Oct. 6, 1936.

B. M. CARTER

2,056,564

APPARATUS FOR ROASTING ORES

Original Filed Aug. 11, 1930

2 Sheets-Sheet 1

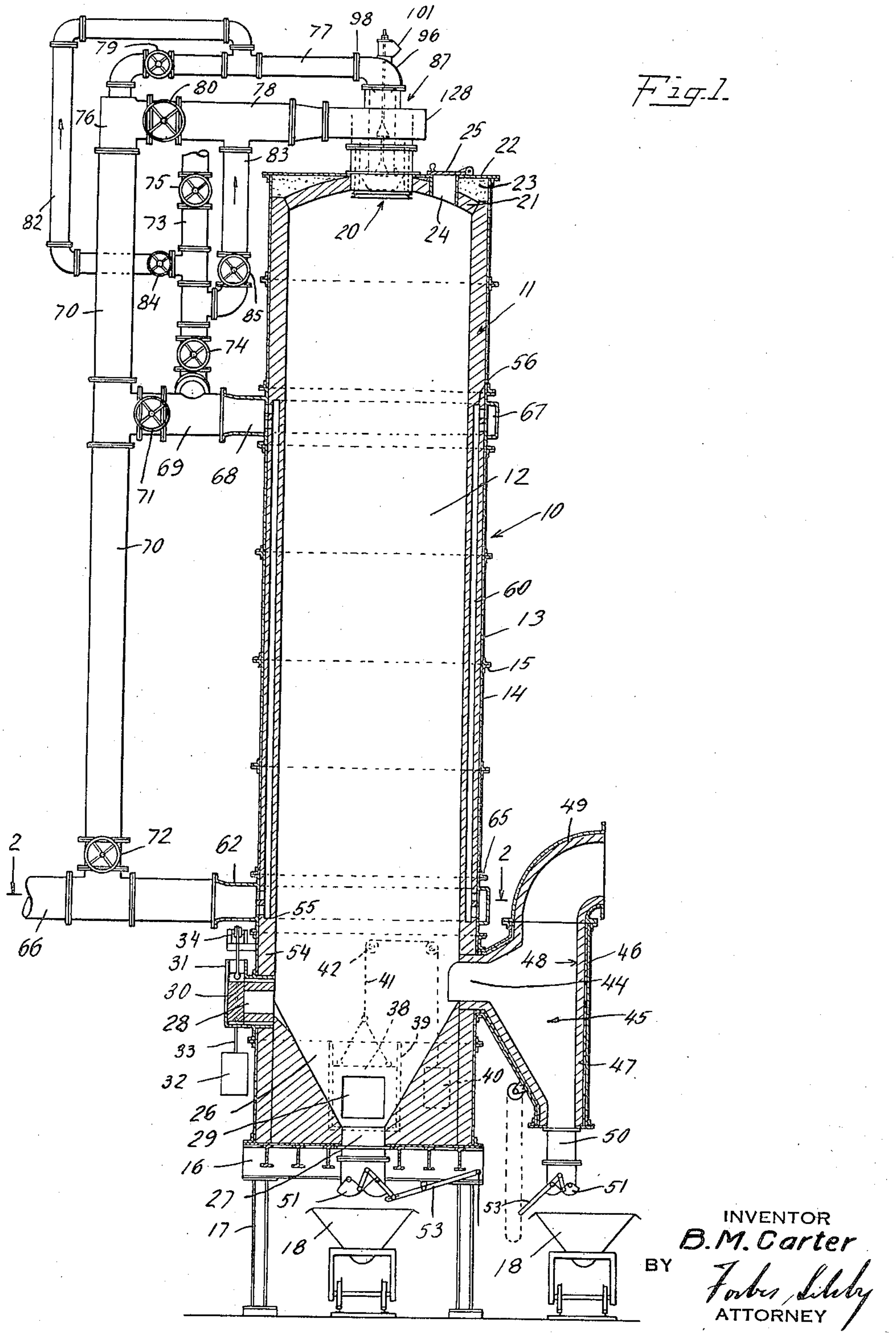

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Fig. 4.

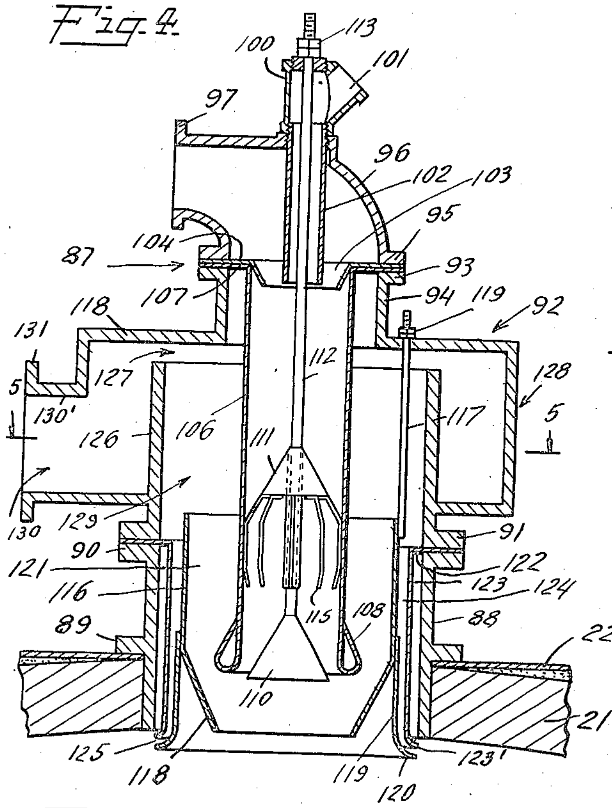



Fig. 2.

