UNITED STATES PATENT OFFICE.

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BESSEMERIZING OF COPPER MATTE.

943,280. Specification of Letters Patent. Patented Dec. 14, 1909.

No Drawing. Application filed October 1, 1909. Serial No. 520,565.

To all whom it may concern:

Be it known that I, ELIAS A. C. SMITH, a citizen of the United States, residing at Baltimore, State of Maryland, have invented certain new and useful Improvements in Bessemerizing of Copper Matte; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In an application for Letters Patent of the United States, filed by William H. Peirce and myself jointly, under date of June 13th, 1908, Serial Number 438,286, we have described at length certain new and useful improvements in the bessemerizing of copper matte in a converter having a non-corrodible lining, which improvements involve the maintenance of the desired reactions in the converter and the preservation intact of the converter lining as it expands and contracts under the changing heat conditions to which it is subjected, by conducting the air blast required for the blow through the non-corrodible lining and delivering it into the charge, while at the same time guarding it, during transit through the lining, against diminution of its volume and leakage into the body of the lining.

In carrying out, on a commercial scale, the bessemerizing of copper matte in a converter having a non-corrodible lining, and with the employment of an acid flux, I have ascertained that the integrity of the lining is further endangered by the action of the slag produced during the operation, unless the process is conducted under such conditions, hereinafter specified, as will insure against the attack of the slag upon the lining. These conditions may be briefly summarized as consisting in so proportioning the amount and character of the silicious flux added to the bath of molten matte to be bessemerized to the volume of the air blast admitted during the smelting blow that the silicious flux will not only fully subserve its function of fluxing the iron and of adding its own content of matte-forming material to the bath, but will form a thin and fluent slag capable of being readily poured off and producible at such a temperature that it will not substantially attack the non-corrodible lining.

In the practice of the invention, in order to obtain the maximum output, to the best advantage, from the converter, I initially charge, or otherwise form therein a body of molten matte of such large volume as will maintain fluidity during the blow. This bath of molten matte of large volume, is maintained substantially constant during the entire smelting conversion, despite the shrinkage due to the loss of iron and sulfur during the blow, by employing an acid flux containing not only the necessary silica to flux the iron, but also a certain quantity of matte-forming constituents which supply, in part at least, the diminution in volume due to the elimination of the iron from the charge as it is being converted by the smelting blow into white metal. The matte-making constituents thus supplied, I further supplement by adding additional molten matte to the charge, from time to time as required. The temperature of the molten matte additions is usually somewhat lower than that of the matte in the bath at the termination of the preceding blow, but, of course, it contains fuel in the shape of iron and sulfur, whose subsequent combustion in the next succeeding blow adds heat to the charge thereby counteracting the chilling effect of the additions of silicious flux. In realizing this practice, I prefer to employ as the silicious flux a silicious copper ore, containing other metals, such as gold and silver, which, added to the matte increase its value and which are thus recovered incidentally without the necessity of a separate smelting operation. In order to make use of these silicious fluxes in large quantity, and without over-chilling the matte the smelting conversion is divided into a number of fractional blows; that is to say, after providing an initial charge of molten matte in the converter and charging thereon a suitable quantity of the silicious flux, the matte is blown until a portion only of the iron contained therein has been fluxed, the amount of the silicious flux being so proportioned that at the termination of the first fractional blow the silicious fluxing ore introduced shall have exercised the desired fluxing effect upon the iron eliminated and shall have produced a thin fluent slag, and so that, at the same time, whatever matte-forming constituents it contains shall have joined the main body of the charge of matte in the converter.

