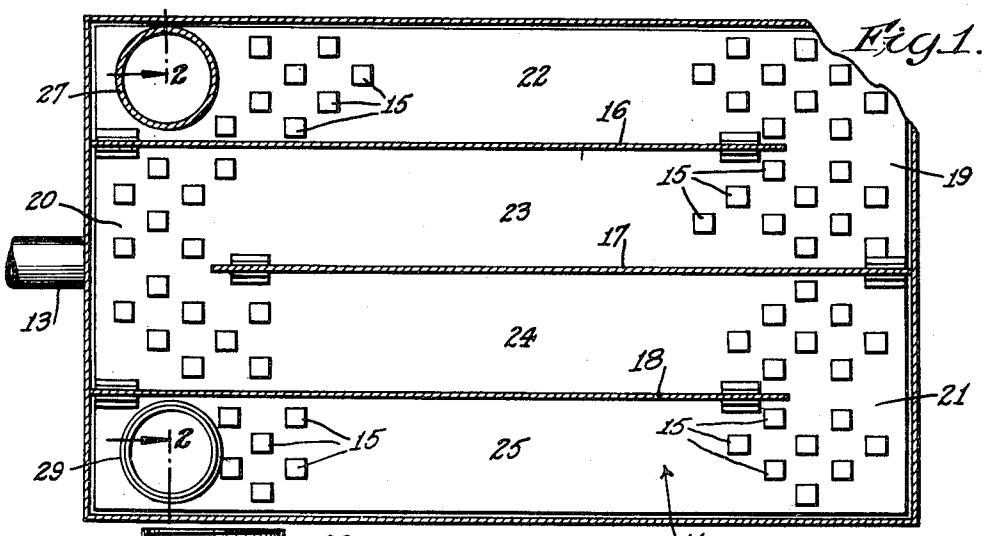
Nov. 30, 1948. C. F. RAMSEYER ET AL 2,455,092

APPARATUS FOR REACTING FINELY DIVIDED SOLID MATERIAL AND A GAS

Original Filed April 6, 1943 3 Sheets-Sheet 1

Fig. 1.



