Career of a metal:
Looking back at 66 years of titanium production in Germany

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Authors:

Born in 1942, graduate engineer Dietmar Fischer worked in the German titanium industry for almost forty years. His career started at Contimet and, following its merger with the titanium division of Krupp, continued at Deutsche Titan GmbH. Thereafter, he was the head of the ThyssenKrupp Titanium technical division, and today he is a technical-scientific management consultant in Geldern.

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Oliver Fischer

Abstract

In 1949, large parts of Germany still lie in ruins, when a small group of engineers and technicians set to work in Essen on a material unfamiliar to most people: titanium, the new miracle metal from the USA, which is ideally suited for constructing airplanes and chemical plants. The four men from the Krupp Group know only very little about producing and processing this metal which - until recently - was only considered a laboratory oddity. They experiment with furnaces which they built themselves, and acquire basic knowledge of the melting, forging and rolling of titanium.

In fact, they already start with commercial production by the end of the 1950s. At about the same time, Contimet, a subsidiary of Deutsche Edelstahlwerke that is located in Krefeld and is partially owned by the American company Timet, starts supplying customers. Both companies-which merge to Deutsche Titan in 1988 – rapidly become one of the most important suppliers on the European market. They supply semi-finished products and alloys to the chemical and aviation industry on a large scale. German titanium is found in space on the fuel tanks of the International Space Station (ISS); on oil rigs off the coasts of Scotland and Norway and in the mammoth Hassan II mosque in Casablanca. A success story that only ends when, from 2010 onwards, the parent company, ThyssenKrupp, slithers into a crisis which threatens its very existence.

Following numerous hectic changes of ownership, and after almost seventy years, the final owners VDM Metals announce the end of titanium operations in the spring of 2016.

The Story

Eight words were enough to end 66 years of history: "VDM Metals discontinuing titanium production at Essen location," says the press release headline received by the employees of the plant in Westendstraße in the middle of March 2016. The managers state that the plant has not been running profitably for years. And, due to low titanium prices and the generally "competitive situation with regard to raw materials" no improvement is anticipated in the foreseeable future either. A decisive turning point for the 75 employees and, at the same time, for Germany's industrial history: with the Essen plant, the last titanium producer in the country is closing down - only one kilometre away from the location where the production of this material in Germany once began.

1. The pioneers of Harkortstraße

In August 1949, the month of the first post-world war II parliamentary elections, a few men came together in Essen's Harkortstraße for a meeting in the research institute of WIDIA Tungsten- carbide factory (**Wi**e **Dia**mant), which was owned by Fried. Krupp. Back then, large areas of the city are still in ruins, and significant parts of Krupp's industrial facilities have been disassembled by the Allies. WIDIA factory is one of only a small number of Krupp operations where work is still possible.

The men want to confer about titanium - the metal that is currently booming in the USA. In the United States of America, it is considered a material of the future, as it doesn't rust and is hardly attacked by chemical substances. In addition, since it has a low specific weight, in combination with high mechanical strength, it is very well suited for manufacturing aircraft or submarines – important products during the Cold War, which is why the

government in Washington supports titanium production with tax rebates and credits.

The new material also appears promising for the WIDIA employees: during their conference, they decide to commence first investigations regarding working with titanium. The engineer Helmut van Kann † starts an intensive study of the research literature. In the WIDIA research institute's laboratory, he starts preliminary trials with the metal.

As of 1951, he is supported by a team of four technicians. The small group's work is arduous: it is merely twelve years ago that the Luxembourg researcher Wilhelm Kroll† developed a commercially useful procedure, by means of which pure titanium can be obtained from the titanium oxide of the minerals rutile and ilmenite. However, there is hardly any experience on how the thus obtained, loosely formed, titanium sponge can then be melted into ingots, as required for further industrial processing. All the processes that are standardised about a decade later are now first being developed and put to the test.

The men in Essen have to do pioneering work. Following first trials to manufacture titanium sponge themselves, as of 1951/52, the decision is taken to concentrate instead on the further processing of titanium sponge that can already be sourced externally. One employee of the titanium team constructs a small skull melter furnace in the laboratory. Only small one kilogram ingots can be produced in this unit. However, the men were able to acquire "fundamental knowledge of titanium melting," as is subsequently stated in a company chronicle. In 1953, they design a second furnace in which they can initially melt 25 kilogram ingots and, later on, 100 kilogram ingots.

One of the pioneers' greatest challenges: intensely heated titanium rapidly reacts with other substances. It bonds quickly, especially with the atmospheric elements nitrogen, oxygen and hydrogen, resulting in it becoming very brittle. For this reason, a

vacuum or inert gas atmosphere is required in the melting furnace. Since the hot metal would also react with the copper crucible, its wall was continually cooled with water from the outside.

