No. 833,406. PATENTED OCT. 16, 1906.

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METHOD OF SMELTING ORES.

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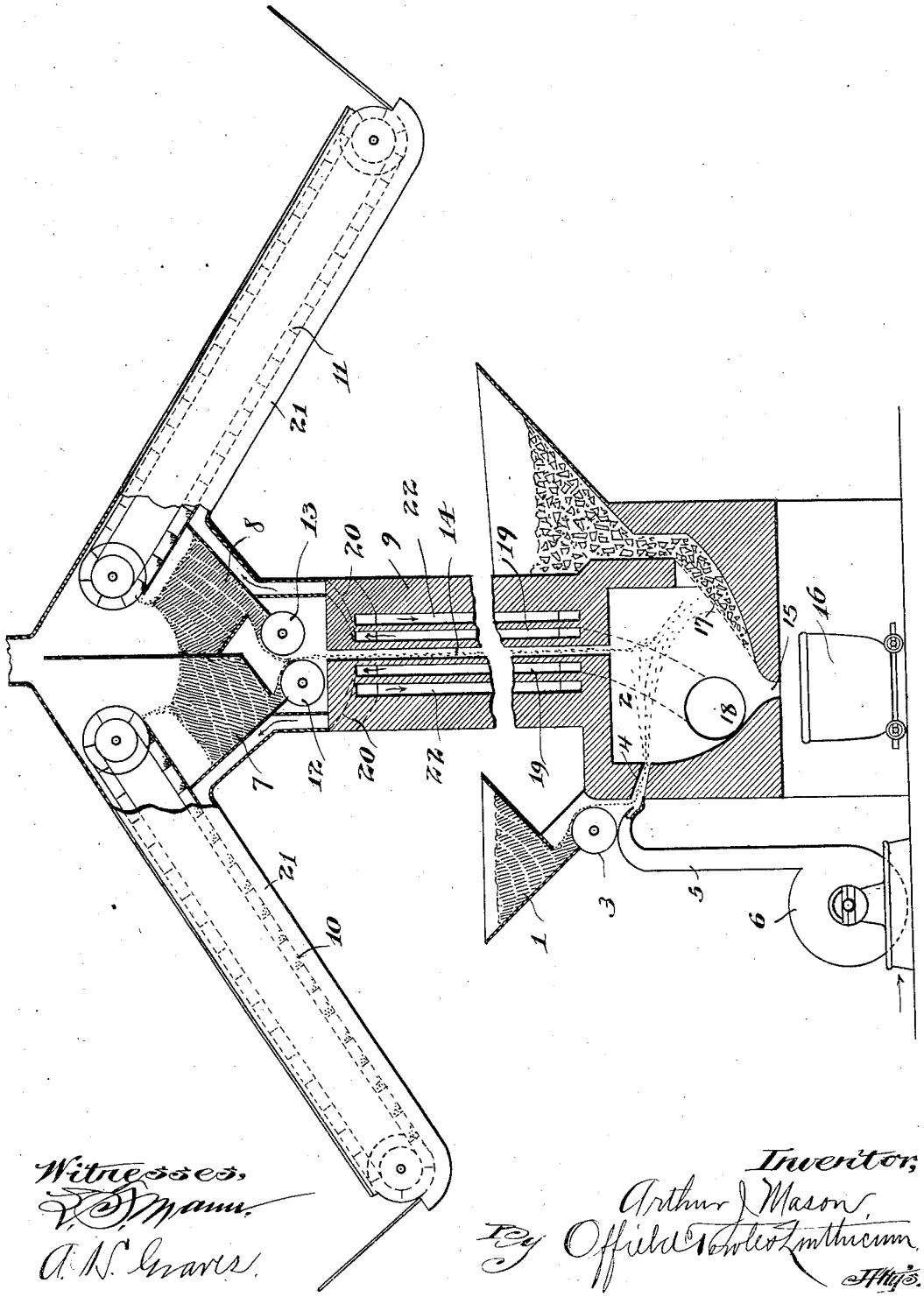


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# UNITED STATES PATENT OFFICE.

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## METHOD OF SMELTING ORES.

No. 833,406. Specification of Letters Patent. Patented Oct. 16, 1906.

Application filed May 1, 1903. Serial No. 155,182.

*To all whom it may concern:*

Be it known that I, ARTHUR J. MASON, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Method of Smelting Ores, of which the following is a specification.

My invention relates to a radically new, and, as I believe, improved, method of smelting ores; and in order that my present method and the advantages claimed therefor over the existing method may be fully understood I will briefly describe in connection with the present method of smelting ores some of the faults and disadvantages which it is the aim of the present invention to eliminate and overcome.

