July 6, 1937. C. F. SILSBY 2,086,193

METHOD AND APPARATUS FOR ROASTING ORES

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Fig. 1.

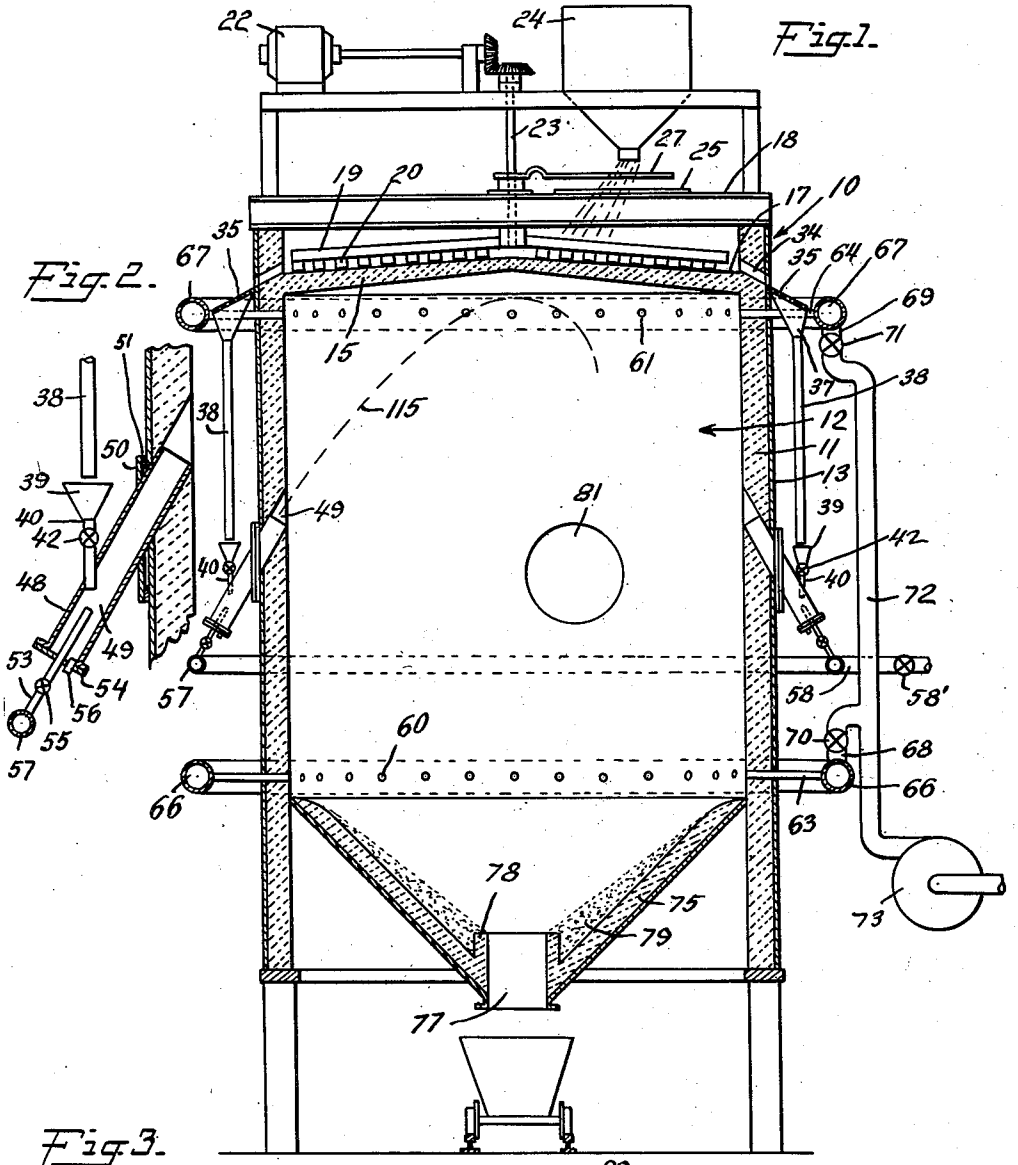
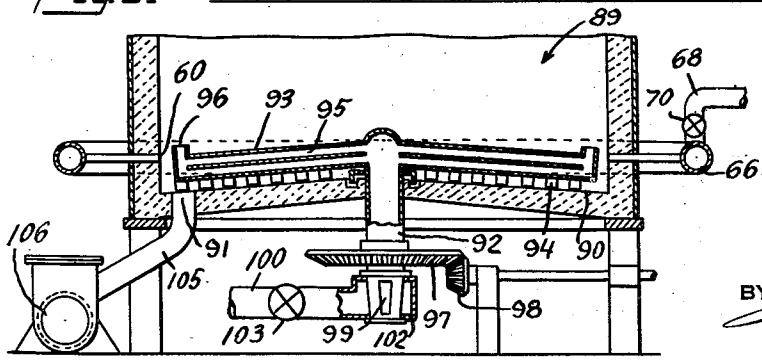