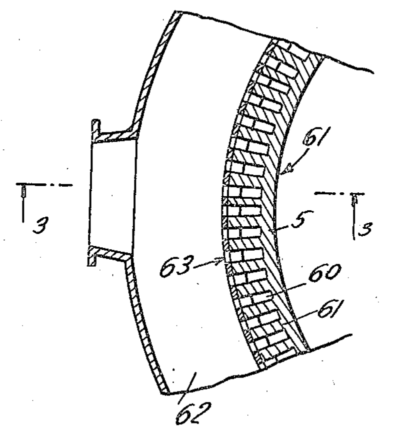



Fig. 3.

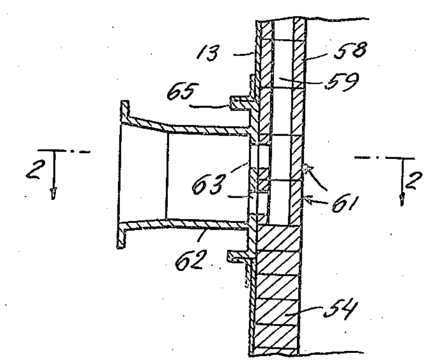
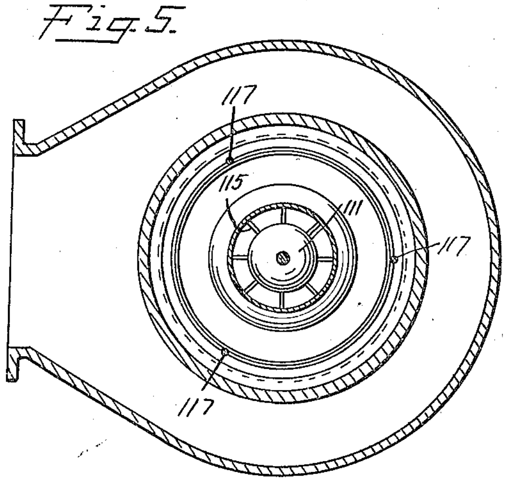



Fig. 5.

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# UNITED STATES PATENT OFFICE

2,056,564

## APPARATUS FOR ROASTING ORES

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Application August 11, 1930, Serial No. 474,457
Renewed June 9, 1934

10 Claims. (Cl. 266—28)

This invention relates to an apparatus for roasting finely divided sulfide ores, flotation concentrates and the like, and more particularly to apparatus for roasting finely divided pyrites ores or flotation concentrates, for the purpose of thoroughly desulfurizing the same and producing sulfur dioxide for use in the manufacture of sulfuric acid.

The present practice in pyrites fines roasting generally involves the use of mechanically operated multiple hearth constructions, such, for example, as the well known MacDougall, Herreshoff, and Wedge burners, and while these burners provide a very effective roasting of the fines, their complicated construction and operation involve considerable initial and maintenance expense.

As distinguished from the "bed" roasting operation of these burners, it has been suggested to roast the fines while in gaseous suspension, wherein the fines are either injected into a roasting chamber in suspension in an oxidizing gas, or are simply showered downwardly into the roasting chamber wherein they encounter cross or counter currents of the suspending gas.

This suspension roasting is best applicable when the fines are in a very finely divided state, e. g. as flotation concentrates, and presents the notable advantage over the mechanical multiple hearth operation of considerably lowering the cost of production, by reason of the elimination of the involved and expensive rabbling and other apparatus which distinguishes the construction and operation of the mechanical burners. In the practice of this suspension roasting, however, and particularly as applied to roasting pyritic fines, difficulties of some moment are presented which must be overcome before the theoretical advantages of this type of operation are practically available.

As indicated in U. S. Patent No. 1,758,188, dated May 13, 1930, to H. J. Cordy and W. J. Burgoyne, a serious difficulty encountered in the suspension roasting of pyrites fines is the objectionable formation of accretions or "scar" on the walls of the roasting chamber during the roasting operation. These scar masses rapidly assume imposing proportions, and in a relatively short time, masses weighing several hundred pounds are commonly formed. Unless these masses are removed, obstruction of the roasting passage will result, and the operation will be otherwise seriously hindered. The accretions may be manually broken away, or "barred" down from the walls periodically, but the frequency with which this operation must be repeated to keep the scar formation within reasonable limits results in too frequent interruption of the operation and, in addition, the wear and tear on the apparatus occasioned by the heavily falling masses raises even more serious objection to this manner of removal. Moreover, the problem of incomplete desulphurization is not solved thereby for considerable amounts of undesulphurized material confined within the accretions pass off in the cinder substantially unaffected.

The scarring problem noted has been previously extensively investigated and, while the exact reason for its occurrence is rather difficult to determine, it has appeared to be more or less ascribable to the pronounced tendency which sulfide fines, particularly iron pyrites, exhibits to sinter at a particular stage of its desulphurization, at which stage it readily adheres to the inner walls of the roasting chamber and builds up accretions thereon. Investigation of a typical iron-pyrites ore in this relation appeared to indicate that at a point in its transition from $FeS_2$ to $Fe_2O_3$ which would roughly correspond to the oxidation of one atom of the sulphur in the $FeS_2$, the partially desulphurized material sinters much more readily than at prior or subsequent stages in the desulphurization. This may perhaps be explained either on the basis that FeS is the major form existing at this particular stage, and that the FeS per se sinters much more readily than any of the other transition or final products, or possibly that there is a formation of a eutectic of FeS and $Fe_2O_3$.

Various methods of roasting the pyrites fines in suspension have been heretofore investigated, in an endeavor to find a means of overcoming the effect of this transitory sintering condition. It has previously been found (see U. S. Patent No. 1,758,188, referred to above) that by injecting a quantity of the oxidizing gas adjacent the walls of the roasting chamber in the upper part thereof, that scarring of the chamber walls is largely eliminated, thorough desulphurization of the fines is obtained, and concentrations of sulfur dioxide are obtainable which are very suitable for use in the manufacture of sulphuric acid.