Another problem: the heat in the melt furnace is generated by an electric arc that burns between the crucible bottom and an electrode made of tungsten. However, thermal pressure often results in tungsten splintering, which causes minute crumbs and reactions that contaminate the titanium blocks.
The men in Essen search for a material to replace the electrode, study specialist articles and probably find the solution in American literature: the titanium itself must become an electrode. With this procedure, which has been deployed in the USA since about 1945, the entire titanium sponge is pressed to so-called compacts at room temperature and fused to a rod. As such, a titanium electrode weighing hundreds of kilograms is obtained. Workers hang these into the furnace, creating a high vacuum, and ignite the electric arc between the furnace bottom and electrode. By means of the arising high temperatures, the electrode itself melts away within several hours.

To be in a position to use this procedure for larger amounts of the material, WIDIA's experts commission a furnace from Heraeus in Hanau, which goes into operation in 1957. Now, blocks can be produced with a weight of up to 800 kilograms. Enough to finally enter the large-scale commercial production market which, apart from the production of the ingots, also includes further processing into semi-finished products, to metal sheets, rods and tubes.

In the years prior to this, and with the purpose of promoting the new material, Helmut van Kann† and other WIDIA engineers held lectures and visited potential customers. They exhibit at the Paris Air Show in Le Bourget in 1955 and present a 50 kilogram titanium slab at the Hanover Fair in the same year. A company report notes that the public reacted with "great interest, in theory". Initially, though, no orders are placed.

Nevertheless, at least the visit in Paris appears to have been worth the effort: one year later, the French aircraft manufacturer Dassault orders titanium sheets from WIDIA – the team's first real order (prior to this, there were only trial deliveries, for instance to BASF). However, due to insufficient pickling bath depths, the people in Essen have great difficulties delivering the sheets in the correct thickness. Hence, they have to send back the order placed by another aircraft manufacturer in the following year.
In 1957, the titanium production is outsourced from the research institute and from that time as a production site of Widia.
Now, commercial production commences at the beginning of 1958: the Bavarian chemical company Wacker approaches WIDIA and orders pipe work components for a test facility for the production of acetaldehyde. Clearly satisfied with the first deliveries, a few months later, Wacker commissions WIDIA once again, this time with a significantly more extensive project: the construction of a large acetaldehyde facility for their new plant in Cologne-Merkenich. With equipment produced in their own factory, the people in Essen have to come to grips with a number of initial difficulties during construction. They constantly encounter problems with the welding of the highly reactive material. However, when the facility becomes operational about one year later, it is proven: titanium is suited for large-scale deployment in the chemical industry.

Due to the orders placed by Wacker, titanium production increases to 16 tons in 1959 - four times the volume of the previous year. The titanium division generates profits for the first time. Shortly thereafter, more orders are received from other chemical companies, for instance the French Rhone-Poulenc Group. To be added to this are orders from suppliers to the chemical industry such as the equipment manufacturer Klaus from Bochum, which produced titanium pumps.

Thus, in 1960, WIDIA's production increases once more to now 24 tons per year, and the company again generates profits. However,

apart from competitors from abroad such as the British IMI, a German competitor that – as is recorded in a company chronicle – is “exceptionally active”, now also makes itself felt and “has demonstrated remarkable success”: Contimet GmbH from Krefeld, a subsidiary of Deutsche Edelstahlwerke, in which the Thyssen group has a majority interest.

2. USA meets the Lower Rhine: the competitor from Krefeld

The engineers in Krefeld started work on titanium slightly later than those in Essen: as of 1954, employees of the Edelstahlwerke research institute started familiarising themselves with research literature. They, too, initially built a small vacuum arc furnace in the laboratory before ordering larger melting equipment from Leybold that can be used to produce 250 kilogram ingots.

When compared with the competitors in the Ruhr region, they have one great advantage: Deutsche Edelstahlwerke has outstanding business contacts with the American Allegheny Lludlum (ALS) steel manufacturer. Together with the National Lead Corporation, each holds a fifty per cent share in the 1950 founded Titanium Metals Corporation of America (TMCA), with its headquarters in N.Y., the company that soon becomes well-known under the acronym TIMET and goes on to become the largest titanium manufacturer in the United States of America.

In 1957, the Krefeld employees and their American colleagues start talks regarding intensified cooperation. An Edelstahlwerke employee flies to the USA, spending several weeks there, visiting TIMET laboratories and facilities, and getting to know state-of-the-art titanium production.

On his return, Edelstahlwerke and TIMET found a mutual company for the European market. On 30 July 1958, Continental Titanium Metals Corporation starts business and soon becomes well-known as Contimet - an abbreviation for “Continental Timet”.