As is well known, in the present procedure of smelting iron ore, the ore, flux, and fuel are introduced into and through the top of a lofty and capacious furnace, while the air for promoting combustion is introduced below. It is necessary to introduce the air at a pressure sufficient to enable it to force its way upward through the mass of material above the critical reducing and melting portion of the furnace, and in view of the great height of the latter and of the immense column or mass of material through which the air must find its way it is necessary to introduce the air at a very high pressure. This requires powerful air compressing and forcing machinery and also requires great strength in the construction of the furnace. It is also known that the presence of this great mass isolates the critical portion of the furnace in such a manner that any remedy introduced through the burden to correct abnormal or undesirable conditions can be applied only by a slow process, since it can only do its work with the descent of the mass within the furnace. The whole rationale of the present blast-furnace depends upon the descent of the various contained materials as they pass downward to take the place of those already converted into gases or liquids. This descent must be made against an upward current of gases seeking escape at the top, and it is notorious that this descent is capricious and uncertain. The ascending gases affect the descending masses of material in a very complex manner, so much so that after a century of practice there is still a great divergence of opinion as to what the procedure taking place within the furnace really is. Modern blast-furnace practice represents the extension and elaboration of the earlier blast-furnace practice, wherein the ores used were generally hard ores. A preponderance of the iron ores used in the United States at the present time are in a finely-divided granular or more or less powdered condition, being vulgarly known as "soft" ores. Now these soft ores greatly add to the caprices of the furnace for these reasons. The fuel and fluxes being generally lumpy and the ore fine, there is a disposition when the materials are first dumped in at the top of the furnace for the fine ore to segregate from the lumps in a manner differing with every change in the level of the top of the stock with the speed with which the round is added, with the changes of the weather, with the sizes of the bell used, and from various other causes. Furthermore, the velocity and pressure of the blast carries off, as so-called "flue-dust," a very considerable amount of fine unreduced ore with the escaping gases.

The primary object of the present invention is to utilize and take advantage of the fact of the finely-divided condition of the iron ores extensively mined and used in this country in the carrying out of a novel process of smelting, in which all the phenomena are under perfect control and subject to almost instantaneous correction, thus avoiding the accidents which at present occur through the existence of irregular and abnormal conditions in the furnace, as well as the waste of unconsumed ore, which at present passes off with the escaping gases.

In order to render my novel method intelligible, I have illustrated in the accompanying drawing an apparatus adapted for the carrying out of the same, it being understood that the invention is in no sense limited to the particular mechanism herein illustrated as adapted to the carrying out of the method.

The drawing represents in substantially central vertical section one form of apparatus which I have designed for the carrying out of my new and improved method of smelting iron ores.

In accordance with the present invention the fuel is pulverized and introduced into the reducing and melting chamber by a stream

of air. This pulverized fuel is represented in the drawing as contained in the hopper 1, conveniently located with reference to the reducing and melting chamber 2, said hopper being provided with a discharging-roller 3, adapted to effect the uniform feed of the fuel in a broad thin stream in the manner described in Letters Patent to Frank K. Hoover and Arthur J. Mason, No. 702,731, June 17, 1902, the fuel being delivered to an inlet-passage 4, formed through the side wall of the melting-chamber 2, preferably near the top thereof. Communicating with the passage 4 is the top end of a chimney or flue 5, leading from an air-blower 6, whereby a powerful blast of air is made effective upon the falling stream of finely-pulverized fuel to force the latter in a condition most favorable for instantaneous and thorough combustion into the reducing and melting chamber.

7 and 8 indicate twin hoppers placed face to face above a vertical stack 9, superposed upon the reducing and melting chamber 2. The hoppers 7 and 8 are supplied with ore and flux, respectively, by any suitable means—as, for instance, the drag-conveyers 10 and 11—and said hoppers are in accordance with the Letters Patent to Hoover and Mason, hereinabove referred to, provided with discharging-rollers 12 and 13, respectively, designed to discharge the pulverized material in broad thin streams over the surfaces of said rollers, said rollers being so positioned relatively to each other as that the stream of flux will be discharged directly upon the surface of the already-discharging stream of ore, whereby the two streams become thoroughly intermingled and together fall through a central vertical flue 14 in the stack 9, thence impinging upon and entering the stream of hot gases generated by the combustion of the fuel. By virtue of the finely-powdered condition of the fuel, ore, and fluxes and the intimate intermingling of said materials in the reducing and melting chamber the powerful heat of the oxidized fuel decomposes the iron ore, the fuel taking up the oxygen and leaving the comparatively pure metallic iron in a molten state to fall upon the base of the retort, whence it flows in a molten stream through a discharge-spout 15 into a pot or crucible 16 therebeneath, whence it may be withdrawn for subsequent treatment.