The present invention relates generally to methods of suspension roasting as outlined in the foregoing paragraphs. The general aim of the invention is directed toward the improvement of such processes with the particular object in view of increasing the flexibility of operation of such methods, and increasing the efficiency thereof. The invention further contemplates the provision of improvements in apparatus for suspension roasting of sulfide fines and broadly includes general improvements in several items of furnace construction, ore feed mechanism, and means for economically regulating the temperature of the combustion supporting gas in such a manner as to facilitate efficient roasting in the furnace or reaction chamber.

The invention accordingly comprises the several steps of the process and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combination of elements and arrangements of parts which are adapted to carry out the improved process, together with such other features of novelty which will appear from the following description taken in consideration with the accompanying drawings.

In the drawings—

Fig. 1 is an elevation, mostly in section, of a preferred form of roasting furnace embodying the present invention;

Fig. 2 is an enlarged fragmental horizontal section on the line 2—2 of Figs. 1 and 3;

Fig. 3 is a vertical section on the line 3—3 of Fig. 2;

Fig. 4 is a vertical section of the feed mechanism;

Fig. 5 is a horizontal section on the line 5—5 of Fig. 4;

Referring to the drawings, and particularly to Fig. 1, the reference numeral 10 indicates a shaft burner comprising a shell generally indicated at 11, constructed of some suitable refractory material such as firebrick or the like, which defines a roasting or reaction chamber 12 of cylindrical cross-section throughout the major portion of its length. A casing 13 of steel or similar material about the sides of the shell 11 serves to reinforce the same. It will be apparent that the height of the burner is several times greater than its cross-sectional dimension. For convenience in construction, the steel shell 13 may be made up of several cylindrical sections 14 suitably secured together at their contiguous edges by bolts or rivets passing through flanges 15. The shaft burner as a whole rests on a suitably constructed platform 16 elevated by the supports 17 sufficiently to permit the operation of the cinder cars 18 beneath the outlets of the cinder pit of the burner and the dust chamber.

The chamber 12 is provided with a feed inlet 20 in the center of the burner crown 21. The top of the steel shell 13 is closed off by the cover plate 22 suitably attached at its edges to the upper flange of the top section of the steel shell 13. The space 23 between the crown 21 and the cover plate 22 is filled with suitable insulating material. The top of the burner is provided at several points about its circumference with suitable poke or inspection holes 24. Each hole 24 is equipped with an outwardly opening closure 25 which may be provided with suitable sight glasses as are customarily employed in such apparatus. In the embodiment of the invention illustrated on the drawings, only a single poke hole 24 is shown. It will be understood that any number of such holes may be employed, arranged in any manner necessary or desirable to facilitate the proper operation of the burner.

The lower end of the roasting chamber 12, as indicated on the drawings, is constructed to provide a trough-like cinder pit 26, constituting the bottom of the chamber. The cinder pit extends diametrically across the burner and terminates at the lower end in any suitable number of cinder outlets 27. The upper end of each outlet 27 is covered by a grate, not shown, which serves to prevent the passage of large chunks of cinder through the outlets 27. The lower end of the burner is equipped with work holes indicated at 28 and 29. While the burner is in operation the work hole 28 is closed off by the sliding door 30 constructed of a suitable steel frame enclosing a firebrick panel which, when the door is closed as shown in Fig. 1, is directly in line with the opening 28. The door 30 is vertically movable in a frame 31, but normally rests in the position shown in Fig. 1. However, the closure may readily be moved upwardly in the frame 31 by movement of the counterweight 32 connected to the door 30 through the cable 33 running over suitably arranged pulleys 34. Work hole 28 is generally for the purpose of inserting oil burners into the chamber 12 to preheat the furnace before the roasting operation is initiated.

The work hole 29 is essentially for the purpose of affording access to the bottom of the cinder pit 26, so that any large accretions which may form on the walls of the roasting chamber and fall into the pit, may be broken up by sledges by workmen to such size as to permit passage through the grates covering the upper ends of the outlets 27. The door 38 is constructed similarly to the door 30, and is arranged to slide vertically in the frame 39. The door 38 is counterbalanced by the weight 40 connected to the door 38 by the cable 41 passing over the pulleys 42. It will be apparent from the drawings that the work hole 29 and the door 38 are arranged on the far side of the burner shaft. Any number of work holes 28 and 29 suitably arranged about the lower circumference of the burner may be employed as desired.

The main gas outlet 44 is constructed in the wall of the burner immediately above the upper edge of the sloping walls forming the cinder pit 26. The outlet 44 is of substantial cross-sectional dimensions, and serves to connect the roasting chamber 12 with the cinder pocket indicated at 45. The pocket 45 is a comparatively large chamber of substantial vertical length. The steel casing 46 forming the outer shell of the pocket is rigidly connected to the shell of the burner, and is supported in the position illustrated in Fig. 1 by suitable superstructure not shown in the drawings.

The cinder pocket is lined with firebrick 47, and is arranged with a vertically disposed wall 48 directly opposite the axis of the outlet 44. A stream of gas issuing from the burner through the outlet 44 strikes the vertical wall 45 at a right angle, thus abruptly changing the course of the gas stream and causing the gas stream to drop substantially all the heavy cinder particles carried out of the reaction chamber in suspension in the exit gas. The pocket outlet terminates in an elbow 49, suitably lined with firebrick, and arranged to permit connection between the pocket and the exit gas main, the latter including the usual dust chamber not shown. It will be apparent that the course of the gas through the cinder pocket 45 is upward, this arrangement serving to cause a large quantity of the fine dust particles to separate and settle out of the gas stream. The pocket 45 is formed with a funnel-shaped bottom terminating in an outlet 50. The numeral 51 indicates conventional gates on the lower ends of the outlets 27 and 50, which gates may be manipulated by any necessary mechanism indicated diagrammatically on the drawings at 53.