The young engineer Klaus Rüdinger †, who already worked in the research institute, was the technical manager of the joint venture. He goes on to head the company for thirty years and, thanks to numerous scientific papers, advances to one of the most renowned German experts on titanium.

The company headquarters is located on the Edelstahlwerke premises in Krefeld. At this time, Rüdinger †and his team do not have an own melt furnace at their disposal (apart from the small melt facility in the research institute). TIMET supplies the raw ingots from the USA; the Germans process them to semi-finished products (flat and long products), either in Krefeld or in other group facilities.

The "exceptionally active" Contimet employees rapidly acquire their first customers such as the steel and tube manufacturer Benteler or the equipment manufacturer Canzler from Düren. They are particularly successful with aviation industry companies. From the end of the 1960s, Contimet sells titanium to Rolls-Royce for the front fan unit of the jet engine RB 211 which, for instance, propels the Lockheed TriStar. Contimet also supplies aero engine manufacturers such as Snecma and Turbomeca in France.

During the East-West conflict, numerous orders were also received for armaments projects, for instance for the MRCA Tornado jet fighter: with the combat aircraft, which was built from 1973 on, the so-called wing boxes - in which the pivoting wings are mounted - are made of alloyed titanium. Then they work on numerous additional Tornado parts, which place high demands on the engineers. (Competitors from Essen are also involved in the Tornado project; representatives from both companies frequently consult with the developers of Messerschmitt-Bölkow-Blohm (MBB) in Ottobrunn).

The Eurofighter also flies with titanium from Krefeld. The metal used for its engine, the EJ 200 compressor, is constructed by MTU. Titanium from Contimet is used for almost all aircraft models,

whether for military or civilian purposes. . Rüdinger and his employees supply material for the Airbus product range, Boeing and the French or Italian aircraft manufacturers.

Otto Fuchs in Meinerzhagen goes on to become a particularly important customer. In the meantime, the Essen based titanium pioneer, Helmut van Kann, has commenced work here and built up the manufacturing of die forgings made of titanium - a semi-finished product that is among others essential for the production of turbines and other aircraft parts that are subject to great stress.

By the end of the 1960s, Contimet is already receiving so many orders that its shareholders have an own smelting furnace built. Within a mere ten months, a 7,000 square metre hall is erected for the new facility: a 2-station vacuum arc furnace by Heraeus, with consumable electrode.

It was the first furnace of its kind worldwide, in which a new cooling system was deployed: instead of cooling with water, the melting crucible was cooled by a NaK eutectic, a mixture of sodium and potassium. The operators wish to use this to increase the facility's safety: when water enters the furnace through a leak, steam is created in the presence of liquid titanium, hydrogen and oxygen. This leads to the formation of titanium dioxide and detonating gas - a mixture that can result in a highly dangerous explosion. The NaK eutectic mixture, however, does not react with the metal - and thanks to this and other safety precautions, there never was any significant accident in the Germany titanium industry.

In the new plant, ingots weighing 7,000 kilograms can be produced. Apart from ingots consisting of pure titanium, around eleven different alloys with "Contimet" as brand name are manufactured, thus titanium that is melted with small amounts of another metal. Aluminium made the material harder and Vanadium increased the ductility. In the majority of cases, the Krefeld-based company purchases the titanium sponge raw

material that is needed for its production in Japan or the Soviet Union.

In the following years, the name and owner of the company frequently changes: in 1973, TIMET withdraws almost entirely from Contimet. One year later, Contimet is integrated into the German parent company: “Contimet GmbH” becomes the division “Contimet Titanbetriebe” (titanium operations) of Deutsche Edelstahlwerke or, as of 1975, Thyssen Edelstahlwerke.

The Krefeld employees remain highly innovative. Whilst the concept of recycling only slowly starts taking hold in West-German society in the seventies, Contimet is already proactively putting it into practice. To be in a position to recycle titanium scrap, as of 1977, Rüdinger has cleaned scrap parts assembled to an electrode in a plasma welding device and, with or without the use of sponge compacts, has these remelted in an electric arc vacuum furnace. Thus, from 1977 to 1981, the share of scrap used in the production of blocks increases from 5 to 13 per cent.

In 1981, Contimet also commissions the construction of a pre-melting furnace mainly for titanium scrap, a fixed copper electrode, the design of which is patented in the USA. Since the NaK cooling was constantly causing problems in the course of daily work, the company management decided to once again use water for cooling the melting pot of this furnace. Due to significantly greater safety precautions and thanks to intensive training of the employees in their dealings with this equipment, the risk of explosion – when compared with that of previous ovens – was reduced considerably.