Fig. 2.

Fig. 3.



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METHOD AND APPARATUS FOR ROASTING ORES

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8 Claims. (Cl. 75—9)

This invention is directed to methods and apparatus for roasting metallic sulfides, and more particularly for roasting finely divided sulfide ores to desulfurize the same and to produce sulfur dioxide for use in the manufacture of sulfuric acid, or for any other purpose desired.

Generally speaking, to a large extent present practice in sulfide fines roasting includes use of mechanically operated multiple hearth furnaces, such, for example, as the well known MacDougal, Herreshoff, and Wedge burners. While burners of this type provide effective roasting, the complicated construction and operation thereof involve considerable initial and maintenance expense.

As distinguished from the "bed" roasting operation of these burners, it has been previously suggested to roast the fines while in gaseous suspension, in operations in which the fines are either injected into a roasting chamber in suspension in the oxidizing gas, or are showered downwardly into the roasting chamber wherein the fines enter cross or countercurrents of suspending gas.

Suspension roasting is best applicable when the fines are in a relatively finely divided state, and this method presents the notable advantage over mechanical multiple hearth operation of considerably lowering costs of production, by reason of elimination of relatively complicated and moving parts, expensive rabbling and other apparatus inherent in the construction and operation of such mechanical burners. The present invention is directed especially to improvements in suspension roasting methods.

The principal object of the invention resides in the provision of a process which may be carried out so as to provide for the presence of relatively large amounts of oxygen in the roasting atmosphere at the beginning and at the end of roasting of the ore particles, to facilitate rapid ignition of the ore on introduction into the combustion zone, and to effect substantially complete oxidation of the ore particles at the end of the roasting operation.

In carrying out one preferred embodiment of the process of the invention, the sulfide fines are initially dried and preheated by utilization of heat of the top of the roasting furnace so that relatively large quantities of sulfide fines may be dried and preheated to thus promote rapid ignition of the ore particles on introduction into the roasting zone. The dried and preheated fines are run into feed mechanisms positioned in the side walls of the furnace at approximately the midpoint of the combustion zone. These feed mechanisms inject the fines into the roasting chamber at a relatively high angle so as to cause the particles to rise substantially to the top of the combustion zone, at which point a dispersion of partially roasted fines is formed relatively uniformly over at least a major portion of the area of the top of the roasting chamber.