The lower end of the shell 11 is constructed of the usual firebrick 54 up to the point indicated on the drawings by the numeral 55. The same construction is employed in the upper end of the shell from the point indicated by the numeral 56 upwardly to the crown 21. That section of the shell 11 disposed between the points 55 and 56 may be conveniently termed a heat transfer section. The heat transfer section comprises horizontal series of radially disposed firebrick indicated at 58 in Fig. 3. The individual bricks each include a central passage 59, so arranged that when the several horizontal series of bricks are superposed, and in position to form the shell of the roaster, there are then provided within the walls of the transferrer section, the several vertical passages or conduits 60 which begin at the lower end of the transferrer section at 55, and terminate at the upper end thereof at 56.

As shown in Fig. 3, two horizontal series of bricks 61 are arranged at the lower end of the transferrer section immediately within the circumference, the bustle pipe 62 surrounding the burner at the lower end of the transferrer section. The bricks of both series 61 are provided with suitable openings 63, thus establishing communication between the several vertical conduits 60 and the interior of the bustle 62. The construction of the shell 11 immediately adjacent the bustle 62 is clearly shown in the enlarged details in Figs. 2 and 3. In Fig. 2 it will be seen that the bricks constituting a series 61, are each radially disposed with reference to the vertical axis of the burner, and that each vertical conduit 60 is in direct communication with the bustle 62 by reason of the openings 63 in each brick of a series 61.

The bustle 62 is suitably attached to the adjacent steel section of the shell 13 by flanges as indicated at 65 in Fig. 3. The bustle 62 is in direct communication with the inlet pipe 66, Fig. 1, which is in turn connected through another pipe line, not shown, to the plant blowers.

The burner 10 is also encircled at the upper end of the transferrer section by an outlet bustle 67. The construction of the bustle 67, and the arrangement by which the same is in communication with the upper ends of the vertical conduits 60 is in all respects the same as that previously described in connection with the bustle 62, and illustrated in the enlarged details in Figs. 2 and 3.

The outlet 68 of the bustle 67 is directly connected to the short pipe section 69 which is joined at its opposite end to the main inlet pipe 70. The passage of gas through pipe 69 into the main vertical pipe 70 is controlled by the valve 71. The lower end of the vertical main 70 is connected to the inlet 66 as shown in Fig. 1, and the admission of gas from the inlet 66 to pipe 70 is controlled by valve 72. The pipe 69 is in communication with the plant stack and the atmosphere through the pipe 73 which includes therein the control valves 74 and 75. The upper end of the vertical main 70 terminates in a T 76. The T 76 is in communication with conduits 77 and 78 controlled by the valves 79 and 80 respectively. That section of the pipe 73 between the valves 74 and 75 is in direct communication with the conduits 77 and 78 through pipes 82 and 83 respectively, each controlled by the valves 84 and 85. The pipe system just described supplies air or other oxidizing gas to the ore feeding mechanism indicated generally by the numeral 87.

The feed mechanism, illustrated more or less diagrammatically in Fig. 1, is shown in detail in the section of Fig. 4. In Fig. 4 the crown 21 of the burner, and the top plate 22 are apparent. The cast iron cylindrical sleeve 88 is set into a circular opening in the crown 21, and is held in the position shown by the horizontal flange 89. A flange 90 is formed on the upper edge of the sleeve 88 and is adapted to be bolted or otherwise attached to the bottom flange 91 on the casting or coupling member indicated generally at 92. The top flange 93 on the upper end of the cylindrical portion 94 of the coupling 92 is similarly arranged to support and to be attached to the bottom flange 95 on the lower edge of the primary gas inlet casting 96. The flange 97 on casting 96 affords means for connecting the casting 96 to the inlet conduit 77, as indicated at 98 in Fig. 1.

The ore inlet chamber casing 100 having the inlet connection 101 secured thereto rests on the top of the casting 96. The upper end of the pipe 102 is threaded into the lower end of the chamber casing 100. The exterior threads on the upper end of the pipe 102 extend downwardly far enough to thread into the opening in the top of casting 96, thus retaining casing 100 and pipe 102 in place. The frusto-conical shaped orifice plate 103 is supported in the position shown by the horizontally disposed flange 104 which is gripped between the flanges 93 and 95. The terminal cylinder 106, forming a primary inlet conduit, is likewise provided at its upper edge with a flange 107 similarly clamped between the flanges 93 and 95. The cylinder 106 extends downwardly and terminates in a curved rim 108, the function of which will hereinafter appear. The dispersion cones 110 and 111 are fixed to the adjusting rod 112 which extends upwardly through the center of the terminal cylinder 106, through the ore feed pipe 102, through the ore inlet chamber and projects through the cap in the top of casing 100. The upper end of the rod 112 is threaded to receive the adjusting and lock nuts 113. The dispersion cone 111 has fastened to its base and to the spindle projecting downwardly therefrom several radially disposed vanes 115 which serve to center the dispersion cones 110 and 111, and maintain the same in a relatively fixed position in the center of the terminal cylinder 106.

The numeral 116 indicates what may be generally designated as a gas mixing sleeve. The sleeve 116 is supported in the position shown in Fig. 4 by vertical rods 117, the lower ends of which are welded or otherwise rigidly fastened to the upper edge of the sleeve 116. The free ends of rods 117 pass through suitable openings in the annular top 118 of the casting 92. The upper ends of the rods 117 are threaded to receive the adjusting and lock nuts 119. The lower end of the sleeve 116 is bent inwardly to form a funnel-shaped deflecting or mixing portion 118. The short cylindrical member 119 is fixed to the lower end of the cylindrical portion of the sleeve 116 in such manner as to form substantially a continuation thereof. The lower edge of member 119 is bent to provide an outwardly directed flange 120. The arrangement of the sleeve 116 and the cylinder is such as to constitute between these two members an annular passage 121, the dimensions and capacity of which depend upon the relative size of the cylinder and the sleeve. It will be understood that the cross-sectional dimension of both cylinder 106 and sleeve 116, together providing a sectional feed conduit, may be subject to variation.