In the new facility, the treated scrap is consolidated to a stable electrode with titanium sponge and alloying elements, after which it is remelted one or more times in the vacuum arc remelting furnace (VAR). This was thus significantly less labour intensive than the process of painstakingly welding the scrap parts by hand. By 1987, the recycling share increases to more than 40 per cent.

3. Between boom and recession: the battle with the economic situation.

Since the construction of the large smelting furnace in 1970, apart from the Essen producers, Contimet is the second titanium producer of the federal republic. The market is effectively divided up: whilst Contimet generates about 80 per cent of its turnover with deliveries for the aviation industry, its Ruhr colleagues deliver mainly to the chemical industry and its suppliers.
In the meantime, however, the Essen-based company has separated from the WIDIA factory: since 1961, organisationally, it is part of Krupp's forging and foundry. In 1969, it also moves to another location away from Widia, from Harkortstraße to Westendstraße, thus on the traditional Krupps plant grounds, on which the huge cast steel factory was located around 1900.

At the time of the move, the titanium division has about 50 employees. One of the managing directors is the engineer Willy Knorr †, who attracts attention with numerous internal and external publications.

He and his employees melt titanium in a 1966 Heraeus-constructed vacuum electric arc furnace. Ingots with a diameter of up to 1,000 mm and 10 tons in weight can be produced. They sell their products under the "Tikrutan" (for Ti-Krupp-tan) brand name. Apart from pure titanium, they also offer a variety of different alloys such as, for instance, Tikrutan LT31. With 6 % aluminium and 4% vanadium, this is the most important aircraft alloy to this very day.

The pump manufacturer Klaus remains an important customer. Additional customers are the equipment manufacturers Schiller from Essen and Vallourec, a French steel manufacturer that manufactures longitudinally welded pipes from cold-rolled titanium strips, used among other things for heat exchangers and coolers of power plants.

Although both companies long since have a fixed customer base, orders and profits fluctuate greatly: in the aviation industry, an economic boom is frequently abruptly followed by a recession. Thus, it is hard to anticipate the orders from this important industrial sector and, as a result, there is often too much titanium on the market. This, in turn, results in prices falling, whilst the manufacturing costs remain consistently high, also due to the considerable energy consumption of the furnaces.

The Germans also lack what makes their competitors in the USA and the Soviet Union strong: large-scale military orders. From 1960 on, for instance, the Soviet Navy has numerous Alpha class submarines built. Per submarine, about 2,000-3,000 tons of titanium is required for the pressure hull - almost as much as a whole year's production for the Essen- and Krefeld-based companies. The orders for the Tornado or Eurofighters do not even come close in compensating this difference.

Thus, for quite some time already, the company executives of Thyssen and Krupp consider merging their forging activities. When, in 1988, Vereinigte Schmiedewerke VSG decides to merge the titanium operations under this umbrella as well, the Contimet and Krupp titanium division is now Deutsche Titan GmbH.

4. A marriage but not made in heaven: the merger of 1988

The new company commences work on 1 March 1988. The company headquarters are located in the production facility of the Krupp employees in Westendstraße in Essen. The Krefeld location is given up, and the furnaces there are sold to China.

Now, about 170 employees work for the company. The majority of the customers to date are retained; the company now receives about the same amount of orders from the chemical sector and the aviation industry. Apart from this, as already their predecessor companies, but on a smaller scale, they deliver to medical

companies that make hip joints or bone screws from the highly biocompatible metal.

Deutsche Titan products are soon to be found at a great variety of different places: deep in the human body as a pacemaker, high up in space, on the fuel tanks of the international space station ISS, on the oil rigs off the coasts of Scotland and Norway or in the mammoth mosque of Hassan II in Casablanca, the portals of which contain 30 tons of titanium from Essen. The doors of the structure which is located directly by the Atlantic coast are to be protected from the moist sea air.

After difficult years, on the first of May 1994, VSG reorganises with four independent business divisions, including Deutsche Titan.

Nevertheless, in the mid-nineties, VSG is bankrupt and Deutsche Titan falls into economic difficulties. For this reason, the management establishes contact with the Italian manufacturer Titania SPA in Terni, a subsidiary of the stainless steel producer AST, in which the Krupp Group in turn holds a share.

In 1996, the Italians take over Deutsche Titan. Under the management of Titania CEO, Marco Stoppoloni, both companies can utilise synergies: Deutsche Titan mainly produces ingots, slabs, long products and flat products for the aviation industry, whilst the Italians concentrate on cold- and hot-rolled flat products made of pure titanium.