The oxidizing gas, such as air, for supporting roasting of the ore is introduced into the combustion zone partly at the base and partly at the top through ports spaced peripherally about the top and bottom of the roasting chamber. The gaseous products of combustion are withdrawn from the roasting zone preferably below the point at which the sulfide fines are injected into the roasting chamber. The fines are thus introduced into a highly heated section of the reaction zone, and consequently become rapidly heated during the upward passage of the ore particles to the top of the combustion chamber. Since a large portion of the air utilized in the roasting operation as a whole is introduced into the combustion zone at the top, preferably under slight plus pressure, there is thus provided at the upper end of the reaction chamber a zone relatively rich in oxygen. The presence of a comparatively large amount of oxygen in this part of the reaction zone promotes rapid ignition and initial roasting of the ore particles. While dropping through the upper portion of the reaction zone, above the combustion gas offtake, the ore particles pass downwardly, cocurrent with the gases, through an atmosphere decreasingly rich in oxygen. After having passed through the upper section of the combustion zone, the sulfur content of the ore particles has become depleted, and thereafter roasting proceeds less readily. The ore particles then enter the lower portion of the reaction zone, below the reaction gas offtake, and pass downwardly countercurrent to a rising stream of oxidizing gas. Thus, during the final stage of the roasting operation the ore particles pass through an atmosphere increasingly rich in oxygen and decreasingly rich in sulfur dioxide. In the lower end of the lower portion of the reaction chamber, conditions are such that the gas therein is substantially all air and contains little sulfur dioxide. In this zone, the cinder particles are surrounded by an atmosphere rich in oxygen which promotes and hastens completion of roasting of the ore particles. The oxide cinder is then discharged from the bottom of the roasting zone.

Further objects and advantages of the invention will be apparent from a consideration of the following description taken in connection with the accompanying drawing, in which

Fig. 1 is a vertical section of a preferred furnace for carrying out the process of the invention;

Fig. 2 is an enlarged vertical section of a preferred type of ore feed mechanism, and

Fig. 3 is a vertical section of the lower end of a modified burner.

Referring particularly to Fig. 1 of the drawing, 10 designates a shaft burner comprising a

shell 11 constructed of suitable refractory material, such as firebrick, and defining a substantially unobstructed roasting chamber 12 of cylindrical cross-section. Surrounding shell 11 is a steel casing 13 acting as a protective reinforcement for the furnace. The upper end of the combustion chamber is closed off by a crown 15, the top side of which forms a drying and preheating hearth 17. The cylindrical shell 11 and casing 13 project upwardly beyond the crown 15, and carry a steel framework 18 which in turn supports ore feeding and rabble mechanisms for the drying hearth.

The surface of hearth 17 is slightly cone-shaped and slopes downwardly toward the shell of the burner. Positioned above the hearth are rabble arms 19 having downwardly projecting plows 20 pitched to work sulfide fines gradually toward the circumference of the drying hearth. Arms 19 are rotated by a motor 22 through shaft 23 supported in bearings so as to maintain the lower ends of the plows 20 properly spaced with respect to the surface of the drying hearth 17. An ore bin 24, mounted on framework 18, discharges ore onto a platform 25 from which fines are intermittently dropped onto approximately the center of hearth 17 by a sweep 27 rotating with shaft 23.

Cut in shell 11 near the upper end are downwardly sloping passages or conduits 34 through which ore is passed from the drying hearth 17 onto the surfaces of screens 35 covering funnels 37 forming the upper ends of ore pipes 38 which discharge into funnels 39 on the upper end of feed pipes 40 provided with control valves 42.

The preferred ore injectors comprise principally a metallic pipe section 48, the inner end of which is set into the shell of the burner at approximately the mid-point of the combustion chamber, pipe 48 providing an ore inlet conduit 49. Tube 48 is held in position by circular plate 50 and flange 51 bolted to steel shell 13. The axis of tube 48 is directed upwardly at a relatively sharp angle, and in the particular embodiment of the apparatus illustrated, this angle may, for example, be about 60° to the horizontal.

As shown in Fig. 2, valve-controlled pipe 40 projects through the upper side of tube 48. A gas inlet pipe 53 passes through end plate 54, closing the bottom of conduit 49, and terminates at about the discharge end of pipe 40. Admission of air or other gas to pipe 53 is controlled by valve 55. Plug 56 affords means for cleaning out conduit 49 should the same become clogged up.

The burner may be provided with any suitable number of injectors. In the embodiment of the invention, the two injectors shown in Fig. 1 are diametrically opposed. In some instances, it is desirable to employ say three or more injectors equally spaced about the circumference of the burner.