The horizontal flange 122 of the sleeve 123 is clamped between flanges 90 and 91, and thus supports sleeve 123 in the position shown. The lower edge of sleeve 123 is bent outwardly to form a flange 123' shaped similarly to flange 120. The relation of sleeve 123 and sleeve 116 is such as to provide between these members an annular chamber 124 terminating in an annular mouth or passage 125. Sleeve 116, cylinder 106, together with that portion of the ore inlet passage above cylinder 106, may be said to constitute a sectional ore inlet conduit.

The interior of the casting or coupling 92 includes a vertically extending ring member 126 which is so formed as to constitute in effect an upwardly directed continuation of the inner surface of the sleeve 88. The upper edge of the ring 126 stops short of the under side of the horizontal portion 118, and thus provides an annular passage 127 which affords communication between the interior of the bustle 128, and the gas inlet chamber, indicated at 129, formed between the inside of the ring 126 and the outside of the terminal cylinder 106. Passage 124, previously mentioned, may be considered a part of or an extension of the gas inlet chamber 129. The bustle 128 is connected to the conduit 78, Fig. 1, through the outlet 130 having on its edge a flange 131 to facilitate connection between the casting 92 and the conduit 78. It is apparent that the ring 126 may be extended to meet the underside of the annular top 118, and a series of perforations provided near the upper end of ring 126 to establish communication between bustle 128 and inlet chamber 129.

For convenience, the operation of the invention will be described in connection with the roasting of iron pyrites. The operation of the invention is substantially as follows.

The furnace is first preheated, for example by means of one or more oil burners inserted through work holes 28, until a temperature is obtained in the chamber 12 of for example about 425° C. During the preheating operation the work holes 24 in the crown of the chamber are uncovered to provide flues for escape of the products of combustion.

Finely divided iron pyrites which has been dried until the moisture is not greater than about 0.3% and preferably between 0.1% and 0.2%, and of a particle size such that 100% will pass a 60 mesh screen, is fed into the feed mechanism ore inlet 101. The ore may be continuously supplied to the inlet 101 by a chute from suitable hoppers or by means of a screw conveyor or any other desirable feed mechanism. The finely divided ore passes downwardly through the ore inlet feed pipe 102 into the interior of the terminal cylinder 106.

Air or oxygen may be used as the oxidizing gas, preferably the former for economic reasons, and either at atmospheric temperature or preheated to any desired degree as will be hereinafter more fully explained. The oxidizing gas enters the feed mechanism 87 through the conduits 77 and 78 connected respectively to the inlet casting 96 and the inlet 130 of the bustle 128 of the feed mechanism. For operation under usual conditions, about 5 to 15% of the total air required for the complete combustion of the ore in the roasting chamber is introduced into the feed mechanism through the conduit 77 and the inlet casting 96. For the purpose of this description the air introduced into the roasting chamber through the conduit 77 and the casting 96 may be termed primary air, and that introduced into the roasting chamber through the conduit 78 and the bustle 128 may be considered secondary air.

After introduction of the air from the conduit 77 into the inlet casting 96, the same passes into the terminal cylinder 106 through the annular passage between the edge of the orifice plate 103 and the lower end of the feed inlet pipe 102. On account of the funnel-like shape of the orifice plate 103, the air passing therethrough is deflected to a certain degree toward the vertical axis of the cylinder 106. This causes an initial mixing of air and ore dropping out of the lower end of the feed pipe 102. A further advantage of this arrangement is that the air enters the upper end of the terminal cylinder 106 with something of an injector action which aids in drawing in the ore from the pipe 102, and at the same time tends to prevent the escape of any gas from the roasting chamber upwardly through the ore inlet pipe 102.

The initial mixture of ore and gas drops downwardly through the upper end of the terminal cylinder 106, and the greater part of the mixture strikes the upper surface of the dispersion cone 111. The falling mixture leaves the lower edge of the cone 111 in a sheet resembling the surface of a cone, and strikes against the inner wall of the cylinder 106 at a point somewhat below the lower edge of the dispersion cone 111. On so striking the inner surface of the cylinder 106, the particles of ore are for the most part deflected back toward the axis of the cylinder, i. e., towards the adjusting stem 112, and in so doing become more thoroughly mixed with the air which is not deflected from the inner walls of the cylinder 106 in such a pronounced manner as the heavier particles of solid material. The ore and gas in this intermediate state of mixture continues its downward passage through the cylinder 106, and striking the upper surface of the dispersion cone 110, is again deflected outwardly from the axis of the cylinder. The mixture thus leaves the lower end of the cylinder 106 in the form of a cone-shaped sheet.

About 85–95% of the total quantity of air necessary for the combustion of the ore in the roasting chamber is, as previously mentioned, admitted to the feed mechanism through the conduit 78. Air entering the inlet 130 of the bustle 128 from the conduit 78 immediately fills the bustle, and passes therefrom through the annular passage 127 into the upper end of the gas inlet chamber 129. It will be noted that the ring 126 projects upwardly in the casting 92 to such an extent that its upper edge is some distance above the top of the inlet passage 130, indicated on the drawings at 130'. The purpose of this construction is to provide for a complete filling of the bustle 128 before any appreciable quantity of the air leaves the same through the annular passage 127 into the gas inlet chamber 129. It will be apparent that this arrangement is such that the air is caused to enter the inlet chamber 129 from all points on the circumference of the upper edge of the ring 126. This radial introduction of air from the bustle 128 into the gas inlet chamber 129 is such that undesirable turbulent air currents are not created within the inlet chamber 129. It has been found that in certain instances where too great a turbulent action is set up in the gas inlet chamber 129, and accordingly in the feed mechanism as whole, certain strong currents are set up which tend to carry large portions of ore against some particular spot on the interior of the reaction chamber wall. These undesirable eddy currents are prevented by the construction just described.