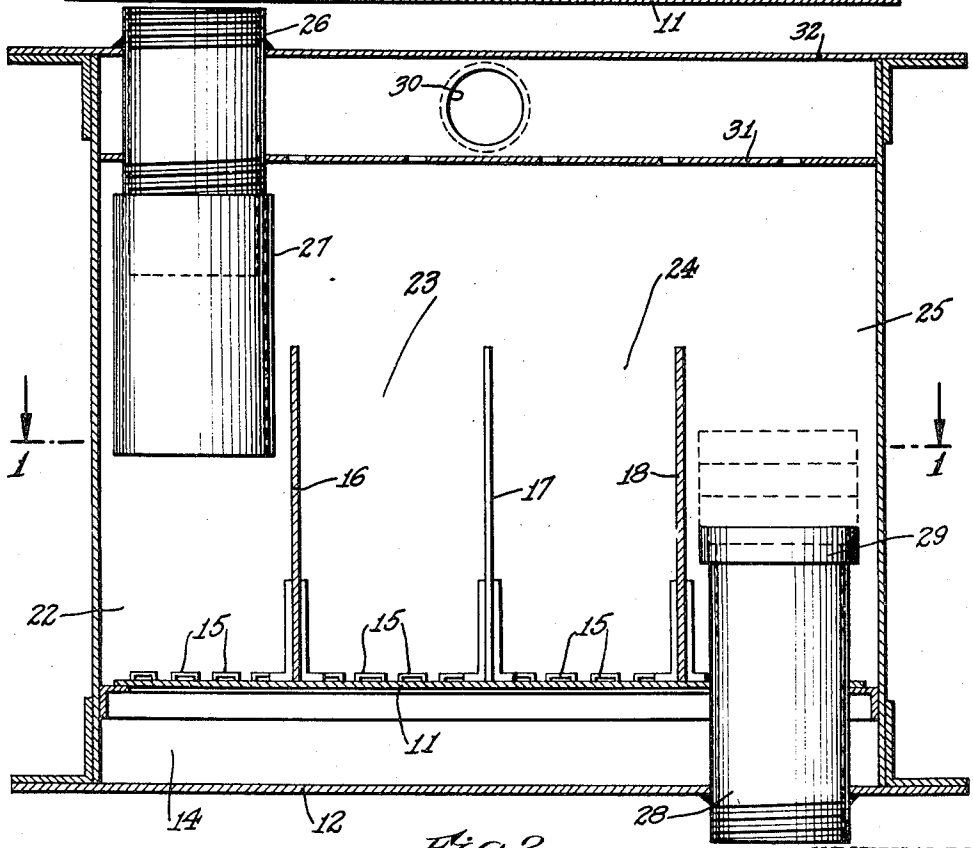


Fig. 2.

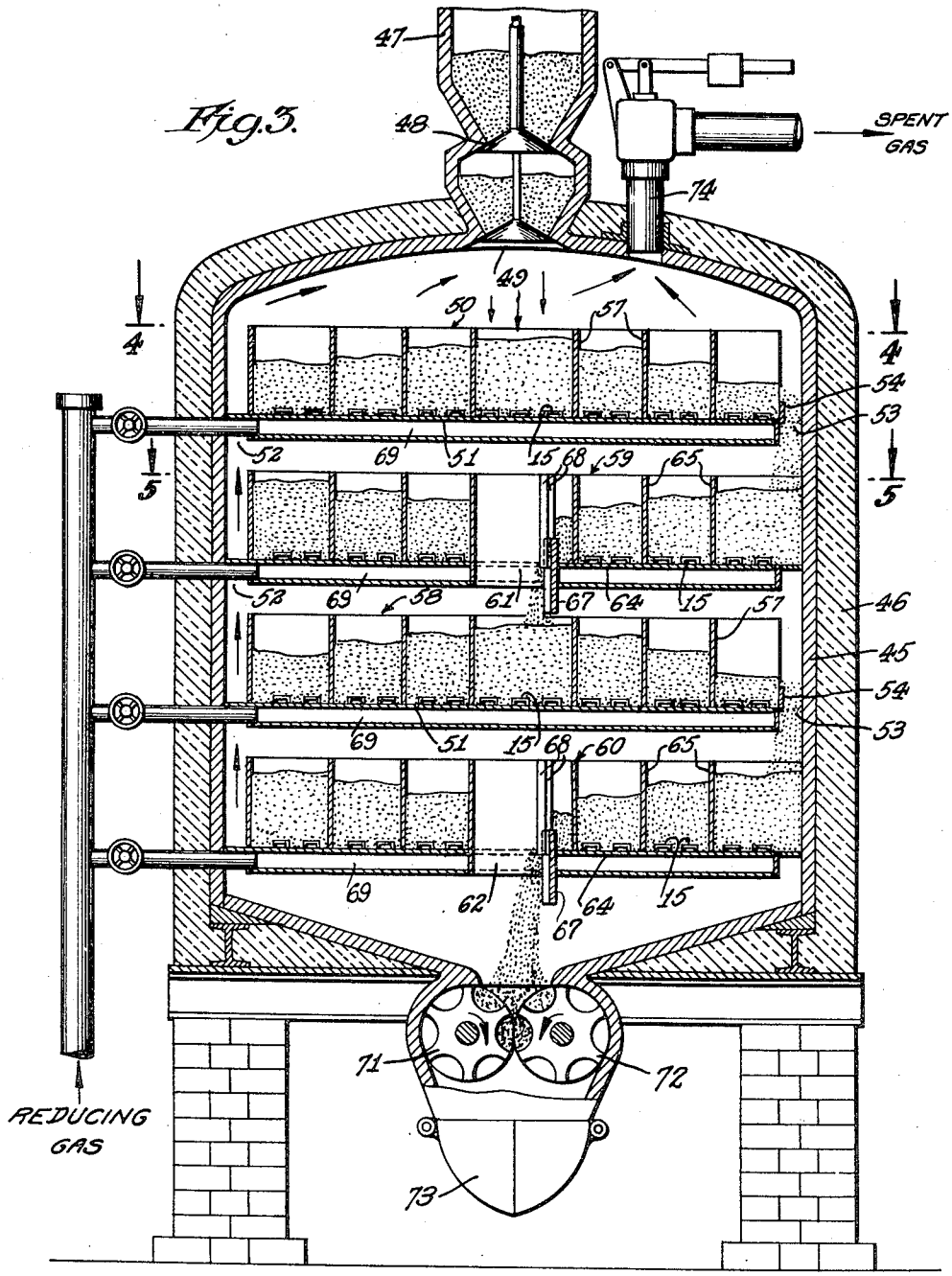
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Fig. 3.



