alcoa, Kaiser, Harvey and Curtiss Wright. A German engineer named Johannes Croning developed a method to fabricate aluminum for aircraft parts called shell molding, which used a plastic shell instead of the more expensive metal die method. After the war ended, Croning joined the Polygram Casting Co. Ltd., an English foundry that later applied for a U.S. patent. Interested U.S. companies included Union Carbide and Monsanto. By 1953, more than 100 foundries had adopted the process, but one metallurgist said it "is no panacea." The aircraft industry was also a driving force for invention in Italy, where engineer Ilario Properzi developed a continuous-casting process for aluminum. Properzi made more improvements to his process after the war, and the Nichols Wire and Aluminum Co., an independent aluminum fabricator, introduced the process to the U.S. Continuous-casting enabled a single machine to convert aluminum ingot directly into redrawn rod, thus eliminating several intermediate steps from the conventional process. There were seven installations in the U.S. by 1962, but the success of the process was discouraged by the initial cost, $175,000 per machine, and the radical changes required in operating techniques. [111]

One company that benefited from Properzi's invention was the Southwire Co. In 1937, Roy Richards founded a successful electrical construction company after graduating from Georgia Tech, stringing 3,500 miles of power lines as the second largest Rural Electrification Administration contractor. Construction stopped during World War II, but when Richards returned he discovered a wire shortage and decided to get into the wire-manufacturing business. Southwire was formed in March 23, 1950, with 12 employees. By 1952, the company had shipped 2 million pounds of wire that was made by welding lengths of aluminum rod end to end. The result, however, was a friable product. Richards then bought a continuous-casting and rolling machine from Properzi. With improvements by his company engineers, the company developed the Southwire Continuous Rod method that continued to be used years later to make about half of all copper rod for wire and cable. In 1967, Southwire opened six manufacturing plants, an aluminum smelter in Hawesville, Ky., and a copper refinery. New aluminum alloys were developed for building wire in 1968. Richards died in 1985 and his son took over the company. [112]

War research can go in many directions – rockets that eventually put a man in space, atomic weapons that are later turned into power plants. In 1942, Reynolds Metals executive vice president Julian Reynolds, son of the company's founder, began to develop the concept of an all-aluminum submarine. At 34, Reynolds was head of the company's foil division, which accounted for 64% of the company's sales before World War II. The company played an active role in the U.S. war effort, but the all-aluminum submarine project did not materialize again until 1964, when Reynolds had the Electric Boat Division of General Dynamics in Groton, Conn., build the world's first all-aluminum submarine – the Aluminaut. The 80-ton, 51-foot manned deep-ocean research vessel was based in Miami, Fla., and was operated by Reynolds Marine Services from 1964 to 1970. [113]

The Aluminaut's large size relative to other deep-ocean research vessels allowed it to carry a crew of three along with three or four scientists. The submarine was made from 11 forged cylinders that were 6.5 inches thick and capable of withstanding 7,500 pounds per square inch. The initial design work was done at the Woods Hole Marine Station in Massachusetts, and a full-scale wooden mock-up was built to engineer the interior spaces. First tested in 1956, the project was classified top secret. In 1966, the Aluminaut was used to find a 1.45-megaton thermonuclear bomb that was lost in the Mediterranean Sea when a B-52 crashed near Spain. The bomb was found by the deep sea submersible Alvin and brought up intact. The Aluminaut was used to salvage the Alvin in September 1969 after the Alvin sank in 5,000 feet of water in October 1968. Through its career, the Aluminaut performed work for the Navy and helped Jacques Cousteau make movies. It reached depths of up to 6,000 feet while working for the U.S.

Naval Oceanographic Office. The Aluminaut was retired in 1970 and was donated by Reynolds to the Science Museum of Virginia in Richmond, Va., where it was put on permanent display. [114]

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