At Deutsche Titan, Dr Markus Holz takes on the position of spokesperson of the management board in 1999 and, as of 2006, is also on the executive board of Titania. Fuelled by the economic boom in China and that of the New Economy, Deutsche Titan was then to experience some of its best years. Essen receives more orders than ever before. The orders for the new Airbus A 380 mega liner are particularly lucrative. For instance, Deutsche Titan delivers parts for the brake system, also for the engines that are

manufactured by Rolls-Royce and General Electric / Pratt & Whitney. It also manufactures materials for the new Boeing 787, the Dreamliner. During this time, the Essen-based company produces a total of 4,000 tons of titanium ingots per year.

And, according to Holz and his engineering team, it is set to become even more. Thus, they take the decision for a large investment: they have two new melting furnaces built for 30 million euros. At 2005, initially, a new vacuum electric arc furnace is commissioned, which supplements the two old furnaces from 1966 and 1982.

The most spectacular project, however, is the construction of an electron beam furnace. A large new hall of approx. 3 500 m^2 is erected especially for this facility. After about two years of construction, the most modern titanium melting facility produced the first ingots end of 2007 and is later inaugurated on 15 October 2008 by the mayor of Essen: instead of the 7.5 ton ingots that were produced until then, it can now produce 15 ton ingots and slabs - and this up to two times per day. The company, which in the meantime is called “ThyssenKrupp Titanium GmbH”, has 25 new employees for the operation and maintenance of this furnace. The total workforce of the Titan Group consists of 140 employees in Essen and another 130 employees in Terni.
However, already while the inauguration is being celebrated in Essen, the good times are coming to an end. Only two weeks prior to this, the Lehman Brothers Bank went bankrupt in New York. What starts with a real estate crisis in the USA, now increasingly turns into a global economic crisis – which also has a detrimental effect on the aviation industry, which is so important for the Essen-based company.

“Negative changes, especially in the aviation industry,” the company’s final report of the 2007/2008 fiscal year states. Apart from decreasing passenger numbers due to the economic downturn, the report also mentions technical problems that Airbus and Boeing are having with their wide-body aircrafts. This

leads to “delayed acceptance of titanium volumes that are already in production”, as well as “increased stocks”. In this year, gross proceeds decline by more than two million euros. At this time, military projects such as Eurofighter, Transporter Airbus 400M and helicopters such as the Nato Helicopter NH 90 are also delayed.

An annual report from 2009 also complains about declines in aviation industry orders and high stocks - the titanium people have a hard time getting rid of their products. Furthermore, the very existence of the parent company, ThyssenKrupp, is threatened due to bad investments made when constructing a steel mill in Brazil.

The group is hectically restructured and entire divisions are sold. In 2009, the group executives merge ThyssenKrupp Titanium GmbH with VDM, which was also part of the company and specialised in nickel alloys. ThyssenKrupp Titanium is disengaged from Titania SPA and, ThyssenKrupp sells VDM together with the titanium division to a Finnish steel concern in 2013. It buys it back again in the following year, after the Finns get into financial difficulties. In September 2015, it sells VDM Metals once again, this time to a group of financial investors. From the outset they make it clear that they only see a slim chance of the titanium division making a profit, which hasn’t made any profit for five years: as the only plant of VDM Metals, the company in Westendstraße gets no location guarantee from the new owners.

They search for a partner or buyer for the titanium company for several months and, according to their own statement, they speak to more than 70 companies. However, they find no matching offer.

And so, on 10 March 2016 - less than half a year after the change in owners - they issue the statement that means the end of the German titanium industry.

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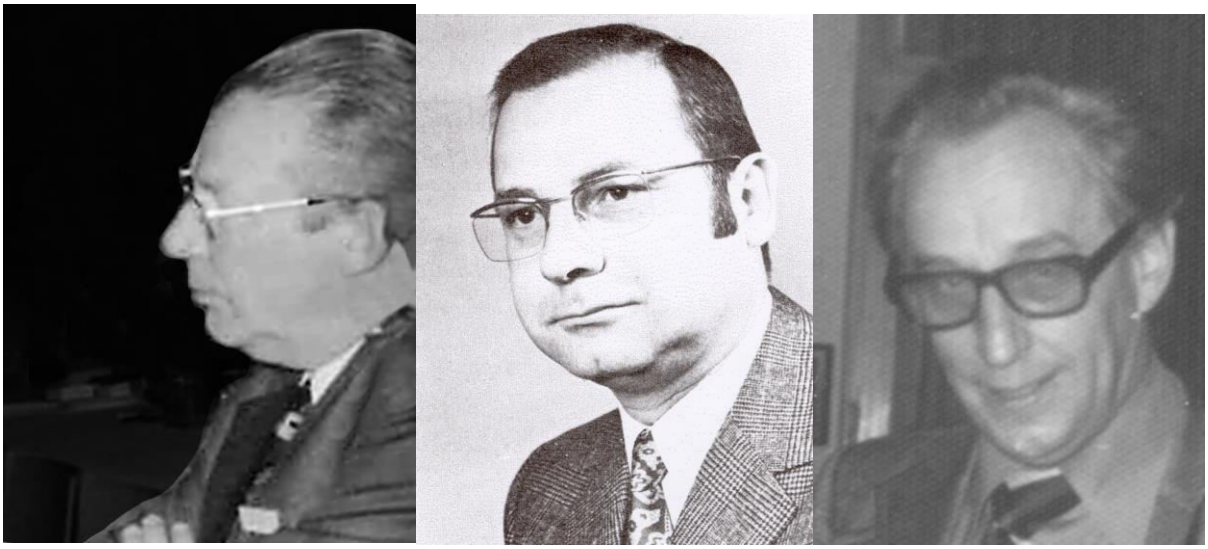


