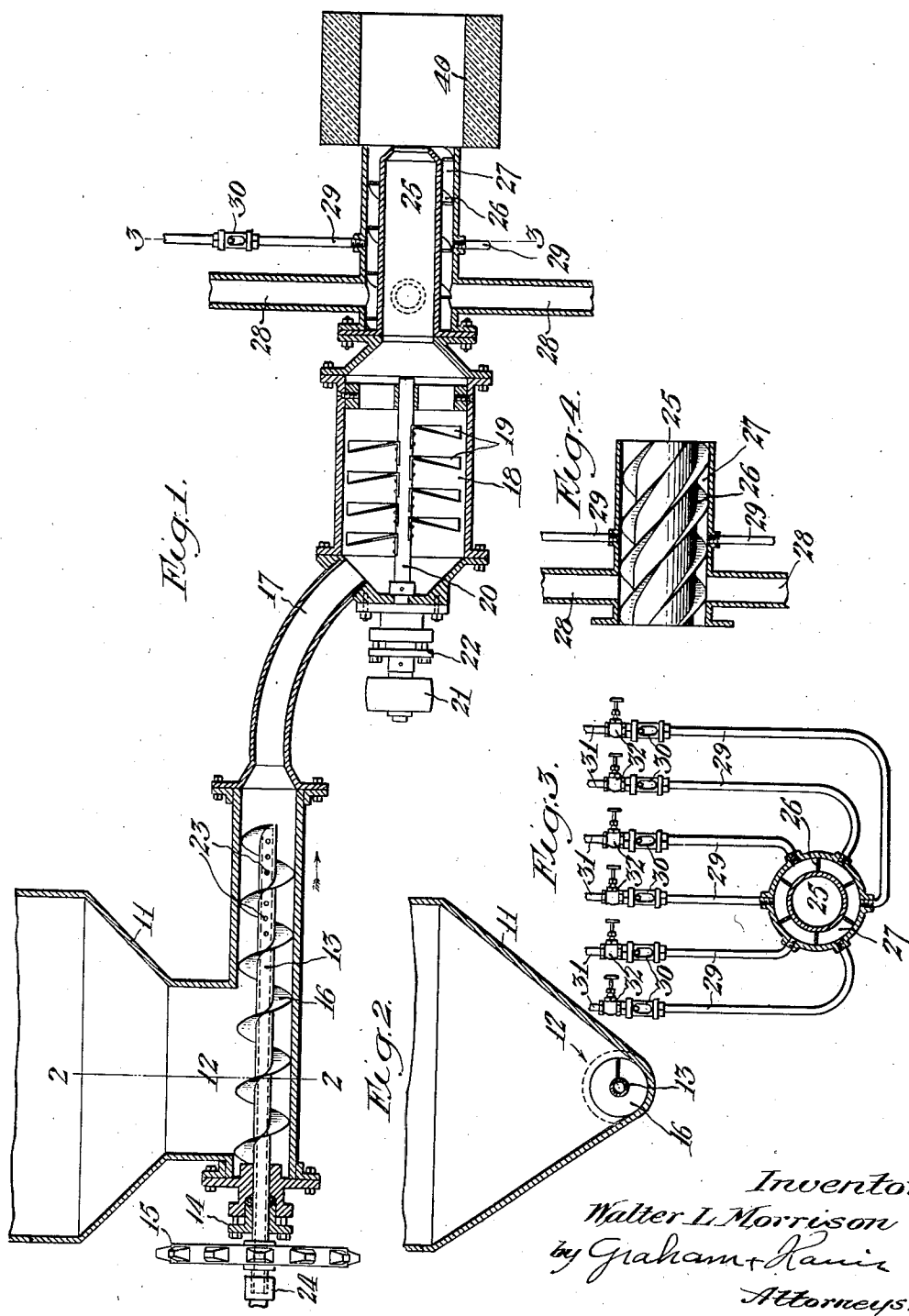


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 PROCESS AND APPARATUS FOR REDUCING METALLIC OXIDS.  
 APPLICATION FILED JAN. 22, 1918.

1,350,419.

Patented Aug. 24, 1920.