Surrounding the burner near the injectors is a bustle 57 for supplying gas to the injector jets 53, the bustle being connected to a gas supply through pipe 58 having a control valve 58'. Substantially all of the air to support the roasting operation is introduced into the chamber 12 through ports 60 and 61 spaced circumferentially about the lower and upper ends of the combustion zone. These ports are connected through short pipe sections 63 and 64 with bustles 66 and 67, provided with air inlet connections 68 and 69 having control valves 70 and 71. Inlet pipes 68 and 69 communicate with an air main 72 one end of which is connected to the pressure side of a fan or blower 73 providing means to supply air to the burner under positive pressure.

The bottom of the combustion chamber 12 is formed by a hopper shaped brick-faced hearth 75 terminating in an outlet 77 through which cinder is continuously discharged into a conveyor. As desired, the surface of hearth 75 may be pitched at an angle greater than or less than the angle of repose of the cinder. In the drawing, hearth 75 is shown as being pitched at an angle greater than the angle of repose of the cinder, and in this instance the bottom of the hearth may be provided with an upstanding flange 78 which serves to maintain on the hearth a bed of cinder indicated at 79. A gas off-take main 81 opens into the combustion chamber at about the mid-point thereof, and preferably slightly below the inlet ends of the ore injectors.

Referring to the modified construction shown in Fig. 3, the upper end of the burner is constructed substantially as described in connection with Fig. 1. The bottom 90 of the combustion chamber 89 pitches downwardly toward shell 11, and is provided at the circumference thereof with one or more cinder outlets 91. Bottom 90 has a central opening to accommodate a hollow rotatable shaft 92 carrying rabble arms 93 each having a plurality of downwardly extending plows 94 for feeding cinder into openings 91. Rabble arms 93 are constructed so as to include longitudinal conduits 95, opening into the hollow interior of shaft 92 to permit passage through the arms of cooling air which is discharged into the combustion chamber through openings 96. Shaft 92 is supported in suitable bearings, and is rotated by a gear 97 meshing with a pinion 98, driven from a source of power not shown.

Cooling air is introduced through slots 99 into the interior of shaft 92 from an air inlet pipe 100, having a control valve 103, terminating in a casing 102 surrounding the lower end of the shaft. Cinder discharged from the combustion chamber through outlet 91 runs through pipe 105 into a closed chamber 106 having therein a screw conveyor or other suitable means for discharging cinder without admitting air to the combustion chamber.

The modified furnace shown in Fig. 3 is particularly adapted for carrying out roasting under a slight positive or negative pressure. It will be understood the furnace is provided with upper and lower bustles 66 and 67, pipe connections 68 and 69, and control valves 70 and 71 as in the construction of Fig. 1. When proceding so that at least the lower portion of chamber 89 operates at negative pressure, air inlet pipe 68 may be opened to the atmosphere. On account of the difference in temperature of the gases in the combustion chamber and the outside atmosphere, the "chimney effect" created in the combustion chamber 89 (Fig. 3) may cause gases in the top of the combustion zone to attempt to leave the furnace through ports such as 61 if pipe connection 69 (at the top of the furnace of Fig. 3 and not shown in the drawing) were opened to the atmosphere. Hence, to avoid difficulties of this nature, it is preferred to connect the upper bustle, as 67, of the furnace of Fig. 3 with the pressure side of a blower as 73 of Fig. 1.

The invention is applicable to the roasting of divided metal sulfides such as iron pyrites, pyrrhotite, zinc sulfide or arsenopyrite, but for convenience the operation of the process may be

described in connection with the roasting of iron pyrites.

A supply of sulfide fines is maintained in the bin 24 by suitable conveyor or elevator mechanism, not shown. Before roasting is begun, combustion chamber 12 is preheated to temperatures above the ignition point of the particular ore to be roasted, as by the use of oil burners inserted through conveniently located workholes, not shown. When the desired degree of preheat is obtained in the combustion chamber, the motor 22 is started, and rabble arms 19 and sweep 27 may be rotated at a rate of, say, one revolution in two minutes. Fines run continuously out of the bin 24 onto platform 25, and on each revolution of shaft 23 a regulated quantity of ore is swept off the platform to approximately the center of hearth 17.