The temperature of the matte, which had been lowered by the admission of the charge of silicious flux, is raised by the chemical reactions due to the blowing in of the air and the fluxing of the fractional portion of iron eliminated; so that, upon pouring off the slag, the temperature of the charge is sufficiently high to permit the addition of a further amount of silicious flux for the fluxing of the iron in the next succeeding fractional blow. A sufficient quantity of molten matte is likewise charged into the converter from time to time (usually after each fractional blow) until the final blow to white metal, so as to assist in the maintenance of the proper heat conditions and to maintain a practically constant volume of matte within the converter. Toward the end of the smelting conversion, the amount of silicious flux added is somewhat diminished, in my usual practice, as will hereinafter more fully appear. Finally, immediately before the blowing of the white metal to blister copper, and after the slag from the last charge of silicious flux has been poured off, I take precaution to leave in the matte a sufficient quantity of iron to more than compensate for the silica present in those portions which have escaped the pouring off operation. This precaution is for the purpose of preventing "foaming" in the converter, which I find will occur, if, after the final pouring off operation, there is left a quantity of silica in excess of the iron still remaining in the white metal. In fact, as indicated, the amount of iron remaining in the matte, should be, in practice, somewhat in excess of what is necessary to satisfy the silica of the residual slag. It will appear in the slag in the form of thick pasty lumps or balls consisting principally of magnetic oxid of iron.

Referring generally to the operation as hereinbefore outlined, it is characteristic of my discovery and invention that the process should be so conducted that the temperature of the thin and fluent slag produced at the termination of the several fractional blows during the smelting conversion shall remain insufficient to permit the slag to substantially attack the non-corrodible lining, which latter I prefer to make of magnetite brick, chrome ore brick, or the like. To the eye of the operator, the molten slag will, when at a suitable temperature, present a yellowish appearance. At higher temperatures, the slag will assume a cream white tinge, from which it will, at still higher temperatures, attain a white color. These cream white and white colors indicate that the temperature is too high, inasmuch as under such conditions the slag will seriously attack the lining, finally breaking it down and decreasing its life to a degree incompatible with fair commercial results.

Referring now, more particularly, to the specific details for the preferred practice of my invention, I will assume the employment of a converter having a non-corrodible lining and twyers, such as illustrated in application Ser. No. 438,286 hereinbefore referred to, and that the lining is in a highly heated condition so that it will not materially chill the molten matte to be charged. The lining is in such highly heated condition immediately after the blister copper from a preceding blow has been tapped from the converter, or, if the lining has cooled off, it may be brought to the desired temperature, by heating it by means of fuel, supplied, for instance by an oil or gas burner, or the like. Into the converter, there is then to be charged a quantity of molten copper matte, say forty (40) tons in amount, rising to about six inches below the level of the twyers, when the furnace is in its normal position. The matte thus charged (say forty (40) per cent. copper matte) may conveniently be obtained from any of the usual matte-producing furnaces. Its temperature may vary from say 1900 to 2300 degrees Fahrenheit. The skilled furnace man is able to judge from its appearance, with substantial accuracy, as to its temperature and as to the quantity of silicious flux to be supplied as the first addition.

As soon as the converter has received its initial charge of matte, the silicious flux is added, in quantity appropriate to the temperature of the matte, the amount of the first addition being usually somewhat smaller than the subsequent additions, (because of the lesser temperature of the initial body of matte,) until near the termination of the entire fluxing operation. The silicious flux may consist say of an ore containing 60% of silica, 10 per cent. of copper and 8 per cent. of iron, or, say, of an ore containing 40% of silica, 20 per cent. of copper, or of other like ores, preferably containing metal values which will enter the matte, as, for instance, copper, as just noted, or higher metal values such as silver or gold, either with or without copper. The amount of silicious flux thus added for the first fractional blow will usually be about six thousand (6000) pounds, more or less, according to the temperature of the initial bath of matte. After this silicious flux has been added, the blast is turned on at the twyers and the converter is rotated upon its horizontal axis until the twyers are immersed from twelve (12) to eighteen (18) inches below the level of the matte. Blowing is then proceeded with for a period of about forty-five (45) minutes, a volume of air being admitted equal to about six thousand (6000) to seven thousand (7000) cubic feet per minute. The furnace man is able to determine the time for interrupting the blow by observing the condition of the slag, which should be thinly fluid and of a yellowish color (comparable to the color of melted butter). To observe the color of the slag, it is necessary for the furnace man to rotate the furnace in such manner as to raise the twyers above the level of the charge and shut off the air supply, whereupon the charge will subside, and the slag which has been in agitation will come to rest on the surface of the matte. If it has attained the desired color and is correspondingly thinly fluid it is in condition to pour but if it has not reached that stage, the furnace man again turns on the air supply and by rotating the furnace back to its original position resumes the blowing operation.