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Fig. 4.

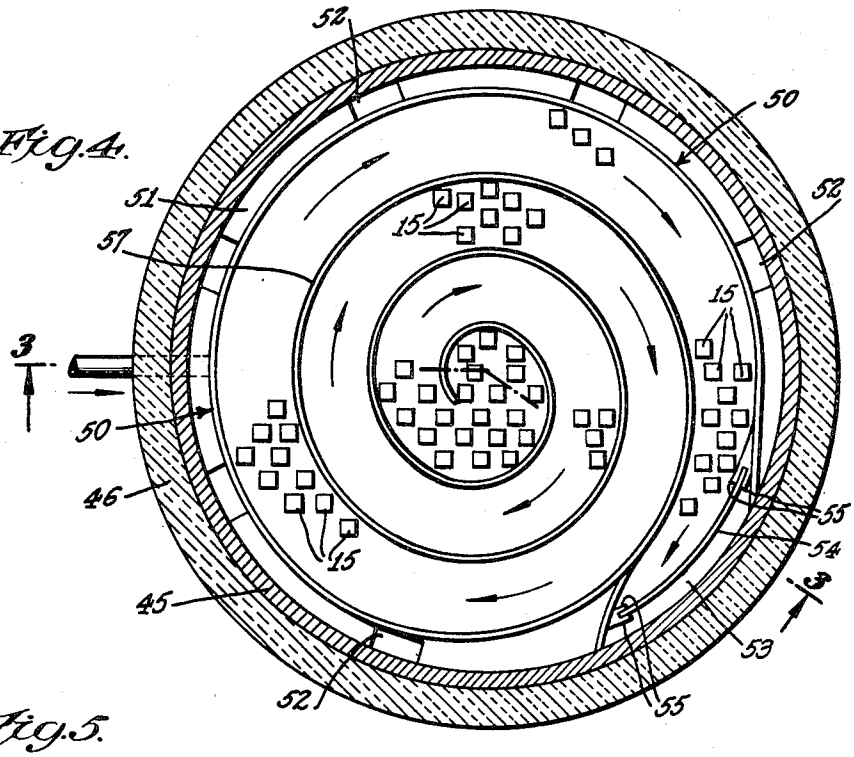
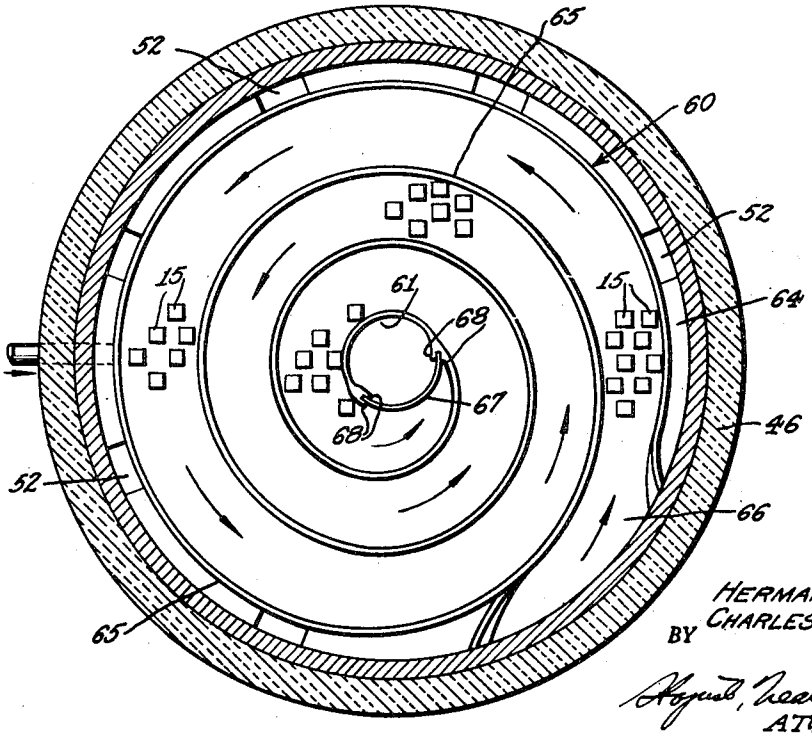