Source: own archive

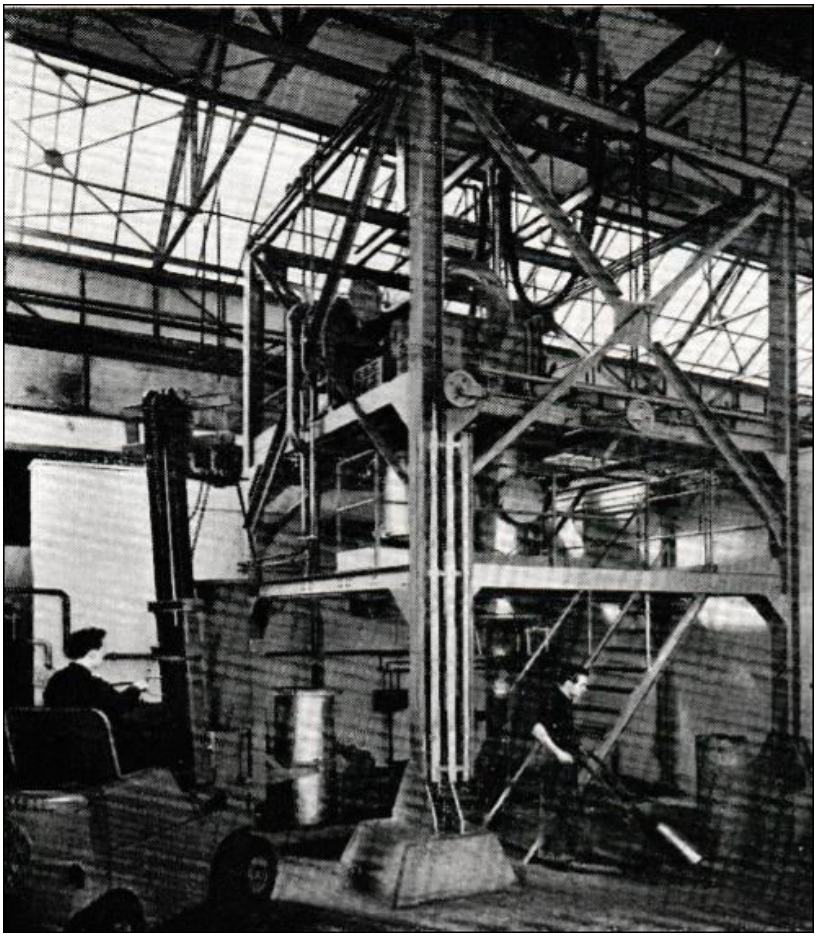
Dr.Hans van Kann† Dr.Klaus Rüdinger † Dr. Willy Knorr †

The three Titanium Pioneers from Krupp, Essen and Contimet*, Krefeld

(*DEW/Thyssen Edelstahlwerke)

Source: own photo

The address where everything has begun!