2 SHEETS—SHEET 1.



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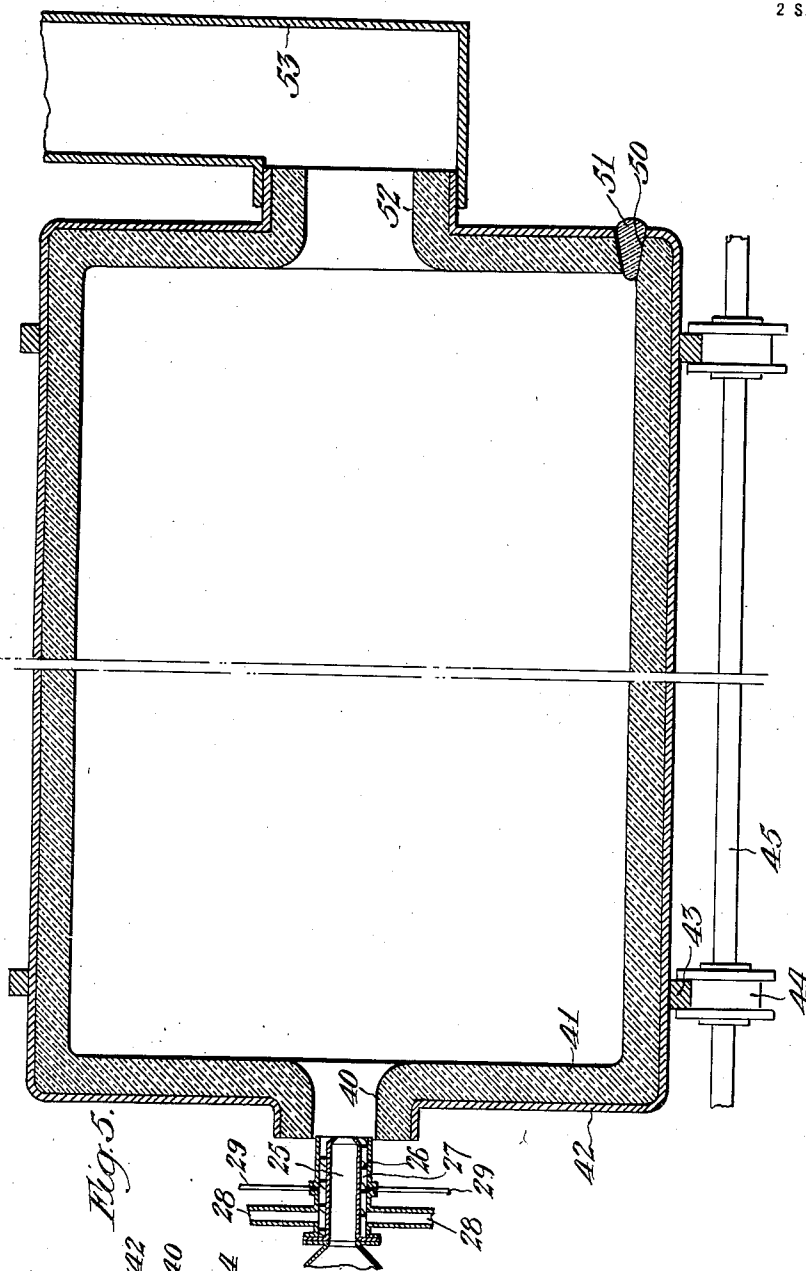
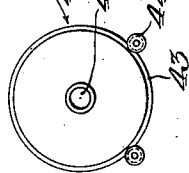


Fig. 6.



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# UNITED STATES PATENT OFFICE.

WALTER L. MORRISON, OF LOS ANGELES, CALIFORNIA.

PROCESS AND APPARATUS FOR REDUCING METALLIC OXIDS.

1,350,419.

Specification of Letters Patent. Patented Aug. 24, 1920.

Application filed January 22, 1918. Serial No. 213,259.

*To all whom it may concern:*

Be it known that I, WALTER L. MORRISON, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented a new and useful Process and Apparatus for Reducing Metallic Oxids, of which the following is a specification.