The normal temperature of the converter and the temperature of the slag at the time when it should be poured varies from say 2100 degrees to 2400 degrees Fahrenheit. Should the blowing be continued after the slag has attained these temperatures, its temperature would rise rapidly and its color would change from a yellowish tint to a cream white and finally to a dazzling white. At these higher temperatures the slag, still thin and fluid would begin to attack the magnesite brick lining, and would rapidly wear it down along the surfaces of contact principally along the zone of the twyers. A continuation of the blow beyond the point where the thin and fluent slag of yellowish tint is obtained would ultimately result in encumbering it with additional masses of pasty and lumpy slag consisting principally of magnetic oxid or iron.

At the termination of the first fractional blow, the percentage of iron in the matte has been reduced from say 30% to about 22% and the iron thus oxidized has, as above indicated, united with the silica present. The interruption of the blow, at this stage, is necessary for the reason that if continued further the passage of an additional quantity of iron into the slag would make it still more fusible and the oxidation of the additional quantity of iron would raise the temperature of the slag within the furnace to such a degree that it would attack the magnesite lining along the twyers as described.

In addition to judging by the color of the slag as to the time at which to terminate the first fractional blow, the furnace man can further confirm (though with less certainty) from the color of the products of combustion issuing from the converter the time when the blow should terminate. At that time, the products of combustion have a bluish cast and exhibit incandescent particles of fused slag in very small quantity. A still further guide to the furnace man as to the proper time at which to interrupt the blow is afforded by the expedient of inserting at a time approaching the expected end of its duration, an open-ended iron pipe, of say an inch bore, into the converter, from above, through the opening which has served for the pouring off of the slag. This opening, after the charge has been admitted, is filled with clay and the pipe referred to is inserted through a small aperture made in this clay filling. The pipe may conveniently be bent at its outer or handle end, so as to be readily manipulated by the furnace man, and, by lowering its free or testing end into contact with the slag, the furnace man can determine by the resistance offered to its downward movement whether the slag is in condition to be poured. If it has not reached the thin and fluent stage, the pipe will not readily penetrate it, but as soon as that stage has been attained, the fact is made manifest by the practical absence of resistance to the downward movement of the pipe, incident to the circumstance that the slag has attained the requisite thinness and fluidity. Furthermore, the ascertainment of the proper period for terminating any one of the fractional blows, gives to the furnace man a fairly accurate intimation as to the desired time for terminating the next succeeding fractional blow, inasmuch as it instructs him as to the general behavior of the particular charge of matte and flux treated, under the other furnace conditions prevailing.

At the termination of the first blow, the thin and fluent slag is poured from the top of the matte in any suitable manner. The slag thus poured will usually be found to contain in the neighborhood of 47% or 48% of iron and 27% of silica. The amount of silica present in the slag will be dependent, however, upon the composition of flux, and will be proportionally less if the flux contains alumina. It is desirable to obtain like slags throughout the entire smelting conversion; therefore, the amount of flux added and the length of each blast period are so related that this normal slag shall always be produced at the end of each fractional blow during the smelting conversion, within say a few per cent. one way or the other.

After pouring off the slag at the termination of the first fractional blow, a further addition of molten matte, together with silicious ore is made, in order to reëstablish the volume of the original charge, it being desirable to maintain as nearly as possible a constant volume in the converter up to the final blow from white metal to blister copper. The amount of the additional matte added will vary according to the grade of matte employed, but, in the instance supposed will consist of about eight (8) tons after each fractional blow; so that, including the initial bath of forty (40) tons, the converter, at the beginning of the last blow from white metal to blister copper, will have received a total charge of about 100 to 110 tons of matte of say 40% copper. If the matte is of higher grade, a proportionally smaller amount of matte will be required to produce the same volume of white metal. The specific gravity of the matte, of course, increases as the bath becomes enriched by the elimination of the iron and the charging of additional matte into the converter, the white metal finally obtained containing about 78 to 80 per cent. of copper.