During rotation of the rabble arms 19, the sulfide fines are gradually worked across the heated surface of hearth 17 and into passages 34. The dry and partly heated ore runs onto sloping screens 35, which remove lumps, and thence into ore feed pipes 38 discharging into funnels 39. This preliminary heating serves to dry the fines, thus facilitating the formation of more satisfactory dispersion of ore in the combustion chamber, and at the same time preheats the fines to some extent. By causing the ore to be roasted to pass over the top of the roasting chamber, a large amount of heat usually lost to the atmosphere is utilized to dry and preheat the fines. By this procedure, the capacity of a burner unit of given size is largely increased.

Valves 42 in pipes 40 are adjusted so that a substantially steady stream of fines runs into feed conduits 49. The next step of the process involves injection of the sulfide fines into the combustion chamber, which operation may be satisfactorily effected by use of injectors of the type shown in Fig. 2 of the drawing. These injectors may be placed in the side walls of the furnace, adjacent either the top or bottom but are preferably located approximately as indicated in the drawing. Air, steam, or other gas, not adversely affecting oxidation of the sulfide, may be employed to charge the fines into the combustion chamber. It is preferred to employ air for this purpose, and in this case the air may be admitted to the lower ends of conduits 49 through valve controlled jets 53 at pressures of, for example, about 5 pounds per square inch.

If the ore being roasted is of such nature that extraneous fuel is required to maintain proper roasting temperatures, such fuel in any suitable form may be introduced into the combustion chamber through the ore feed mechanism. For example, a combustible gas might be employed to inject the fines.

The angle of the axis of conduit 49 is dependent upon the particular size and type of combustion chamber which may be employed. The angle of the axes of conduits 49, the amount of fines fed into the injectors through pipes 40, and the air pressure in jets 53, adjusted by valves 55, are all regulated with respect to the particular size of the roasting chamber so that the ore particles from each injector rise through the combustion chamber, away from the walls thereof, to an elevation just below the underside of crown 15. The angular position of conduit 49 and the rate of supply of ore and air thereto are likewise controlled so that the horizontal travel of the ore particles, while reaching the top of the combustion chamber and after dropping to the bottom thereof, preferably does not exceed, say, three-quarters of the diameter of the roasting chamber. In this manner, contact between any substantial quantities of ore particles and the hot walls of the roasting chamber is prevented, thus avoiding accumulation of scar on the walls. Referring to Fig. 1, the dotted line 115 indicates the approximate path of travel of an ore particle of average size introduced through the injector on the left side of the burner. Two or more injectors are preferably employed. The ore particles move upwardly at an angle somewhat less than the pitch of injector conduits 49, to an elevation just below crown 15, and then because of commingling of particles of several individual streams of fines, a relatively uniform dispersion is formed over a major portion of the upper end of the combustion chamber, and thereafter the particles settle in more or less straight lines, at a rate substantially as induced by gravity, toward the hearth in the bottom of the combustion chamber.

In the preferred procedure, air is supplied to the combustion chamber 12 under positive pressure, and substantially the total quantity of air or other oxidizing gas necessary to support the oxidation reaction is introduced into the combustion chamber through ports 60 and 61 at the bottom and at the top of the combustion chamber. Where air is employed for injecting the fines through conduits 49, as a rule not more than about 10% of the total air required for oxidation would ordinarily be introduced through air jets 53, although larger amounts may be used if desired. In the preferred operation, where only a relatively small proportion of the total air is fed through the injectors, it may be considered that substantially all the air utilized in roasting is introduced into the combustion chamber through ports 60 and 61 at the bottom and at the top of the furnace.