About 85 to 95% of the total quantity of oxidizing gas necessary for the roasting of the ore in the reaction chamber is introduced into the reaction chamber by way of the gas inlet chamber 129. In the neighborhood of 5 to 10% of the total air utilized in the roasting operation is introduced into the reaction chamber through the annular passage 124 between the sleeve 123 and the outer surface of the distributing sleeve 116. This air passes through the annular mouth 125, and forms a gas blanket between the walls of the reaction chamber and the burning gaseous suspension therein. The remaining quantity of air in the gas inlet chamber 129 passes into the annular space 121 between the inner surface of the sleeve 116 and the outer surface of the cylinder 106. It will be observed that the lower end of the cylinder 106 is bent up to form the curved rim 108. Air passing downwardly through the annular passage 121 strikes the sloping surface of the rim 108 and is deflected outwardly from the vertical axis of the feed mechanism and impinges upon the inwardly directed funnel-shaped deflecting portion 118 of the sleeve 116. This rapid change in the direction of the gas stream serves to further increase the mixing of the ore and air issuing from the lower ends of the cylinder 106 and the annular passage 121.

The total amount of air introduced into the feed mechanism 87 will depend upon the amount of sulfur in the fines to be desulfurized, the concentration of the sulfur dioxide desired in the exit gases, and other factors evident to one skilled in the art. The regulation of the air supply as to quantity may be accomplished in any suitable and well known manner. In practice, determination of the sulfur dioxide content of the exit gas and the character of the cinder will usually indicate the necessary regulation of the air supply to provide the desired results, the fines being supplied at a substantially constant rate. The pressure under which the air is introduced may be regulated to suit operating conditions, although it is usually desirable that a pressure approximately atmospheric is obtained over the cinder outlet.

When the furnace is in operation, the sleeve 116 should be so adjusted by means of the suspension rods 117 and the associated regulating and set nuts that the size of the mouth 125 is such that only sufficient air is admitted thereto to prevent scar formation on the walls of the roasting chamber. This may be determined by varying the size of the mouth 125, and observing the effect upon the chamber walls through one of the sights in a work hole cover 25. The amount of scar inhibiting air necessary is usually a minor proportion of the total amount of air admitted and, as previously noted, ranges generally from 5 to 10% of the total quantity of air necessary for combustion in the furnace. The sheet of pyrites fines issuing from the lower end of the terminal cylinder 106 will be swept up by the current of secondary air from the annular passage 121, and the suspension of intimately mixed air and fines thus obtained is introduced into the hot roasting chamber 12. On entering the preheated chamber, the suspension of fines in air will be ignited and oxidation will thereafter proceed at a very rapid rate.

The oxidation of the iron pyrites is a strongly exothermic reaction, to the extent that it is substantially self-sustaining, and other than the necessity of initiating the reaction, for example by preheating the furnace to a suitable temperature above the ignition point of the pyrites, no substantial heat is required. In operation, the temperature will be quite high throughout the roasting chamber 12. In the production of an approximately 10% $SO_2$ gas, from a typical iron pyrite ore, the temperature in the roasting chamber for example may be in the neighborhood of 1000° C.

Upon the entry of the gaseous suspension into the enlarged space presented by the roasting chamber, expansion of the suspension takes place, and this expansion is enhanced by the large amount of heat supplied by the combustion of the fines in addition to that emanating from the heated walls of the roasting chamber. This expansion tends to cause an appreciable proportion of the suspended particles to be drawn toward the chamber wall, and such particles as are in the transitory sticky stage hereinbefore discussed would under ordinary circumstances tend to adhere to the walls upon contacting therewith and rapidly build up accretions thereon.

In the roasting of different grades of pyrite and pyrrhotite ores and sulfide flotation concentrates from various sources, it is highly desirable to be able to control to a certain degree the temperature of the mixture entering the roasting chamber 12 and to a corresponding degree the temperatures obtainable within the roasting chamber are thus regulated. Such desired control may be obtained by suitable manipulations of the several valves in the piping system between the inlet of the main pipe 66 and the feed mechanism 87, and by controlling the quantity of air circulated through the conduits 60.

If it is desired to supply air of ordinary temperature to the feed mechanism 87, the valve 71 in the line 69 is closed, and the valve 72 in pipe 70 opened sufficiently to permit the passage of the required amount of air to support the combustion in the reaction chamber 12. When proceeding under this mode of operation, the valves 79 and 80 in the lines 77 and 78 are so adjusted to permit the admission of the desired proportions of primary and secondary air to the feed mechanism through the inlet casting 96 and the bustle 128. Further, if it is desired at the same time to circulate air through the vertical conduits 60 for the purpose of cooling the walls of the reaction chamber, the necessary quantity of air may be admitted to the passages 60 from pipe 66 through the bustle 62. After passing through the transferrer section and cooling the burner walls, and thus further serving to control the temperature of the reaction within the roasting chamber, the heated air leaves through the bustle 67 and is vented to the atmosphere through the line 73. In such situation, the valves 74 and 75 are opened, and the valves 84 and 85 are closed.

When it is desired to preheat the primary air and the secondary air to the same degree, cold air is circulated through the transferrer section and preheated therein, and is then mixed with the main stream of cold air entering the apparatus through the main vertical pipe 70. To accomplish this mixing of cold and heated air, the valve 71 is opened as required and the valve 74 closed as required. In this manner, the air in the upper end of the pipe 70 beyond the connection with the pipe 69 is heated to some required degree of preheat, and this heated stream of air is then divided and passed into the feed mechanism through the conduits 77 and 78. It will thus be seen that under such operation the primary and secondary air for the feed mechanism 87 is preheated to the same degree. The degree of preheat is regulated by the proportions of cool and heated air mixed at the connection between pipes 69 and 70.

