

Nov. 6, 1928.

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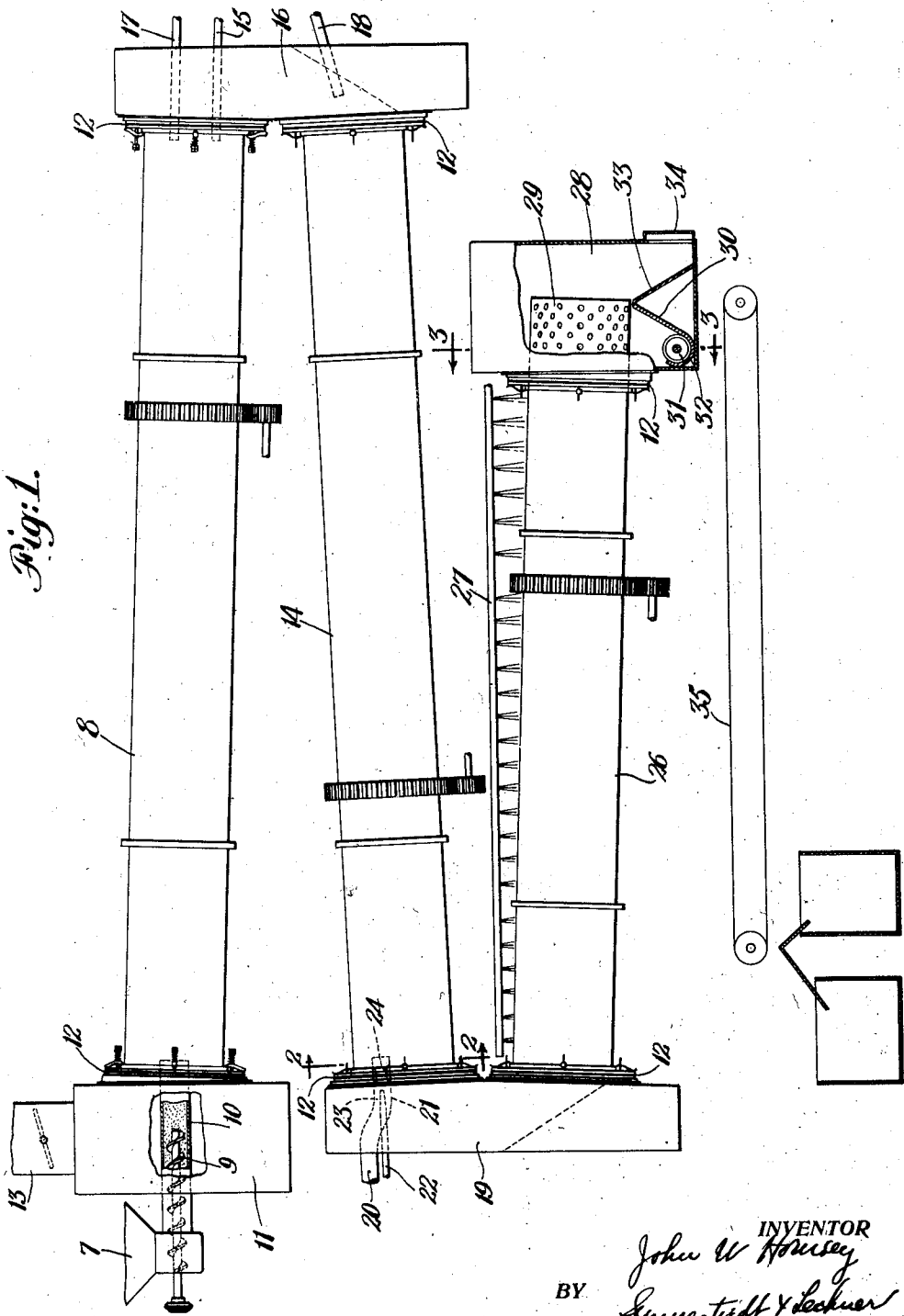
J. W. HORNSEY

REDUCTION OF METALS FROM ORES

Filed Nov. 25, 1925

2 Sheets-Sheet 1

Fig. 1.