Source: own archive

Vacuum Arc Remelting Furnace VAR of Fried.Krupp Schmiede und Giesserei, Essen

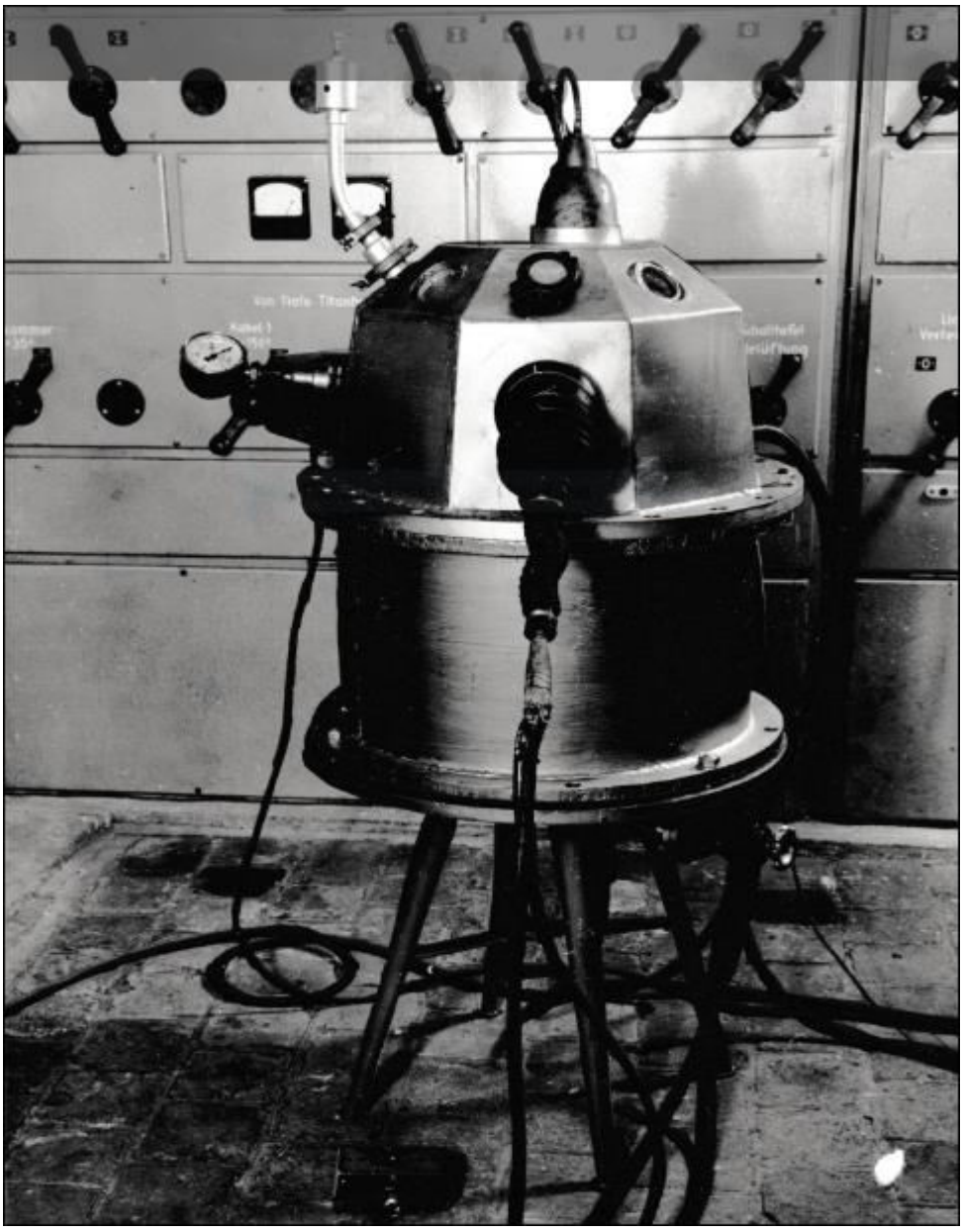
Heraeus VAR furnace from 1957 in operation, has produced ingots up to 800 kgs

Source: own archive

So-called double stick melting procedure to duplicate finally the ingot weight by the needed

Double molten VAR Ingots produced in modern computer process controlled furnaces of ALD Vacuum Technologies, Hanau
Ingot weight 6-8 tons
ThyssenKrupp Titanium Essen, ~2006