There may also be encountered in practice, situations where it will be desired to preheat the primary and secondary air to different degrees. Assuming that it is required to preheat the primary air and not the secondary air, the valves 71 and 79 are closed. The cold air passes upwardly through the main line 70, through the conduit 78 and into the bustle 128. By regulation of the valve 72, the quantity of air required to be preheated is admitted to the bustle 62, and passed through the transferrer section. On leaving the latter through the bustle 67, the stream of preheated air passes through the open valve 74, into the pipe 73 and through the open valve 84 through pipe 82 and then into the conduit 77. In this instance the valve 85 is closed, and the valve 75 is closed to such an extent as may be required by the quantity of gas required to be passed into the conduit 77.

Where it is desired to preheat the secondary air and not the primary air, the valve 79 is opened and the valve 80 is closed. Unheated air is supplied to the conduit 77 from the main line 70. Air preheated in the transferrer section passes through the pipe 69, through the open valve 74 into pipe 73, thence through the open valve 85, through pipe 83 to conduit 78. In this instance, the valve 84 is closed and the valve 75 closed to such a degree as may be necessary. Intermediate temperature adjustments of primary and secondary air may be obtained by suitable manipulation of the several valves in the piping system.

Referring to the roasting of the ore, the initial stages of the roasting operation are the most intense and normally take place in the upper part of the roasting chamber. It is in this upper part of the chamber that the tendency toward scar formation appears to be most marked, and it seems probable that as the proportion of the $Fe_2O_3$ increases, the tendency toward scarring decreases. On that basis it would appear that the provision of the air blanket between the walls of the chamber and the burning suspension need only be confined to the upper part of the chamber in order to prevent scar formation, and it may be that such is the case in the operation of the present method as noted, although the particular path of the air blanket is more difficult to trace the greater its penetration into the furnace. On the other hand it is quite possible that the gaseous suspension of fines could be introduced under such pressure, for example, that the scar forming stage would occur at a point considerably lower down in the roasting chamber, in which event it would be necessary to run the air blanket substantially throughout the length of the chamber.

In view of these considerations it is of importance that the air blanket be interposed between the walls of the chamber and the burning pyrites while the latter is in a state conducive to scar formation, regardless of its relative location in the roasting chamber while in that state. That such is the case in the operation of the present method is evidenced by the fact that by suitably varying vertically the position of the flange 120, and thereby the volume and to a limited degree the direction of the air blanket admitted through the mouth 125, the formation of scar under such variations of the roasting operation as are involved in ordinary industrial practice can be eliminated.

Further improvements in the roasting operation arise from the particular structure of the feed mechanism and the arrangement of the piping system in association with the heat transferrer section of the burner. In regard to the former, the provision of a feed mechanism whereby the oxidizing gas is radially introduced therein serves to avoid the setting up of strong eddy currents which in some instances, as hereinbefore mentioned, tend to direct pronounced streams of ore against some particular portion of the roasting chamber wall. In the present mechanism, the mixing of gas and ore is such that the mixture formed, on leaving the feed mechanism and after the initial expansion of the mixture has taken place, passes vertically through the shaft. Small individual streams of ore do not assume an inclined course, and hence clinkering is reduced to a minimum.

Additionally, by manipulation of the valves in the piping system as described, the temperature of the oxidizing gas entering the feed mechanism may be controlled. The control of the temperature of the oxidizing gas permits control of the temperature within the roasting chamber. This renders the process applicable to the burning of a wide variety of sulfide ores, and permits the maintenance of temperatures within the roasting chamber most favorable for the efficient roasting of a particular sulfide ore.

The length of the roasting chamber and the speed of introduction and travel of the fines and air should be such that a thorough desulphurization is obtained in the passage through the roasting chamber.

By conducting the roasting operation as described, the fines in suspension are quite thoroughly desulphurized by the time the cinder and gas outlets are reached, and by proper regulation of the oxidizing gas pressure, the major portion of the desulphurized particles, mainly in the form of iron oxide collects in the cinder pit 26 whence it is withdrawn through the outlets 27. The gases containing the sulfur dioxide passing into the dust chamber 45 carry entrained therein an appreciable portion of solid particles, consisting mainly of iron oxide which are collected in the dust chamber 45. The gases containing the sulfur dioxide are drawn from the chamber 45 and conducted away for utilization in the production of sulphuric acid, or for other purposes.

While the invention has been specifically described in connection with the roasting of finely divided iron pyrites ore or flotation concentrate, the invention is not confined to the use of that particular material but is applicable generally to the roasting of a wide range of sulfide ores where undesirable sintering is involved and where it is desirable to control the temperature of the roasting operation. The invention contemplates the treatment of different grades of iron and copper pyrites, pyrrhotite, zinc blend and similar ores and flotation concentrates of the same.

I claim:

1. Apparatus of the character described comprising a primary conduit, means for forming in said conduit a mixture of a finely divided material in a primary volume of gas, means for adding to the mixture a secondary volume of gas and form-

ing a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular passage between the bustle and the chamber whereby a secondary volume of gas is introduced radially into the inlet chamber, a sleeve forming a passage communicating with the inlet chamber and projecting beyond the primary conduit, and means in said sleeve for deflecting gas passing through the passage toward the axis of the primary conduit.

2. Apparatus of the character described comprising a primary conduit, means for forming in said conduit a mixture of a finely divided material in a primary volume of gas, means for adding to the mixture a secondary volume of gas including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular passage between the bustle and the chamber whereby a secondary volume of gas is introduced radially into the inlet chamber, a sleeve forming a passage communicating with the inlet chamber and projecting beyond the primary conduit, means in said sleeve for deflecting gas passing through the sleeve toward the axis of the primary conduit, whereby a suspension of said material in oxidizing gas is formed, and means associated with the sleeve for deflecting a stream of gas from the inlet chamber away from the axis of the primary conduit.