Fig. 5.



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2,455,092

APPARATUS FOR REACTING FINELY DIVIDED SOLID MATERIAL AND A GAS

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Original application April 6, 1943, Serial No. 481,968. Divided and this application December 11, 1943, Serial No. 513,910

3 Claims. (Cl. 23—277)

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This invention relates generally to reactions between finely-divided solid material and a gas, and has particular reference to methods and apparatus for effecting reduction of finely-divided metallic ores or other oxides or sulphides, such as iron ore, pyrites, mill scale, and the like, as well as non-ferrous metals, by means of a reagent gas, although the invention is not limited to reduction of metals, but may also be used for other purposes involving reactions between fine solids and gases. This application is a division of application Serial No. 481,968, filed April 6, 1943, and which is now Patent No. 2,389,133, issued November 20, 1945.

As is described in said application, it is known that finely-divided solids behave as a fluid, and particularly so when continuously aerated, as by a reagent gas performing the dual functions of reduction and aeration. This phenomenon has been utilized in reducing finely-divided ores or other oxides by means of hot reducing gases caused to flow through a bed of the ore under such conditions that the bed assumes a state equivalent to fluidity, and accordingly flows along the hearth from the feeding to the discharging point while the ore is being reduced. In order to induce the flow of the finely-divided ores which are thus rendered fluent or "fluidized," a gravity head is maintained between the feed end and the discharge end of the hearth. The head necessary to maintain this flow of the bed varies with variations in the fineness of the solid, the chemical nature and contour of the grains, the speed of flow required for reduction, which depends to an extent on how tightly the oxygen is bound up with the metal in the particular ore, the depth and length of the bed, the pressure and constituency of the reagent gas available or desirable, and the like.

It is accordingly desirable to so arrange the furnace or other treating or processing apparatus, in which the reaction is carried out, that it will accommodate the different enumerated conditions instead of switching from one furnace to another whenever a change in operation is dictated by any one or more of the said conditions. The present invention is directed to methods and apparatus for rapidly and simply accommodating operating conditions in the furnace or other reactor to the requirements of changed or different conditions, whereby the same furnace may be used at different localities without change and may also be adapted to changing local conditions.

In accordance with the invention, the depth

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of the bed from the feeding to the discharge end of the hearth may be varied at will, by adjusting the discharge means, so that the depth of the bed at the feed means is not only higher than at the discharge means to provide the necessary gravity head, but the depth gradient is adjusted so that the material flows along the hearth at the rate and under the conditions best suited to most efficient results. In either case, the discharge end of the hearth is provided with a dam over which the material discharges, and this dam may be raised or lowered to vary the gravity head, or both the feed means and the dam at the ends of the hearth may be adjusted according to this invention, the adjustment thus provided depending upon the above-enumerated variable conditions.

As described in greater detail in said application, the hearth may be of any desired form, but for compactness and thermal operating efficiency, it is preferred that the material be confined to a zigzag course or to a spiral course, in the latter case the material being discharged either at the center of the spiral or at the periphery, as desired. In each case the discharge dam is adjustable to vary the gravity head of the material.