In taking off the last slag, prior to the so-called simple conversion or blowing to blister copper, it is impracticable to remove all of the slag. Consequently, if an excess of silicious flux has been added before finishing the last fractional blow of the smelting conversion, there will be left floating on the white metal an amount of slag of varying quantity containing unsatisfied silica. In order that this unsatisfied silica shall not become a source of future trouble, the last fractional blow of the smelting conversion is so conducted that there is left in the white metal a sufficient amount of iron to satisfy the silica of the residual slag referred to. In fact, in order to insure the full satisfaction of the silica in the residual slag, the amount of iron left in the white metal is in excess of that theoretically required. Consequently, during the blow to blister copper the silica of the residual slag will be more than compensated by the iron, and the excess of iron will pass into the slag principally as magnetic iron oxid, forming therein what is known as "ball slag". The presence of this "ball slag", indicative of the full satisfaction of the silica, is a complete assurance against "foaming" in the converter during the blow to blister copper.

The slag present in the converter at the termination of the blow to blister copper is very rich in copper and of such a nature that considerable time would be required and difficulty experienced in removing it. It is, therefore, left in the converter, and the blister copper is tapped from underneath it. It is, therefore, essential to introduce the next initial bath of matte into the converter quickly in order to prevent this rich copper slag from sticking to the bottom of the converter. Moreover, by leaving this rich copper slag in the converter, its copper is recovered during the next succeeding smelting conversion.

It will be understood that by the expression "non-corrodible lining" as employed in the specification and claims, I mean a lining of a non-acid character, such, for instance, as the magnesite brick or chrome brick lining, or the like, hereinbefore referred to.

Having thus described my invention, what I claim is:

1. The method of bessemerizing copper matte in a converter having a non-corrodible lining with the employment of an acid flux, which consists in forming a molten bath of matte in the converter of such volume as to retain its fluidity as against losses by radiation during the blow, and so proportioning the amount and composition of the flux to the volume of air blast admitted that at the termination of the blow there will result a thin and fluent slag at a temperature insufficient to substantially attack the lining; substantially as described.

2. The method of bessemerizing copper matte in a converter having a non-corrodible lining, with the employment of an acid flux, which consists in forming in the converter an initial bath of molten matte, adding thereto a charge of acid flux containing matte-forming constituents, blowing the matte until a portion of the iron therein contained is fluxed and the matte-forming material from the acid flux has become incorporated with the initial body of molten matte and a thin and fluent slag has been formed at a temperature insufficient to substantially attack the lining; substantially as described.

3. The method of bessemerizing copper matte in a converter having a non-corrodible lining, with the employment of an acid flux, which consists in forming in the converter an initial bath of molten matte, adding thereto a charge of acid flux containing matte-forming constituents, blowing the matte until a portion of the iron therein contained is fluxed and the matte-forming material from the acid flux has become incorporated with the initial body of molten matte and a thin and fluent slag has been formed at a temperature insufficient to substantially attack the lining, pouring off the said thin and fluent slag, adding an additional charge of molten matte and of acid flux containing matte-forming materials, blowing the matte until a further quantity of iron is fluxed and the matte-forming material of the additional charge has been incorporated with the body of molten matte and a thin and fluent slag has been formed, as before, and repeating these operations successively, thus fractionally fluxing the iron and maintaining a substantially constant volume of matte in the converter, until the matte is in condition to be blown to blister copper; substantially as described.

4. The method of bessemerizing copper matte in a converter having a non-corrodible lining and with the employment of an

acid flux, which consists in preventing foaming in the converter by leaving in the molten matte at the termination of the smelting blow and after the pouring off of the slag prior to the blow to blister copper, an amount of iron in excess of that sufficient to compensate for the silica contained in such portion of the slag as may have escaped the pouring off operation; substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

ELIAS A. C. SMITH.

Witnesses:

JOHN C. PENNIE,

LAURA B. PENFIELD.