3. Apparatus of the character described comprising a primary conduit, means for forming in said conduit a mixture of a finely divided material in a primary volume of gas, means for adding to the mixture a secondary volume of gas for forming a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular connection between the bustle and the chamber whereby a secondary volume of gas is peripherally introduced radially into the inlet chamber, and a sleeve surrounding at least a portion of the primary conduit and forming a passage communicating with the inlet chamber and projecting beyond the outlet end of the primary conduit for introducing into the mixture formed in and discharged from the primary conduit a secondary volume of gas.

4. Apparatus of the character described comprising a primary conduit, means for introducing finely divided material into said conduit, means for adding to the material a volume of gas for forming a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular connection between the bustle and the chamber whereby a volume of gas is peripherally introduced radially into the inlet chamber, and a sleeve surrounding at least a portion of the primary conduit and forming a passage communicating with the inlet chamber and projecting beyond the outlet end of the primary conduit for introducing into the material discharged from the primary conduit a volume of gas.

5. Apparatus of the character described comprising a primary conduit, means for forming in said conduit a mixture of a finely divided material in a primary volume of gas, means for adding to the mixture a secondary volume of gas for forming a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular connection between the bustle and the chamber whereby a secondary volume of gas is peripherally introduced radially into the inlet chamber and a sleeve, adjustable axially of the conduit, forming a passage communicating with the inlet chamber and projecting beyond the outlet end of the primary conduit for introducing into the mixture formed in and discharged from the primary conduit a secondary volume of gas.

6. Apparatus of the character described comprising a primary conduit, means for forming in said conduit a mixture of a finely divided material in a primary volume of gas, means for adding to the mixture a secondary volume of gas for forming a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, an annular connection between the bustle and the chamber whereby a secondary volume of gas is peripherally introduced radially into the inlet chamber; a sleeve, adjustable axially of the conduit, surrounding at least a portion of the primary conduit and forming a passage communicating with the inlet chamber and projecting beyond the outlet end of the primary conduit and means in said sleeve beyond said end of the primary conduit for deflecting gas passing through the passage toward the axis of the conduit to thereby introduce into the mixture formed in and discharged from the primary conduit a secondary volume of gas.

7. Apparatus of the character described comprising in combination a reaction chamber, feed mechanism therefor comprising a primary conduit, means for introducing finely divided material into said conduit, means for adding to the material a volume of gas for forming a suspension of said material therein including a gas inlet chamber surrounding the conduit, a bustle encircling the inlet chamber, a connection between the bustle and the chamber whereby a volume of gas is introduced radially into the inlet chamber; a sleeve, adjustable axially of the conduit, forming a passage communicating with the inlet chamber and projecting beyond the outlet end of the primary conduit, means in said sleeve beyond the end of the conduit for deflecting gas passing through the passage toward the axis of the conduit, and means associated with said sleeve for maintaining a layer of gas between the walls of the reaction chamber and the material therein.

8. Apparatus of the character described comprising in combination a reaction chamber, heat transfer means associated with said chamber, means for circulating gas through said heat transfer means, reaction chamber feed mechanism including means for introducing into the feed mechanism a primary volume of gas and for forming a mixture of finely divided material in said primary volume of gas, means for introducing into the feed mechanism a secondary volume of gas and for adding to the said mixture a secondary volume of gas thereby forming a suspension of the material in the oxidizing gas; means for introducing into the primary volume of gas a given quantity of gas circulated through the heat transfer means to preheat the primary volume of gas to a given degree, means for introducing into the secondary volume of gas a different quantity of gas circulated through the heat transfer means to preheat the secondary volume of gas to a different degree to thereby provide different degrees of preheat in the primary and secondary volumes of gas, and means for in-

troducing the suspension into the reaction chamber.

9. Apparatus of the character described comprising in combination a reaction chamber, heat transfer means associated with said chamber, means for circulating gas through said heat transfer means, reaction chamber feed mechanism including means for introducing into the feed mechanism a primary volume of gas and for forming a mixture of finely divided material in said primary volume of gas, means for introducing into the feed mechanism a secondary volume of gas and for adding to the said mixture a secondary volume of gas, thereby forming a suspension of material in the gas; means for introducing into the primary volume of gas a given quantity of gas circulated through the heat transfer means to preheat the primary volume of gas to a given degree, means for introducing into the secondary volume of gas a different quantity of gas circulated through the heat transfer means to preheat the secondary volume of gas to a different degree to thereby provide different degrees of preheat in the primary and secondary volumes of gas, means for introducing the suspension into the reaction chamber, and means for maintaining a layer of gas between the walls of the reaction chamber and the gaseous suspension therein.

10. Apparatus of the character described comprising in combination a reaction chamber, heat transfer means associated in heat transfer relation with said chamber, means for circulating oxidizing gas through said transfer means in quantity to remove variable amounts of heat from the reaction chamber to control the temperature thereof, reaction chamber feed mechanism including means for introducing into the feed mechanism a primary volume of gas and for forming a mixture of finely divided material in said primary volume of gas, means for introducing into the feed mechanism a secondary volume of gas and for adding to the said mixture a secondary volume of gas, thereby forming a suspension of material in the oxidizing gas; means for introducing into the primary volume of gas a given quantity of gas circulated through the heat transfer means to preheat the primary volume of gas to a given degree, means for introducing into the secondary volume of gas a different quantity of gas circulated through the heat transfer means to preheat the secondary volume of gas to a different degree to thereby provide different degrees of preheat in the primary and secondary volumes of gas, and means for introducing the suspension into the reaction chamber.

BERNARD M. CARTER.