

Patented Sept. 29, 1925.

1,555,313

UNITED STATES PATENT OFFICE.

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PROCESS OF MELTING AND DEGASIFYING METALS UNDER REDUCED PRESSURE.

No Drawing.

Application filed March 6, 1920. Serial No. 363,916.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

To all whom it may concern:

Be it known that I, WILHELM ROHN, a citizen of Germany, and resident of Hanau, Germany, have invented new and useful Improvements in Processes of Melting and Degasifying Metals Under Reduced Pressure, of which the following is a specification.

It has been often suggested to melt metals under reduced pressure in several cases, and this suggestion also has been executed but mainly for experimental purposes and in laboratories. It has also been tried to apply the results obtained by such researches to practice, in particular for the purpose of improving certain metals for special purposes. Heretofore, however, it has not been known that such experiments have led to a practical result in industry, neither has it become known in trade that metals treated after such processes have been used on a commercial scale. The said experiments and researches have therefore well improved scientific knowledge but have not advanced technical progress.

These failures were caused by the fact that the experiments were based on an insufficient knowledge of the inevitable conditions of working and on inadequate knowledge of the physical and metallurgical properties of the metals to be treated.

By very extended and costly experiments and scientific research the inventor has extended considerably the knowledge in this direction and has, by his invention, forming the subject matter of the present application, rendered it possible to utilize the results of his discoveries in practice.

For instance, the inventor has subjected soft commercial ingot-iron to the new melting process. The technical improvement obtained thereby will become apparent from the following test results. The commercial iron showed a Brinell hardness of 93. After having been remelted and submitted for one hour to a pressure of 1 millimetre mercury column, the iron showed a Brinell hardness of 72, after a second sample had been remelted and submitted to the same pressure for a period of 3 hours, the Brinell hardness fell to 63. Before and after the melting the chemical composition differed but immaterially.

Samples of the original material and of

the second before mentioned melting as well as of electrolytic iron melted according to the invention were rolled and drawn into wire under exactly equal conditions. For ensuring absolutely unimpeachable results the drawing was done through a diamond drawing stone; the diameter was reduced from 1.9 to 1.82 mm.

The original material required a force between 12 and 13 kilogrammes and the remelted material a force between 9 and 10 kilogrammes. The electrolytic iron required a force between 8 and 9 kilogrammes. The process, forming the subject matter of the present application thus renders common commercial iron by a single melting almost equal to the high quality electrolytic iron as regards softness and ductility.

The present application relates to the general method according to which it will be possible to produce metals of very superior qualities which hitherto could not be produced in a general commercial manner. Applicant's co-pending applications, Serial Numbers 364,602; 364,603; 365,321; 365,684 and Serial Number 432,308, induction furnace, described the novel manner in which this general method is used to produce entirely different metals and alloys of very high purity and extraordinary chemical, physical and mechanical properties, and the latter application described the novel furnace which enables the practical and commercial working of the new processes described.

The present invention refers to metals, alloys of metals and their compounds with metalloids, and is based on the recognition of the following observation:

Until now the suggestions for melting under a vacuum proceeded from the idea of producing a certain vacuum in the melting furnace.

The vacuum was intended to prevent the formation of visible blow holes in ingots and castings and was also intended to withdraw the air, whereby the oxidizing effect of the oxygen was to be obviated.

This proposal did not consider that most metals and alloys expel besides dissolved gases, also such gases which are formed during the melting and the heating, or during the cooling or even during solidification.

It had not been considered that these various gases escape at different pressures in the melting furnace, sometimes even only under a perfect vacuum, and that, in particular with gases which appear only at the solidification, it may be necessary to remelt the metals twice or three times, to ensure a complete withdrawing of the gas. It had not been considered that not only microscopic but also microscopically ascertainable gas inclusions and lastly also microscopically not ascertainable, viz submicroscopical gas inclusions may to a wide extent decrease the quality of the metals, and that therefore an industrially useful process should consider all these conditions.