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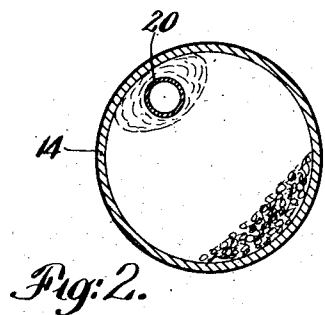
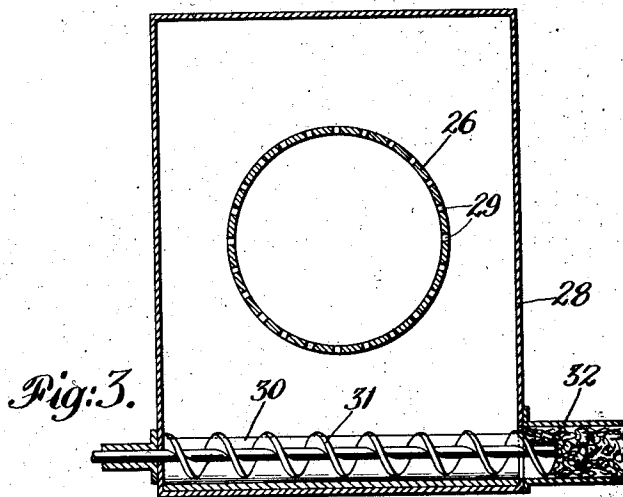
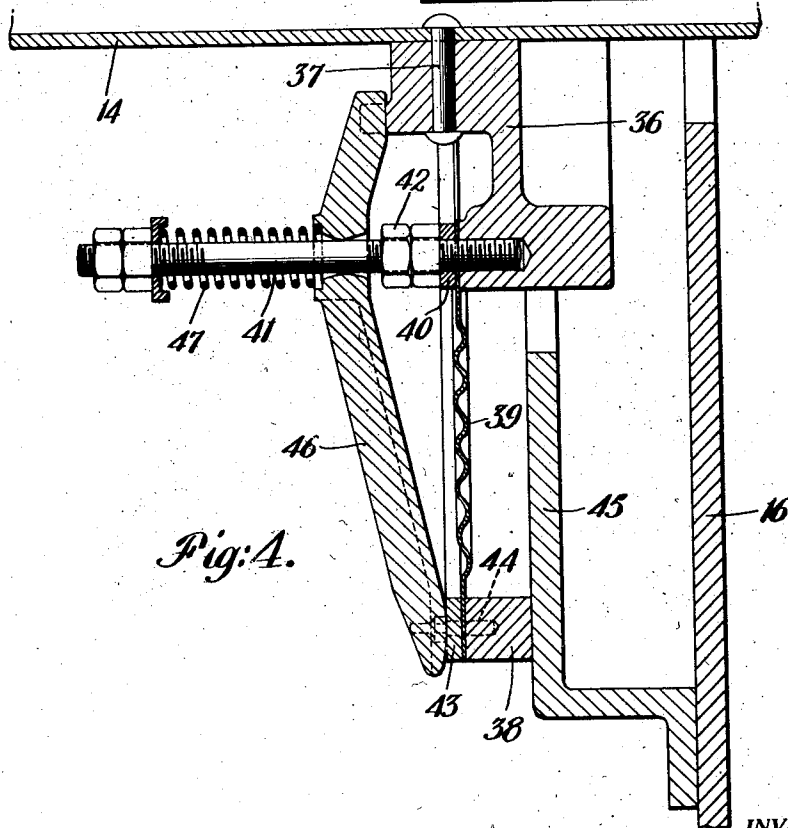
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REDUCTION OF METALS FROM ORES

Filed Nov. 25, 1925

2 Sheets-Sheet 2.



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UNITED STATES PATENT OFFICE.

JOHN WILLIAM HORNSEY, OF NORTON BY SHEFFIELD, ENGLAND, ASSIGNOR TO GRANULAR IRON COMPANY, A CORPORATION OF MICHIGAN.

REDUCTION OF METALS FROM ORES.

Application filed November 25, 1925. Serial No. 71,442.

This invention relates to the reduction of metal from ores and it is particularly useful for the reduction of iron ore in connection with which it will be described.

One of the primary objects of my invention is to simply and effectively reduce ores without going thru the molten state, that is to say to solidly reduce the metal and to lessen the cost of producing the same.

More particularly my invention consists in the special features of construction and the general arrangement and combination of parts hereinafter to be described.

In general, my invention contemplates the provision of means whereby the process of solid reduction may be carried out.

How the foregoing, together with such other objects as may hereinafter appear, or are incident to my invention, are realized, is illustrated in the accompanying drawings in preferred form, wherein

Fig. 1 is a diagrammatic side elevation of the apparatus I employ in carrying out my invention.

Fig. 2 is a section taken on the line 2—2 of Fig. 1.

Fig. 3 is a section taken on the line 3—3 of Fig. 1, and

Fig. 4 is a vertical section thru a portion of the apparatus illustrating details of my invention.