The amount of air introduced through upper ports 61 relative to the amount admitted through lower ports 60 may be varied in accordance with the position of gas off-take 81. For instance, if the latter is located so that about 65% of the roasting is effected above the gas off-take, the amount of air admitted through upper ports 61 is regulated so as to provide in upper portion of the reaction chamber sufficient air to support about 65% oxidation of the fines, the balance of the air needed to complete oxidation being admitted through lower ports 60. In the present example, it may be considered by suitable adjustment of valve 71 approximately half of the air needed for roasting operation may be admitted into the top of the combustion chamber from pipe 72 through air inlet pipe 69, bustle 67 and pipe connections 64 associated with ports 61. By regulation of valve 70 the balance of the air is admitted into the lower part of the combustion chamber through inlet pipe 68, bustle 66 and pipe connections 63. In the specific embodiment of the invention described, the diameter and height of the combustion chamber are about equal. While these proportions are preferred, it is to be understood the diameter of the chamber may, in some instances, advantageously exceed the height by a substantial amount, and may also be somewhat less than the height. Preferably, the diameter of the chamber is not less than the height. Since the combustion chamber preferably has a large diameter, it will be seen the velocity of the upwardly flowing stream of oxidizing gas is low. Since the hot combustion gases are

discharged from the reaction chamber through pipe 81, it will be seen the ore fines are first introduced into a highly heated section of the combustion chamber, this feature serving to aid rapid heating and ignition of the fines.

At the uppermost point of travel of the fines, a relatively uniform distribution of partially roasted particles is formed over the major portion of the upper end of the combustion zone and downward movement of the particles begins. The latter thereafter drop through the combustion chamber at a rate substantially the same as that of similar particles falling under the influence of gravity. In the preferred mode of operation, the blower 73 is operated so as to feed into the furnace enough air to supply sufficient oxygen to effect substantially complete oxidation of the fines, and also so that the velocity of the gas stream through the combustion chamber is not sufficient to interfere with the free gravity fall of the fines. Because of the angular pitch of inlets 49, and other above-noted control conditions, ore particles during the initial movement are not thrown against the walls of the roasting chamber, and thus avoid contact of the fines with the hot walls of the combustion chamber when the fines are in a state conducive to scarring. As the downward flow of the fines is in substantially straight lines or at a high angle, subsequent contact of fines with the walls of the combustion chamber is avoided, thus further preventing conditions under which scarring might take place.

Since the gas in the upper end of the combustion chamber comprises substantially all air introduced through ports 61, it will be seen in the upper end of the roasting zone there is provided an atmosphere rich in oxygen. This procedure insures the presence of relatively large amounts of oxygen at a point where oxygen is needed to promote initiation of the roasting of the ore particles. By the time downward movement of the ore particles begins, roasting is well under way, and during the remainder of the fall of the ore particles through the section of the combustion chamber above the gas offtake 81, the ore particles and the gas stream flow co-current. At about the vertical mid-point of the combustion chamber 12, the sulfur content of the ore has been materially reduced, and further oxidation of the fines tends to proceed less readily. The partially roasted particles then drop into the upper end of the lower section of the roasting zone, and during continued fall, the ore particles pass countercurrent through a stream of oxidizing gas drawn in through ports 60 and flowing upwardly toward gas offtake 81. In the lower half of the combustion chamber the ore particles thus pass through an atmosphere increasingly rich in oxygen and containing decreasing smaller amounts of sulfur dioxide. This procedure provides for the presence of successively larger amounts of oxygen as oxidation of the particles becomes more difficult and hastens removal of sulfur dioxide from the atmosphere surrounding the individual particles. Just above and at the inlet ports 60 the ore particles drop into and through an atmosphere which is substantially all air, a condition which greatly facilitates completion of oxidation of the cinder.

The iron oxide cinder falling on hopper-shaped hearth 75 is finely divided, free-flowing, and runs through opening 77 into a suitable conveyor. The hot cinder collecting on hearth 75 radiates heat upwardly thus aiding in maintaining favorable temperature conditions in the roasting chamber. It will be understood the roasting operation is conducted so that in the combustion chamber there is a very slight negative pressure at opening 77, whatever small amount of air drawn in being utilized for oxidation.