In the preferred form of feed-adjusting means, the feed means comprises a vertical duct, usually a tube, leading into the apparatus and so made as to be adjustable vertically, whereby its lower end feeding the material on the hearth is raised or lowered to a predetermined height above the hearth, the incoming material always entering the bed below the surface, so that a mnimum of dust is produced. The edge of the discharge dam over which the material discharges from the hearth may be raised and lowered at will in order to adjust the depth of the bed at the discharge end of the hearth to conform to operating requirements. In one form the dam may be the upper end of a tube which is adjustable in height, and in another form the dam may be a plate which is adjustable in height, to the same end. Other equivalent or alternative arrangements may be provided within the scope of the invention.

It will be seen that the present invention provides very simple and effective methods and means to adapt a standardized reducing furnace or other processing unit to accommodate the varying conditions encountered in operation, particularly in respect to the chemical nature, physical structure, and fineness of the material being treated, the speed of reaction required,

the constituency and the pressure of the gas desired or available for effecting the dual function of reducing or otherwise treating the material and rendering it fluent for flow along the hearth in the manner described, and the like.

For a more complete understanding of the invention, reference may be had to the accompanying drawings, in which:

Figure 1 is a horizontal section through a rectangular form of furnace embodying a zigzag course for the material, and illustrates the location of the adjustable feed and discharge means, as seen along the line 2—2 of Fig. 2;

Fig. 2 is a vertical section through the furnace of Fig. 1, and illustrates the construction of the adjustable feed and discharge means, as seen along the line 2—2 of Fig. 1;

Fig. 3 is a vertical section through a circular form of furnace embodying a spiral course for the material being treated, as seen along the line 3—3 of Fig. 4; and

Figs. 4 and 5 are horizontal sections therethrough as seen along the lines 4—4 and 5—5 of Fig. 3.

Referring to Figs. 1 and 2 of the drawings, the furnace 10 comprises a rectangular housing preferably formed of chrome steel or other suitable heat-resisting material provided with an adjustable bottom formed by a horizontal upper deck or hearth 11, spaced above the lower deck or bottom 12, so as to provide a sealed gas chamber 14 into which the preheated reducing gas is supplied under pressure by pipe 13. The upper deck or hearth 11 is studded with spaced bubble caps 15 shown in greater detail in said application and providing for diffusion of the gas from chamber 14 through the bed of finely-divided material on the hearth under such conditions as to impart fluidity to the bed in the manner described.

The upper surface of hearth 11 is sub-divided by several parallel vertical partitions 16, 17 and 18, partition 16 extending from the lefthand end of the hearth 11 but stopping short of the righthand end thereof to provide the end passage 19. Center partition 17 extends from the righthand end of the hearth 11, but stops short of the lefthand end thereof, so as to provide the end passage 20, whereas partition 18, like partition 16, extends from the lefthand end of the hearth but stops short of the righthand end thereof, leaving passage 21. It will be observed that these partitions 16, 17 and 18 provide a zigzag channel 22, 19, 23, 20, 24, 21 and 25 of substantial length in a small space equivalent to a long tunnel-like furnace. As shown in Fig. 2, the upper edges of partitions 16, 17 and 18 stop short of the top of the furnace.

Discharging into the closed end 22 of the channel at the lefthand upper corner of Fig. 1 is the vertical feed pipe 26 for charging the furnace 10 with the finely-divided oxides or other material to be processed. Pipe 26 is preferably welded to the top of the furnace 10 and its lower end is threaded and carries an adjustable collar 27 which may be raised and lowered and serves the purpose of predetermining the depth of the feed end of the bed on hearth 11. By screwing this collar 27 upwardly or downwardly on pipe 26, the depth of the bed at the feed end of the hearth 11 may be adjusted at will.

At the discharge end of the zigzag channel on hearth 11 is a discharge pipe 28 welded to the bottom 12 of the furnace and extending through the gas chamber 14 and hearth 11 to a point above the surface of the hearth 11. The upper end of

discharge pipe 28 is threaded for the reception of one or more collars 29, whereby the depth of the bed at the discharge end of the zigzag channel hearth may be adjusted at will. Collars 29 screw into each other as shown and may be increased or decreased in number to obtain the desired depth of bed at discharge, which is always lower than the depth of the bed at the feeding end, so that a head of the material is maintained in order that it may flow in the manner described. The discharge pipe 28 may lead directly to a briquetting machine, not shown, for compacting the reduced material into briquettes while still hot from the reducing operation and while still in a reducing atmosphere, in the manner described in Patent No. 2,287,663, issued June 23, 1942, to H. A. Brassert. If desired, the reduced material may be further concentrated before briquetting, also as described in said patent.