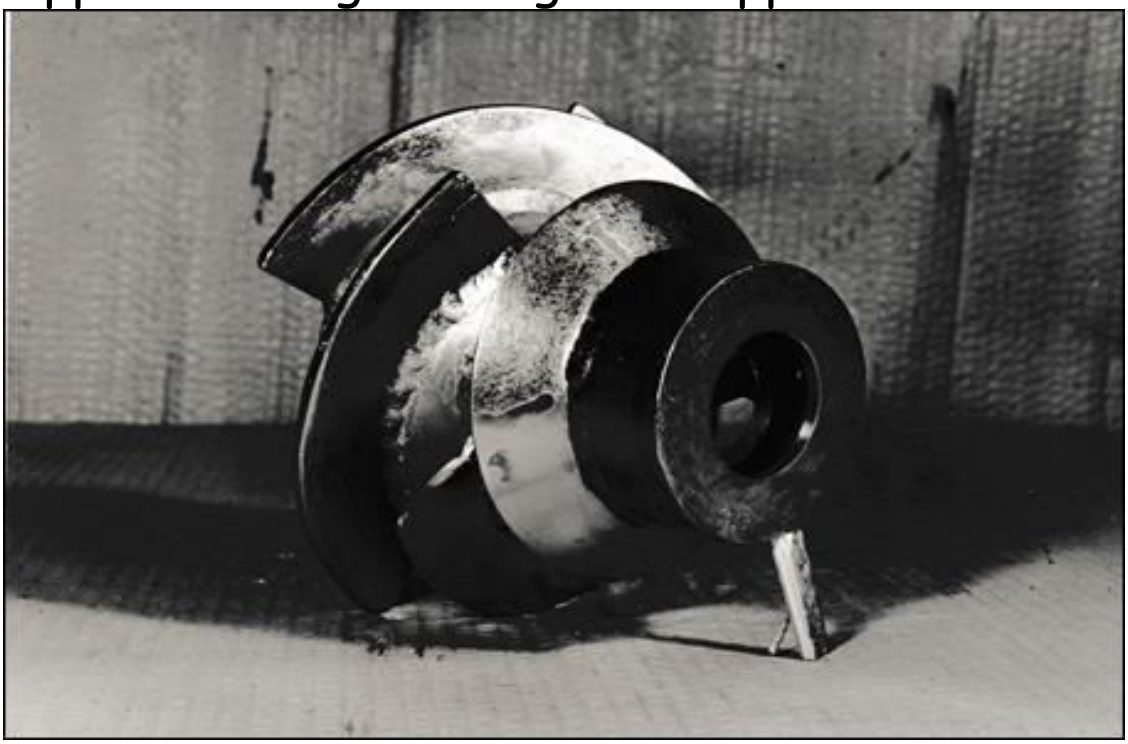
Source: own archive



Source: own archive

Welding Chamber for parts to be welded under Argon or Vacuum to protect from air
Krupp~ 1960

Welded stirring wheel of Titanium made by Apparatus Engineering of Krupp ~1960



Source: own archive

Set of Valves of Titanium "Forged and welded" Apparatus Engineering~1960 of Krupp

Source: own archive

Widia with different semi-finished parts from Titanium showed on diverse exhibitions in the fifties and sixties

Source: own archive

Source: own archive

Working Group of ETTC "Technical Committee of European Titanium Producers" 1975-1989

Committee members left to right:

Yves Michaud, Cezus Ugine
Dr. Knut Hülse, Schmiedewerke Krupp-Klöckner
Dr.Karl-Heinz Kramer, Schmiedewerke Krupp-Klöckner, Essen
R.E. Goosey, IMI Titanium Ltd., Birmingham
A.C. Barber, MD IMI Titanium Ltd., Birmingham
Dr. Klaus Rüdinger†, MD Contimet GmbH, Krefeld
Dipl.-Ing. Albert Ismer †, Contimet GmbH, Krefeld
Dipl.Ing. Dietmar Fischer, Contimet GmbH Krefeld

source: own photos

Titanium Production Hall ca. 3 500 m² work surface for the Electron Beam Melting Furnace, Westendstrasse 15, Essen

Source: ALD

3 600 kW, 6 EB Gun Cold Hearth Electron Beam Melting Furnace of ALD Vacuum Technologies for melting Slabs and Ingots from scrap, Titanium sponge and alloying elements, ThyssenKrupp Titanium, Essen 2007

Source: ALD

Titanium Slab after Electron Beam melt process withdrawn the copper crucible, around 10tons weight, ThyssenKrupp Titanium, Essen, 2007

Titanium
From the Beginning to the End of
A Wonderful Metal in Germany

Fried. Krupp Widiafabrik, Essen
R&D Titanium, 1949-1961

Fried. Krupp GmbH Schmiede und Giesserei, Essen
Krupp Metall-und Schmiedewerke, Essen
Krupp Stahl AG, Schmiede und Bearbeitung, Essen
Schmiedewerke Krupp-Klöckner GmbH, Bochum

1988 Fusion of Contimet GmbH, Krefeld

(R&D Titanium 1955 and Company start up 1958)
and
Schmiedewerke Krupp-Klöckner GmbH, Bochum
to
Deutsche Titan GmbH, Essen

(subsidiary of Vereinigte Schmiedewerke, Bochum 1988- 1995)
1999 incorporated into Titania S.p.A. Terni, Italy, an affiliate
of Thyssen Krupp Stainless

2007 ThyssenKrupp Titanium, Essen- ***new name-***
takenover by
2009 ThyssenKrupp VDM GmbH (Inoxum subsidiary), as
Titanium site without Titanium SpA, Terni, Italy
2012 Sold to Outokumpu VDM Metals GmbH, taken back
2013 by Thyssen Krupp Stainless

2015 VDM Metals GmbH, Werdohl, acquired
- by Privat–Equity- Lindsay- Goldberg Fonds, NY-

2016 -The End-