Referring now to Fig. 1, I take the ore in a suitable state of sub-division say, for example, crushed so as to pass thru a $\frac{1}{4}$ -inch mesh screen, and deliver it from the hopper 7 into a preheating cylinder 8. The material is fed from the hopper into the heating cylinder by means of the screw conveyor 9 and the pipe 10, the screw conveyor preferably terminating short of the inner end of the pipe 10 so that the ore piles up beyond the end of the screw and is pushed in the form of a plug which excludes air from entering thru the feeder mechanism into the cylinder 8. The feeder pipe projects thru a stationary chamber 11 which has a seal 12 to be more particularly described hereinafter, whereby a substantially gas tight connection is had between the revolving cylinder 8 and the stationary chamber 11. Leading from the chamber 11 is a damper controlled stack 13 for carrying off the said gases.

The material in passing thru the cylinder 8 is heated substantially to the temperature of reduction, the heat being preferably sup-

plied by the hot gases leaving the succeeding cylinder 14, supplemented by the introduction of such additional fuel as may be required thru the burner 15 which passes thru the stationary casing 16 at the right hand end of the cylinders 8 and 14. The cylinder 8 has a seal 12, as above, affording a substantially gastight connection as between the cylinder and the casing 16. Thus no air can enter into the cylinder 8 except such as may be deliberately supplied under control thru the pipe 17 and the burner 15 passing thru the casing 16. Air required for burning the fuel admitted to the cylinder 8 is supplied thru this pipe 17 and the burner 15, and I find it desirable to maintain a reducing atmosphere at the discharge end of the cylinder 8 and a slightly oxidizing atmosphere at the feed end. The cylinder 8 is revolved by any suitable driving mechanism such as that indicated and it is to be noted that the inclination of this cylinder, as well as all other cylinders employed in my apparatus, is very slight in order that the grosser particles of the ore shall not move too rapidly in advance of the fine particles, the object being to cause the gross and fine particles to move as nearly as possible together. This, I have found, materially increases the capacity and as a desirable degree of inclination I mention 1-inch to four feet.

The heated material discharging out of the cylinder 8 into the casing 16 falls by gravity thru the casing 16 and into the right hand end of the cylinder 14, which cylinder has a seal 12 in the casing 16 as above. The material as it falls into the cylinder 14 meets with reducing agent introduced thru the pipe 18, such reducing agent being preferably granulated coal. The advantages of introducing the reducing fuel at this point will be hereinafter pointed out. Reduction now takes place and the material gradually moves toward the lower end of the cylinder 14 from which it is eventually discharged into the casing 19 constructed substantially the same as the casing 16, there being a seal 12 between the cylinder 14 and the casing 19.

As the reaction of reduction with coal as the reducing agent is endothermic, there is a tendency for the temperature to become too low and, therefore, I introduce fuel, such as pulverized coal, thru the casing 19 into the cylinder 14 by means of the burner 20. This burner is preferably constructed as to sub-

stantially prevent the air for combustion thereof coming into contact with material being reduced, thereby preventing oxidation of the iron. To this end, I introduce the fuel
 5 with a small amount of carrying air, say, for example, 25 per cent of the air required for combustion thru the burner pipe 21, extending into which is an air nozzle 22 providing an annular space 23 thru which the coal and
 10 carrying air must pass. The coal and carry air is thus caused to assume a cylindrical form, the air admitted thru the nozzle filling the center of the cylinder of coal and air. Immediately beyond the end of the nozzle 22
 15 I provide a Venturi like portion 24. I prefer a pressure of about 40-pounds per square inch in the nozzle 22 and about a 2-ounce pressure in the burner pipe 21. By virtue of these pressures the controlled admission of air and
 20 the arrangement shown, the coal very largely surrounds the central core of air and the flame may be caused to travel a substantial length and the air for combustion to have an opportunity to combine with the combustible
 25 elements of the fuel before the gases so formed come into contact with the material being treated also, the air itself cannot come into detrimental contact with the material being reduced which is indicated at 25 in Fig. 2.
 30 It will also be seen on inspection of this figure that the burner 20 is located well toward the wall of the cylinder, that is to say, removed from the material within the cylinder.

Thus, as is the case with cylinder 8, air is
 35 excluded from the cylinder 14 with the exception of such air as is required for burning the fuel for heating the cylinder and this air is admitted under control.

The material leaving the cylinder 14 falls
 40 from the casing 19 into the cooling cylinder 26, there being a seal 12 between such cylinder and the casing 19. The cylinder 26 is subjected to a cooling means such as water discharge from the pipe 27, the length of the
 45 cylinder being such that the material is cooled below the point at which any appreciable oxidation can occur before it is ultimately discharged to the atmosphere. The lower end of the cylinder 26 discharges into the
 50 casing 28, there being a seal 12 between the cylinder and the casing. The discharge end of the cylinder 26 is perforated or foraminous, the size of the holes 29 being such as to only permit the material being treated to pass
 55 therethru. This material discharges on to the plate or chute 30, the lower end of which is curved to provide a trough, in which works a conveyor screw 31. This conveyor screw 31 terminates short of the end of the discharge pipe 32 of the casing 28 so that the material forms a plug for such pipe, acting as a seal excluding air which would otherwise be drawn into the cylinder 26 and thence into the other cylinders.