In the furnace of Fig. 1, it may be considered the pitch of the surface of hearth 75 is greater than the angle of repose of the cinder. With this construction, the hot cinder at temperatures of about 1400–1600° F. collecting on the hearth radiates heat upwardly thus aiding in maintaining favorable temperature conditions in the roasting chamber.

When carried out in apparatus such as shown in Fig. 3, the operation of the process is substantially as described. In this furnace, the major portion of gas movement may be effected by suction induced by a fan in gas main 81 or, when air is supplied under suitable positive pressure through ports 61 and 60, the furnace may be operated under slight positive pressure. Although the burner may be operated so that all portions of the combustion chamber are under negative pressure, i. e. the air being drawn in through pipes 68 and 69 opened to the atmosphere, for the reasons indicated above, it is usually more desirable to feed air into the top of the combustion chamber under slight pressure. It will be understood the amount of air introduced into the burner is regulated by adjustment of valves such as 70 and 71.

In Fig. 3, the cinder falls onto the bottom 90 and the lower ends of plows 94 and rabble arms 93 are so adjusted as to facilitate the maintenance on the bottom of the combustion chamber of a bed of cinder of appreciable thickness, say 2 to 4 inches. As the area of the cinder bed is relatively extensive and the temperature of the cinder may be around say 1400-1600° F., large quantities of heat are radiated from the cinder bed upwardly into the combustion zone. The burner may be operated under conditions such that the velocity of the gas stream flowing through the combustion chamber is substantially the same as in the operation of the apparatus of Fig. 1. Rabble arms 93 are rotated at a suitable rate, and cinder is ultimately discharged from the bottom of the combustion chamber through one or more air-locked outlets 105. If it should be desired to introduce preheated air through the ports at the bottom and top of the furnace of Fig. 3, such air may be preheated by heat transfer from hot cinder after discharge of the latter from the combustion chamber, or by heat transfer from hot combustion gases discharged through pipe 81. Air used in the furnace of Fig. 1 may be preheated similarly if so desired.

The sulfur dioxide gases produced and withdrawn through line 81 may be used, for example, in the manufacture of sulfuric acid. The sulfur dioxide content of the burner gas may be regulated as desired by adjusting the amount of air fed into the combustion chamber as is known by those skilled in the art. Gases containing say 10–12½% sulfur dioxide may be made by the present process.

I claim:

1. Apparatus for roasting finely divided metal sulfides comprising a shell forming a substantially cylindrical, vertically disposed combustion chamber having a relatively horizontal top, means for feeding finely divided sulfides onto the center of the top, a plurality of ore feeding conduits spaced about the periphery of the shell adjacent the mid-

section thereof, said conduits being inclined at a relatively high angle to the horizontal and opening into the combustion chamber at points higher than the inlet ends of the ore feeding conduits, means for working ore over the surface of the top, means for feeding the ore into said conduits, gas jets in said conduits for charging ore into the combustion chamber, a plurality of gas inlet ports spaced about the periphery adjacent the top and base of the shell, means for introducing gas into the combustion chamber through said ports, means for discharging cinder from the bottom of the combustion chamber, and a gas outlet for the combustion chamber adjacent the midsection thereof.

2. Apparatus for roasting finely divided metal sulfide fines comprising a shell forming a vertically disposed combustion chamber, a plurality of fines feeding conduits spaced about the periphery of the shell adjacent the mid-section thereof, said conduits being inclined at a relatively high angle to the horizontal and opening into the combustion chamber at points higher than the inlet ends of the fines feeding conduits, means for feeding the fines into said conduit, gas jets in said conduits for charging fines into the combustion chamber, a plurality of gas inlet ports spaced about the periphery adjacent the top and base of the shell, means for introducing gas into the combustion chamber through said ports, means for discharging cinder from the bottom of the combustion chamber, and a gas outlet for the combustion chamber adjacent the midsection thereof.