17 designates a bed of coke, which may constitute a lining for a portion of the bottom and side of the melting and reducing chamber, against which the combustible gases and fuel are directed to complete the reduction and melting of the ore by furnishing an incandescent bed on and through which the partially-reduced and melted ore may fall. This bed of incandescent coke will remain unconsumed so long as the pulverized fuel itself furnishes all the carbon with which the oxygen of the incoming air and ore can unite in the process of combustion.

The hot gases may be led away and used in a regenerative manner to heat the air for the blast and also to heat the ore and flux prior to their introduction to the reducing and melting chamber. For this purpose the latter chamber is provided with a discharge-flue the orifice of which is indicated at 18, whence the hot gases pass through vertical flues 19 on either side of the central ore and flux transmitting flue 14, thence through passages 20, around the rear sides of the hoppers 7 and 8, and thence by passages 21 beneath the lower walls of the conduits of the drag-conveyers 10 and 11, finally discharging to the atmosphere at the receiving ends of said conveyers. The blast of air drawn in on the suction side of the blower 6 may pass downwardly through vertical conduits 22, likewise disposed alongside of and parallel with the gas-discharging flues 19, whereby said incoming air is likewise heated before it reaches the blower.

Through a manipulation of the roller 3 at a proper speed the entering stream of fuel and air may be so arranged and proportioned with respect to its components that at the point at which it meets the commingled stream of ore and flux it shall form a gas having a desired admixture of oxygen and carbon best adapted to the complete reduction of the ore, whereby the body of coke 17 may in some instances be rendered unnecessary.

From the foregoing it will be observed that the theory of the above-described process possesses the following salient and novel characteristics: First, by reason of the fact that all the ingredients—air, ore, fuel, and flux—are introduced in a finely-divided condition a perfect admixture most favorable to thorough combustion and reduction is practicable; second, the primary fuel stream is burned in such a manner as to generate its maximum heat units for the purpose of first bringing the ore and fluxes to a high temperature sufficient for their decomposition; third, at that moment the ore and fluxes are brought in contact with incandescent carbon under conditions in which free oxygen is scarce in order that the affinity of the carbon may cause it to rob the ore and fluxes of their oxygen; fourth, all the contributing volumes of air, fuel, ore, and fluxes are introduced in shallow broad streams superimposed, as it were, so that intimate and proportional admixture takes place almost instantaneously.

Although I have described my invention in connection with the smelting of iron ore and contemplate that such will be its principal application, yet it is evident that the

same principle might be employed in the smelting of other ores within the scope and purview of my invention.

I claim—

1. The herein-described method of smelting the ores of metals which consists in impinging a stream of finely-divided commingled ore and flux upon and substantially transversely of a forced blast of commingled burning air and fuel within a reducing and melting chamber.

2. The herein-described method of smelting the ores of metals which consists in impinging a stream of finely-divided ore and flux upon a stream of burning air and fuel, and directing the same against a bed of incandescent coke.

3. The herein-described method of smelting the ores of metals which consists in associating in one stream at a high velocity fine particles of fuel, air, ore and flux in proper proportions, burning them in a reducing and melting chamber, and using the resulting hot gases in a regenerative manner to accomplish the preparatory heating of air, fuel, ore and fluxes.

4. The herein-described method of reducing the ores of metals through combined chemical and heat treatment which consists in fusing the ore and flux previously reduced to a finely-divided condition while passing through and suspended in an atmosphere of air and combustible gases charged with particles of fuel.

5. The herein-described method of smelting the ores of metals which consists in feeding a stream of finely-divided commingled ore and flux into a reducing and melting chamber and simultaneously directing against and through the same while suspended in said chamber a forced blast of commingled burning air and fuel.

6. The herein-described method of smelting the ores of metals which consists in impinging thin streams of flux and ore both in a finely-divided condition one upon the other, directing the stream of commingled flux and ore unobstructedly into a reducing and melting chamber, and impinging under forced draft upon said commingled stream of flux and ore while suspended in said chamber a burning stream of commingled air and fuel.

7. The herein-described method of smelting the ores of metals which consists in impinging a thin stream of flux upon a similar stream of ore both in a finely-divided condition, directing the stream of commingled flux and ore unobstructedly into a reducing and smelting chamber, impinging upon said commingled stream of flux and ore while suspended in said chamber a burning stream of air and fuel, and directing the partially-reduced and melted ore upon an incandescent bed of carbonaceous material.

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