If for any reason bricks forming the lining

of the cylinders 8 and 14 should become dislodged and work down thru the cylinder 26, they can not discharge on to the plate 30 but pass beyond and fall on to the plate 33 for subsequent removal thru the door 34. Thus
 70 the conveyor screw 31 is protected.

The material discharged from the pipe 32 consists of the metal and the gangue. The metal may be separated in any desired way,
 75 as for example, by magnetic separation as diagrammatically indicated at 35 in Fig. 1.

Referring now to Fig. 4, this is a vertical section thru the casing 16 and illustrates the construction of the seal 12. Secured to the
 80 cylinder 14 is a ring 36, rivets 37 or other suitable fastening means being employed. This ring, therefore, revolves with the cylinder. Concentric with the ring 36, but spaced away therefrom, is a wearing ring or shoe
 85 38 and connecting these two rings is a corrugated metallic diaphragm 39, this diaphragm being held to the ring 36 by means of a ring 40 and a stud 41 with lock nut 42. A similar ring 43 secures the outer edge of the diaphragm 39 to the shoe 38, studs 44 being employed for this purpose. By this arrange-
 90 ment there is a tight joint between the diaphragm and the ring 36 and between the diaphragm and the ring 38. The ring 38 bears upon the annular flange 45, forming a part of the casing 16. A plurality of yokes 46 hold the shoe 38 against the flange 45, these yokes being subject to the pressure of the springs
 95 47 carried by the studs 41. The pressure of the springs may be adjusted by the means indicated and I have found from practical experience that a substantially air tight joint is provided between the shoe 38 and the flange
 100 45. If the cylinder 14 should shift longitudinally of its axis with respect to the casing 16, the diaphragm 39 will merely flex, the shoe 38 being firmly held against the flange 45 not withstanding that it revolves with the cylinder. If the longitudinal axis of the cylinder should shift, the shoe 38 will merely
 105 slide one way or another on the flange 45. This seal is a very important part of my invention and I have found it entirely reliable in operation. The simplicity of the seal will readily be appreciated. It is to be understood that the diaphragm and connected parts
 110 may be fastened to the stationary chamber 16 and the shoe 38 made to contact with a ring similar to ring 45 attached to the cylinder.

Reverting now to the desirability of introducing the reducing fuel at the point where
 120 the material discharges from the casing 16 into the cylinder 14, it will be seen that the reducing agent is immediately brought into contact with the material and is entrained
 125 with it, so to speak, becoming embedded therein and thoroughly mixed therewith instead of being segregated. Reducing action is thus immediately initiated and effectively continued at all points thruout the material so
 130

that not only the time of reduction but also the quantity of reducing material employed is reduced to a minimum. Since the ore is not melted and the temperatures employed are considerably lower than is customary, it will be obvious that there is a very heavy saving in fuel as compared to standard practice.

The product, if iron ore be the material treated, is very pure iron. It is not sponge iron as that term has been heretofore used in this art. At the temperatures which exist and other conditions and the general environment, no iron cyanogen compounds can be formed or absorbed and hence the iron contains no ferrite dissolved nitrides, which are objectionable. In any event the iron is rust resisting to a most remarkable degree and when it is used in the making of steel it produces a steel, the properties of which are far in excess of steel containing iron produced in the usual ways.

What I claim is:

1. Apparatus for the solid reduction of ores including a cylinder, means for rotating the cylinder, a stationary casing into which an end of the cylinder projects, an annular

flexible diaphragm rotatable with the cylinder, an annular shoe rotatable with the diaphragm, a plate on the casing against which the shoe bears for sliding movement thereover, and means for holding the shoe in engagement with said plate. 30

2. Apparatus for the solid reduction of ores including a cylinder, a stationary casing into which an end of the cylinder projects, a ring on the cylinder and rotatable therewith, a flexible diaphragm secured at its inner periphery against said ring, a shoe secured against the diaphragm at its outer periphery and rotatable therewith, a plate on the casing on which the shoe slides, and means yieldingly pressing the shoe against said plate. 35 40

3. Apparatus for the solid reduction of ores including a rotating cylinder member, a casing member for an end thereof, and a seal therebetween including a flexible diaphragm carried by one member, and annular shoe carried by the other member and slidably engaging the first member. 45

In testimony whereof, I have hereunto signed my name. 50

JOHN W. HORNSEY.