Leading from the upper end of the furnace 10 is a spent gas discharge pipe 30 which may conduct the gas to a reforming or recovering plant providing for re-use of the gas. A perforated plate 31 is preferably suspended in spaced relation to the top 32 of the furnace, so that the spent reducing gas diffuses uniformly therethrough and its velocity retarded so that it does not carry out of the furnace any substantial amount of fines that may result from dusting.

In operation, in accordance with the process of this invention, the furnace 10 is supplied with iron ore or other oxide or material to be processed through feed pipe 26, the material being previously ground to 20 to 150 mesh and concentrated to substantially remove the gangue according to known methods. The depth of the bed at the feed end is predetermined by the position of the collar 27 on the feed pipe 26 and the depth of the bed at the discharge end is predetermined by the length of the discharge pipe 28, as adjusted by varying the number of collars 29. As previously mentioned, the height of the upper end of the discharge pipe 28 above the deck 11 is always less than the height of the lower end of the upper collar 27 above the deck 11, so that a head of the finely-divided material is maintained at the feed end, the depth gradient depending upon depth of bed desired, speed of reduction required, nature and fineness of the ore, nature and pressure of reducing gas, temperature, etc.

The reducing gas, preferably preheated to have a temperature in the bed of from 1100 to 1500° F., is supplied by pipe 13 to the chamber 14, below the hearth 11, and at a pressure of, say, three pounds per square inch above the internal furnace pressure. At this temperature the gas readily reduces the oxide but is not high enough to cause the particles to agglomerate and frit together, so that they remain separate and distinct throughout the operation and hence retain the fluid-like flow when permeated by the gas in the manner described. The furnace is sealed and may be operated at superatmospheric pressure, as described in said application, and several such furnaces 10 may be superimposed on each other for successive operation for progressive reduction. If the furnace is operated on hydrogen gas, a convenient pressure is 250 pounds per square inch, since in the common method of producing hydrogen, the gas is compressed to this pressure.

Instead of arranging the elongated hearth channel in zigzag fashion as shown in Fig. 1, it may be arranged spirally, as shown in Figs. 3, 4 and 5. Referring to Fig. 3, the furnace preferably comprises a cylindrical housing 45 of steel

or other suitable heat-resistant metal, enclosed in suitable heat insulation 46 and preferably capable of withstanding internal superatmospheric pressures on the order of 15 to 30 pounds per square inch gauge, and preferably much higher pressures, as aforesaid. The upper portion of the housing is provided with a centrally located double bell and hopper arrangement 47 including the separately-operated upper feed bell 48 and lower sealing bell 49. This arrangement serves as a pressure lock, enabling feeding of the finely-divided metallic oxide to be reduced into the housing 45 without losing pressure during the opening of the feed bell 48.

Located within the housing 45 and positioned one above the other is a series of independent, self-contained hearths, four of which are shown in Fig. 3, but more or less may be used, depending upon requirements. The top unit 50 comprises a hearth deck 51 extending across the housing and having spaced peripheral spent gas slots 52 and one peripheral discharge slot 53 for the material under treatment. The discharge slot 53 has a dam 54 extending across its mouth, and frictionally held in any vertical height between flanges 55 at each side, as shown in Fig. 4.

The top hearth deck 51 is studded with bubble caps 15 as shown in Fig. 4, and which are the same as those described in connection with Figs. 1 and 2, diffusing reducing gas into the finely-divided material constituting the bed on each hearth and thereby rendering it fluent.

Secured on the upper surface of the top hearth 51 is a spiral partition 57 of heat-resistant steel. The length of the spiral partition 57 from the center, to which the material is discharged from the double bell and hopper feed 47, to the discharge passage 53 at the periphery, depends upon the volume of material to be treated and the rate of its travel necessary to secure the desired reduction.