My invention relates to the art of reducing ores which contain metallic oxids, and the object of the invention is to provide a process and apparatus by which various metallic oxids may be reduced, using liquid, gaseous or finely divided solid reducing agents so that the metal may be recovered therefrom.

The invention has a particular utility in the reduction of iron ores, and while it is adapted to other purposes, the following specification will be limited to a description of its use in connection with iron ores.

Practically all of the commercial reduction of iron ore now carried on in the United States is accomplished by feeding the ore with a suitable flux and with coke into a blast furnace which is maintained at a high temperature. The method of operation and the reactions which take place in such a furnace are well known and need not be described here.

There are, however, in various parts of the world large deposits of iron ore which are remote from any deposits of coking coal, which is absolutely essential in the operation of the present commercial forms of blast furnace. The coke used in the blast furnace must be free from certain impurities and must have enough mechanical strength to support the burden of the charge. Coal suitable for producing such coke is not widely distributed.

The purpose of my invention is to render possible the reduction of iron or other metallic oxids using finely divided coal, coke, charcoal or other solid carboniferous material unsuited to ordinary blast furnace operation or using natural or artificial gas or oil.

Further objects and advantages will be set forth hereinafter.

Referring to the drawings, which are for illustrative purposes only,

Figure 1 is a side elevation partly in section of the feeding means.

Fig. 2 is a section on a plane represented by the line 2—2 of Fig. 1.

Fig. 3 is a section on a plane represented by the line 3—3 of Fig. 1.

Fig. 4 is a partial section of the apparatus shown in Fig. 1, showing the mixing vanes.

Fig. 5 is a sectional elevation showing the furnace and a portion of the mixing means.

Fig. 6 is an end view of the furnace on a very much reduced scale.

In the drawings, a hopper 11 is shown having an opening 12 below which a primary pipe 13 revolves, this pipe passing through a stuffing box 14 and being driven by a sprocket or other convenient means 15 and being provided with a conveyer 16 on the periphery thereof. The extreme inner end of the pipe 13 is perforated with a plurality of holes 23 and its outer end is connected to a primary supply pipe 24. The delivery end of the conveyer 16 is provided with a pipe 17 which communicates with the interior of a disintegrating chamber 18 in which a series of paddles 19 are revolved by means of a shaft 20 and a pulley 21, the shaft 20 passing through a stuffing box 22. The disintegrator connects with the interior of a nozzle 25 which is provided with a series of mixing vanes 26 on its outer surface, the nozzle 25 being concentrically located inside a mixing chamber 27.

Connecting into the rear of the mixing chamber 27 are a plurality of secondary pipes 28, and also connected into the mixing chamber 27 are a plurality of tertiary pipes 29. The tertiary pipes 29 are fed through sight feed glasses 30 from tertiary supply pipes 31 connected to a suitable source of supply not shown. Valves 32 are provided to regulate the flow of material in the pipes 31.

The nozzle 25 and the mixing chamber 27 communicate with a combustion ring 40, this combustion ring being made of a refractory material and preferably forming a part of a refractory lining 41 of a furnace 42. The furnace 42 is provided with external rings turning on trunnions 44 carried on shafts 45, the shafts 45 being supported in bearings not shown and driven by any convenient means not shown.

Formed in the end of the furnace 42 is an outlet opening 50 which is normally plugged with fire clay 51. A flue opening 52 is also centrally formed in the same end, this flue opening communicating with a stack 53.

The method of operation of the invention is as follows:

The ore or certain other material hereinafter specified which it is desired to reduce is placed in the hopper 11, passing through the opening 12 into the space around the pipe 13 and being forced through the pipe 17 into the disintegrator 18, by means of the conveyer 16 and by means of a stream of fluid under pressure from the openings 23 in the pipe 13. The ore which is initially finely divided by crushing and screening, is thoroughly broken up in the disintegrator 18 so that it forms a very fine powder free from lumps. The ore and any other solid material used in my process must be finely pulverized so that it forms a dust so fine that it will settle very slowly in still air.