3. The method of roasting finely divided sulfides to produce sulfur dioxide which comprises introducing sulfide fines into a substantially unobstructed combustion zone in an upward direction having a substantial horizontal component to form a dispersion of sulfide fines adjacent the top of the combustion zone, passing the fines downwardly in gaseous suspension through the upper portion of the combustion zone co-current with a stream of oxidizing gas and the resulting gaseous combustion products, and then through the lower portion of the combustion zone countercurrent to a stream of oxidizing gas, the total amount of oxidizing gas present being sufficient to effect substantially complete oxidation of the fines, discharging cinder from the bottom of the combustion zone, and withdrawing sulfur dioxide from an intermediate portion thereof.

4. The method of roasting finely divided sulfides to produce sulfur dioxide which comprises radially introducing sulfide fines upwardly into a substantially unobstructed combustion zone heated to temperatures above the ignition point of the fines, forming a dispersion of the fines adjacent the top of the combustion zone, passing the fines downwardly in gaseous suspension through the upper portion of the combustion zone co-current with a stream of oxidizing gas and then through the lower portion of the combustion zone countercurrent to a stream of oxidizing gas, the initial oxygen concentrations of said streams being substantially equal and the total amount of oxygen contained in said streams being sufficient to effect substantially complete oxidation of the fines, discharging cinder from the bottom of the combustion zone, and withdrawing sulfur dioxide gas at a point adjacent the vertical mid-point of the combustion zone.

5. Apparatus for roasting finely divided metal sulfide fines comprising a shell forming a combustion chamber, means including an upwardly directed injector passing thru a side wall of the shell for forming a dispersion of fines in the top of the combustion chamber, means for feeding fines to said injector, means adjacent the top and adjacent the bottom of the combustion chamber for introducing oxidizing gas into the combustion chamber, a gas outlet for the combustion chamber adjacent the mid-section thereof, and a cinder outlet at the bottom of the combustion chamber.

6. Apparatus for roasting finely divided metal sulfide fines comprising a shell forming a combustion chamber, means including an upwardly directed, radially disposed injector passing through a side wall of the shell for forming a dispersion of fines in the top of the combustion chamber, means for feeding fines to said injector, means including inlet ports adjacent the top and adjacent the bottom of the combustion chamber for introducing oxidizing gas into the combustion chamber, a gas outlet for the combustion chamber adjacent the mid-section thereof, and a cinder outlet at the bottom of the combustion chamber.

7. The method of roasting finely divided sulfides which comprises introducing sulfide fines between the ends and in an initial direction toward one end of a substantially unobstructed combustion zone to form a dispersion of sulfide fines adjacent said end of the combustion zone, maintaining said combustion zone at temperatures above the ignition point of the fines, introducing oxidizing gas into said end and into the opposite end of the combustion zone, the total amount of oxidizing gas being such as to supply to the combustion zone sufficient oxygen to support oxidation of the fines, passing the fines in gaseous suspension toward said opposite end through the combustion zone first through a portion of the combustion zone co-current with a stream of oxidizing gas and having in said portion an atmosphere decreasingly rich in oxygen and then through a second portion of the combustion zone countercurrent to a stream of oxidizing gas and having in said second portion an atmosphere increasingly rich in oxygen, discharging cinder from said opposite end of the combustion zone, and withdrawing sulfur dioxide gas from a point between said portions.

8. The method of roasting finely divided sulfides to produce sulfur dioxide which comprises radially introducing sulfide fines into a substantially unobstructed combustion zone in an upward direction having a substantial horizontal component to form a dispersion of sulfide fines adjacent the top of the combustion zone, passing the fines downwardly in gaseous suspension through the upper portion of the combustion zone co-current with a stream of oxidizing gas and the resulting gaseous combustion products, and then through the lower portion of the combustion zone countercurrent to a stream of oxidizing gas, the total amount of oxidizing gas present being sufficient to effect substantially complete oxidation of the fines, discharging cinder from the bottom of the combustion zone, and withdrawing sulfur dioxide from an intermediate portion thereof.

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