The third hearth from the top, designated 58, is identical to the top hearth 50, but the second hearth from the top, designated 59, and the lower hearth 60, are constructed differently in that they have center discharge passages 61 and 62, respectively, instead of peripheral discharge passages, since these two decks receive the material from the corresponding upper decks at their periphery, for travel spirally inwardly to the center. The second and lower hearths, 59 and 60, are identical, and the hearth deck 64 of each is fitted with a spiral partition 65 leading from the periphery at 66 to the center discharge opening 61 fitted with the dam 67 held frictionally at any desired vertical height between flanges 68 at each side, as shown particularly in Fig. 5. Also, like upper hearth 50, the hearths 59 and 60 are provided with an enclosed bottom gas chamber 69.

The depths of the ore bed on the hearths 50, 58 and 59, 60, are adjusted by raising and lowering the corresponding discharge dams 54 and 67 in their corresponding flanges 55 and 68, thus achieving the same result as the addition or removal of the collars 29 to or from discharge pipe 28 shown in Fig. 2.

In operation of the spiral hearth type of furnace illustrated in Figs. 3, 4 and 5, the finely-divided material, such as iron ore or other material to be processed is fed from hopper 47 upon the center portion of upper hearth 50 and, by reason of the preheated pressure gas percolating through the bubble caps 15 the desired fluidity

is imparted to the material and reduction takes place as it flows spirally from the center to the periphery of the hearth to discharge over dam 54, which is adjusted in height as described, in accordance with the gravity head between the feed and discharge ends of the bed as determined by the aforementioned variables. The material discharging from the upper hearth 50 over dam 54 falls on the periphery of hearth 59 below, and the same procedure takes place except that the material flows inwardly to the center of the spiral to discharge over dam 67, which is adjusted to the proper height in accordance with this invention to vary the gravity head of the material on the hearth 59 in accordance with operating requirements, as described.

The operation is repeated on the successive hearths below and the material is progressively reduced to a greater extent as it descends until substantially entirely reduced it discharges on the center of lower hearth 60 over the corresponding adjustable dam 67 to be compacted into primary solids, such as briquettes by the briquetting rolls 71 and 72 while still hot, and still in the reducing atmosphere, as described in said Patent No. 2,287,663. The briquettes collect in hopper 73 and may be periodically removed. The spent reducing gases discharge through pipe 74, and the entire furnace may be maintained under superatmospheric pressure if desired, as described in greater detail in said application.

Although two types of adjustable head discharge dam and one form of adjustable head feed means have been illustrated and described herein, it is to be understood that the invention is not limited to these forms, but that other forms may be used within the scope of the invention as defined by the appended claims.

We claim:

1. In an apparatus for reacting finely-divided solid material and a gas diffused through a bed of the material from below at such pressure as to render the bed fluent, the combination of an elongated substantially horizontal perforate support for said bed, chamber means beneath said support for introducing gas through said support, feeding means spaced above one end of said support for supplying said material thereto, a discharge member having an opening through which the material discharges and means movably mounted on said discharge member so that the height of the opening is varied relatively to said support to vary the depth of the bed on said support.

2. In apparatus for reacting finely-divided solid material and a gas diffused through a bed of the material from below at such pressure as to render the bed fluent, the combination of an elongated substantially horizontal perforate support for said bed, a chamber beneath said support for introducing gas through said support, feeding means spaced above one end of said support for supplying said material thereto, a discharge member at the other end of the support, substantially vertical guide means on said discharge member extending upwardly from said support and a discharge dam slidably mounted in said guide means for adjustment relatively to said support so that adjustment of said dam in said guide means varies the depth of the bed at the discharge end of the support.

3. In apparatus for reducing finely-divided metallic oxides with a gas diffused through a bed of the material from below at such pressure as to render the bed fluent, the combination of an

elongated substantially horizontal perforate support for the bed arranged as a channel, a chamber beneath said support for introducing gas through said support, a housing for said support and bed, feed means for the material leading into said housing at one end of said channel, a substantially vertical tube through which said material is discharged from said support, said tube being fixed to said housing, and at least one collar attachable to and detachable from the upper end of said tube to thereby vary the depth of the bed at the discharge end of the channel.

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