This pulverized material, mixed with the fluid under pressure introduced through the pipe 13, passes into the inside of the ore nozzle 25, being forced from the end of this nozzle into the interior of the combustion ring 40. Material hereinafter described, fed through the pipes 29 into the space between the mixing chamber 27, is thoroughly mixed with the material under pressure delivered by the pipes 28. The mixture delivered from the inside and outside of the nozzle 25 is ignited in the combustion ring 40. The reducing material is partly oxidized in the ring 40 and the combustion is further continued in the furnace 41.

The furnace 41 is shown broken in Fig. 5, it being considerably longer in proportion to its diameter than is shown in that figure. In practice I prefer to make the furnace approximately five diameters long. The proportions are, however, not essential. This furnace is constantly rotated and the hot gases carrying the solid material in suspension pass through the combustion ring 40 into one end thereof. The finely divided solid material together with the highly heated products of combustion flow through the furnace in the form of a dust cloud and a very efficient and perfect reduction of the ore takes place therein.

In practice I prefer to place the finely divided ore in the hopper 11 and to apply a reducing gas to the pipe 24. In some cases I may find it advantageous to mix a finely pulverized flux with the ore and in other cases I may add a solid reducing agent such as finely pulverized coke or charcoal to the ore in the hopper. In either case the pulverized material is blown by the gas from the pipe 13 through the pipe 17. In some cases it may be more convenient to use compressed air in the pipe 13. In any case the blast of gas and solid particles is slowed down in velocity in the disintegrating chamber 18 and the paddles 19 serve to break up and distribute into the gas any small lumps that may be carried therein.

The dust cloud consisting of air or other gases which carry pulverized ore with or without pulverized flux or pulverized solid reducing material is blown through the nozzle 25 into the combustion ring 40. In this ring it meets the material from the outside of the nozzle 25 which may consist of air, gas or finely divided reducing solid or liquid material mixed with air or gas. The nature of the material introduced to the space outside the nozzle 25 depends on the material passing through the nozzle 35. For example, I prefer in practice to use a reducing gas in the pipe 13 thus blowing a finely divided mixture of iron oxid and flux through the pipe 17 and through the chamber 19 into the ring 40. In such a case a hydrocarbon gas may be introduced either with or without air through the pipe 28 or a finely pulverized solid or liquid reducing agent carried in a stream of air or other gas may be introduced through the pipe 28. If, as I prefer, I introduce air through the pipe 28 I can then pass a hydrocarbon oil or gas or other reducing solid or liquid reducing agent through the pipes 29. In practice I prefer to use oil in pipe 29.

Various types of flux may be used in the ore, the exact character of the flux depending upon the sort of ore to be treated. In the case of acid or silicious ores, a basic flux such as lime, soda, etc. may be used, and in the case of basic ores, we would use an acid flux such as silica. The sole purpose of the flux is to render the slag making material more fusible and thus enable a better separation of the slag and metal to take place.

Any method of introducing a metallic oxid with or without a flux into the ring 40 and therein mixing it with a finely divided solid, liquid or gaseous reducing agent and with sufficient air to produce an incomplete combustion will accomplish the object I seek. The material emerging from the ring 40 into the furnace 42 consists of minute particles of ore, in the case we are considering iron oxid, with or without a flux floating in the form of a fine dust in a slowly moving atmosphere of hot gases containing an excess of carbon, that is, containing large amounts of carbon monoxid. By slow moving gases I mean a movement such as would be produced by a pressure in the combustion ring of approximately two ounces above atmospheric pressure. In other words, the gases are not introduced into the furnace under sufficient pressure to produce a blast in the ordinary acceptance of the term; the gases being gently introduced and the finely divided ore flowing very slowly throughout the length of the furnace. This highly heated monoxid at a temperature at or above 1100 degrees Fahrenheit continually robs the ore of its oxygen to form carbon dioxid leaving the metal particles free to agglomer-

ate in the higher temperatures of the furnace into masses large enough to settle out of the dust cloud, falling into the bottom of the furnace together with fused particles of slag-forming materials formed from the flux and the impurities in the materials supplied. The rotation of the furnace works the mass of ferrous material and slag over and over so that the small particles of metal are united into a large mass of molten iron or steel on which there floats a mass of slag. Obviously other means might be used to work the metal out of the slag.