If all these gaseous inclusions should be removed, a melting apparatus had to be designed, which would allow or provide any desired pressure in the furnace and to maintain such pressure for any length of time, in other words, the melting apparatus must be practically absolutely gastight, as else it would be impossible to permanently maintain a given vacuum, or to produce so high a vacuum, that also the submicroscopical gas inclusions were removed.

The apparatus heretofore suggested for industrial purposes were not practically perfectly airtight. The consequence was that in exhausting the air in allowably large quantities of air were sucked in through even the finest leaks, and this air unfavourably affected the melting process.

Instead of excluding the injurious action of the oxygen of the air, this action was even increased. The intention, expressed in the hitherto made proposals to exclude the air, besides securing the emerging of the dissolved gases could not be realized because the continually entering fresh air continuously reacted on the metal bath and incessantly caused gases to be produced in the metal by metallurgical processes and to be dissolved therein. These incidents were until now not sufficiently recognized, and were the reason, why all suggestions heretofore made for melting metals and the like under reduced pressure have not led to an industrial and commercial success.

The present invention consists primarily in submitting the metals to be treated to the melting in a practically absolutely airtight melting furnace and at a constant reduced pressure which may vary from one thousand grammes per square centimeter to practically nil, according to the purpose intended.

The invention is, furthermore, based on the following observation:

The suggestions heretofore made for melting in an evacuated furnace were restricted to melting and heating the metals beyond their melting points, and to exposing them thereupon or simultaneously to the influence of a lower or higher vacuum.

These suggestions did not consider that most metals contain gases not only in a cold state before the melting, but that also during the heating, the melting, the further heating and the cooling down gases are generated, dissolved and expelled again, and that such processes proceed at greatly differing temperatures and pressures.

To degasify metals by melting them under reduced pressure, it will be necessary, in so far as their properties when in molten state are not fully known, to ascertain by experiment, at which temperatures gases are generated and at which temperatures dissolved gases are expelled. These temperatures being ascertained the respective metal can be obtained continuously with the same good qualities by treating it at the said temperatures. For example, an alloy of nickel and chromium which had been melted according to the process forming the subject matter of this invention at a pressure of 1 mm. mercury column and 1440° centigrade after previously showing a liberal evolution of gas remained quite calm and apparently free of gases. When subsequently worked, the metal showed bad qualities and tended to crack. The same alloy being then melted at varying pressures and temperatures, it was found that at a pressure of 3 mm. mercury column and a temperature of 1460° centigrade a second, very violent emission of gas occurred. The product of this melt was, on being worked, found to be perfect. All the numerous alloys of the same composition melted since that time were melted at 1460° centigrade and 1-3 mm. mercury column pressure. They all had a second emission of gas and subsequently showed all the same, unexpectedly good qualities.

In all cases in which gases are emitted or produced during the solidification the metal bath must first be cooled down to a temperature, at which the said gases are emitted. Thereupon the metal should be remelted and the gases liberated be drawn off. With a few metals and alloys it is necessary to repeat such remelting. With iron, for instance, a repeated melting may be necessary in all those cases, in which the perfect chemical equilibrium between all components both in liquid as well as also particularly in viscous and in solid state not yet had been attained after the first melting.

For example, an alloy of iron and cobalt will appear free of gas in the molten state; neither an increase of temperature nor a reduction of the pressure will be able to cause a further emission of gas. Only when solidification sets in, a lively emission of gas commences and will continue until the alloy is fully solidified. An immediate remelting will show neither a further emission of gas during the melting nor from

the molten meal, but only will allow the escape of the mechanically included gases of the first melting. A renewed solidification liberates no more gas, and the product shows in every respect freedom of gas, flawless and good properties.

The non-observance of the foregoing rules is responsible for the lack of any practical results.

The present invention consists therefore furthermore in first ascertaining for a given metal to be treated the temperatures which are necessary to ascertain the desired effect whereupon the commercial and industrial melting is carried out at the same temperatures.

This rule of working represents the best and most definite statement of the problem, because, on the one hand, every expert with some practical experience will be able to find the essential pressures and temperatures for any metal of interest to him, while, on the other hand, it is impossible to name for the large number of metals, and above all the infinite number of possible alloys, which all show a more or less different behaviour, within the limits of a patent application all their special properties and the rules and regulations covering them properly.

It is obvious that the two aforementioned rules for working must be simultaneously applied to all metals to be treated and that they supplement each other. It must be remembered that the emission of gas from the metal depends both on the pressure and on the temperature and that these two conditions can supplement each other.

It is known both in science and in practice that an ascertainable content of gas in metals has had an unfavourable influence on their quality. It has been shown by careful tests, that metals may also contain gases which could previously not be ascertained and that such gases will often unfavourably affect the quality of the metals to a still higher degree than the aforementioned gases. A process, which allows of removing all gases from the metals must therefore lead to a far reaching, heretofore never attained improvement in the quality of the metals. The process forming the subject matter of the present application enables such complete removal of all gases and represents therefore a highly important industrial and commercial improvement.

This importance is further increased by the fact that metals which have been freed from their gases through the present process will not again absorb gases impairing their quality even if they are again reheated for forging and rolling purposes.

What I claim is:

1. The process of melting and degasifying metal alloys and their compounds with

metalloids, consisting in melting these metals, under a reduced pressure in a practically absolutely airtight furnace under a constant pressure of any value between 1000 grammes per square centimeter and practically nil, according to the purpose intended and at a desired temperature, both temperature and pressure being made to act for a more or less long time according to the properties of the components of the alloy and thereafter subjecting the melt to successively different constant pressures and different temperatures.

2. The process of degasifying metals, metal alloys and their compounds with metalloids consisting in melting the metals under a reduced pressure in a practically airtight furnace under a constant pressure of any value between one thousand grammes per square centimeter and practically zero and at a predetermined temperature, both temperature and pressure acting for a predetermined period, permitting the melt to solidify and thereafter reheating said metals above the melting point to remove further gases liberated during solidification.

3. The process of degasifying metals, metal alloys and their compounds with metalloids, which consists in melting the same in a practically airtight furnace at a predetermined constant temperature and at a reduced constant pressure for a predetermined time interval, whereby to practically degasify such metal.

4. The process of degasifying metals, metal alloys and their compounds with metalloids which consist in subjecting the melt to a first treatment in a practically airtight furnace involving predetermined values of temperature and reduced pressure and thereafter subjecting the melt to a second treatment involving predetermined values of temperature and reduced pressure, at least one of which latter is different from the corresponding first value.

5. The process of degasifying metals, metal alloys and their compounds with metalloids which consists in melting the metal in a practically airtight furnace at a predetermined temperature and at a predetermined reduced pressure, both temperature and pressure being maintained constant for a predetermined period and thereafter subjecting the melt to a predetermined different temperature and predetermined different reduced pressure, both being maintained constant for a predetermined period.

6. The process of degasifying metals, metal alloys and their compounds with metalloids consisting in melting these metals under a reduced pressure, which pressure is constant and may be any value between one thousand grammes per square centimeter to practically zero and thereafter subjecting the melt to a different degree of reduced

pressure maintained constant for a predetermined period.

7. The process of degasifying metals, alloys and their compounds with metalloids
5 which consists in subjecting the melt to at least one melting at a predetermined temperature and predetermined reduced pressure in a practically airtight furnace, permitting the melt to solidify and thereafter
10 reheating the melt above the melting point to remove gases liberated during solidification.

8. A process for degasifying metals and the like consisting in melting the metals in a practically air tight furnace at a predetermined constant reduced pressure and at a predetermined temperature and thereafter
15 subjecting the metal to a second melting to drive out further gases.

In testimony, that I claim the foregoing
20 as my invention I have signed my name this 5th day of February, 1920.

DR. WILHELM ROHN.