The iron or steel and the slag are withdrawn from time to time by stopping the furnace 42 with the opening 50 at the bottom and withdrawing the molten material therefrom. The character of this material, particularly as to its carbon contents, can be varied by a suitable regulation of the feeds of the various materials. Some iron or steel particles or uncombined ore particles may escape with the waste gases through the flue opening 52. Such particles must be very fine however or they will not so escape and they may be recovered by various means not shown and re-treated.

In devising a process for reducing iron oxids at the present time it is necessary to bear in mind that the apparatus must be in a measure, commercially competitive to the blast furnace. It must reduce a large percentage of the iron oxid present to metallic iron and it must have a sufficiently high capacity per unit cost to make the cost of reduction per ton of ore low. This I accomplish by finely dividing and intimately mixing the materials. For example I provide the paddles 19 to assist in breaking up the solid materials and I provide the vanes 26 for giving the material outside the nozzle 25 a rapidly whirling motion as it enters the ring 40 so that an intimate mixture of ore, flux, and reducing material floats through the furnace 42. The fine division of the materials gives an enormous area of contact between the ore and the hot reducing gases so the efficiency of reduction is very high.

It is also desirable to separate the metal from the slag with a single heating and this I accomplish for example by the rotation of the furnace 42 which mechanically works the small particles of metal out of the slag and so that the metal and slag can be drawn off successively through the opening 50.

I claim as my invention:

1. A process of reducing metallic oxids which comprises dividing the oxids to a sufficient degree to allow them to be gas borne; subjecting the oxids to the action of hot reducing gases; precipitating the reduced metal together with slag forming material; and working said slag and metal to separate said metal from said slag.

2. A process of reducing metallic oxids

which comprises dividing the oxids to a sufficient degree to allow them to be gas borne; subjecting the oxids to the action of hot reducing gases; precipitating the reduced metal together with slag forming material in a chamber; and moving said chamber in such a manner as to work said slag and metal and cause an agglomeration and separation of said metal from said slag.

3. An apparatus for reducing metallic oxids which comprises a furnace; means for introducing a reducing gas in said furnace; means for introducing pulverized oxid into said gases; and means for moving said furnace to agglomerate and separate any metal precipitated in said furnace from any slag formed therein.

4. An apparatus for reducing metallic oxids which comprises a furnace; means for introducing reducing material in said furnace; means for maintaining reducing temperature in furnace; means for introducing pulverized oxid into said furnace; and means for moving said furnace to agglomerate and separate any reduced material in said furnace from any slag formed therein.

5. An apparatus for reducing metallic oxids which comprises a furnace; means for introducing reducing material in said furnace; means for maintaining smelting temperature in furnace; means for introducing pulverized oxid into said furnace; means for moving said furnace to agglomerate and separate any reduced material in said furnace from any slag formed therein; and means for removing metal and slag from said furnace.

6. A process for reducing metallic oxids which comprises subdividing the oxids to a sufficient degree to allow them to be gas borne, mixing said oxids with finely divided reducing materials and introducing the said mass into furnace and introducing sufficient oxygen into furnace to unite with part or whole of reducing materials, forming reducing gases, said oxids being reduced and precipitated together with the slag forming materials, and working said slag and metal to separate said metal from the slag.

7. A process for reducing metallic oxids which comprises subdividing the oxids to a sufficient degree to allow them to be gas borne, and introducing said oxids into a furnace, and introducing reducing material into said furnace, and introducing sufficient oxygen into said furnace to form reducing gases and maintain the necessary smelting temperature, said oxids being reduced and precipitated together with the slag forming materials, and working said slag and metal to separate said metal from slag, and subsequent withdrawing of smelted materials intermittently.

8. A process for reducing metallic oxids

which comprises subdividing the oxids to a sufficient degree to allow them to be gas borne, introducing the said oxids along with finely divided reducing materials in  
5 suspension into hot furnace, said oxids being reduced and precipitated together with slag forming materials, and working said slag and metal in said furnace to separate said metal from slag.

9. A process for reducing metallic oxids 10 while in suspension in a furnace, and subsequently agglomerating the metal by movement of said furnace.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, 15 this 15th day of January, 1918.

WALTER L. MORRISON.