Aug. 17, 1937. R. B. FERGUSON 2,090,386

METHOD AND APPARATUS FOR ROASTING ORE

Filed July 24, 1935

Fig. 1.

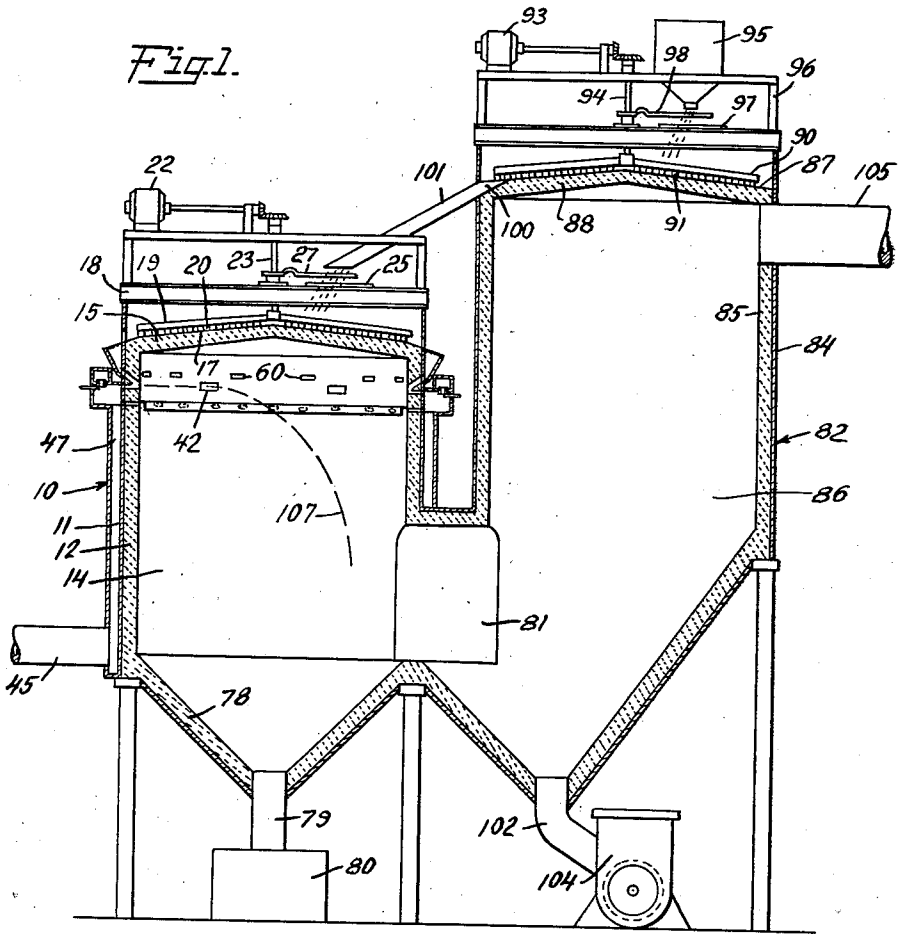


Fig. 2.

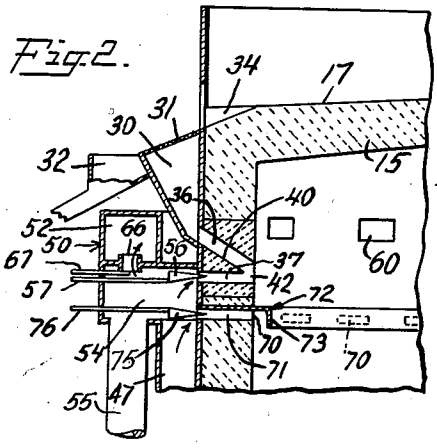
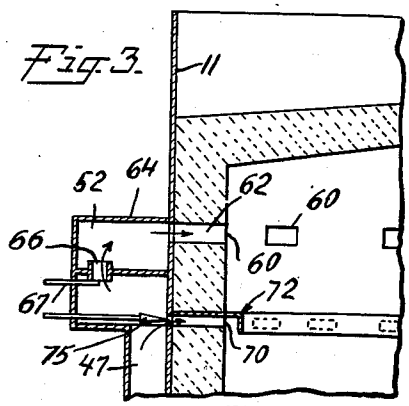


Fig. 3.



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Patented Aug. 17, 1937 2,090,386

UNITED STATES PATENT OFFICE

2,090,386

METHOD AND APPARATUS FOR ROASTING ORE

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Application July 24, 1935, Serial No. 32,849

8 Claims. (Cl. 75—9)

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

The nature of the invention, and the objects and advantages thereof may be more fully understood from a consideration of the following description taken in connection with the accompanying drawing, in which—

Figure 1 is a vertical section of a preferred burner construction;

Fig. 2 is an enlarged vertical section similar to portions of Fig. 1 and taken through the ore feeding mechanism, and

Fig. 3 is an enlarged vertical section taken through an air inlet port.

Referring to the drawing, 10 designates a shaft burner comprising a steel shell or casing 11 within which is placed the furnace lining 12, constructed of suitable refractory material such as firebrick and defining a roasting chamber 14 of circular horizontal cross-section. The upper part of the combustion chamber is closed off by a crown 15 the top side of which forms a drying or preheating hearth 17. The shell 11 projects upwardly beyond the crown 15 and carries a steel framework 18 which supports rabbling mechanism for the drying hearth. The surface of hearth 17 is slightly cone-shaped and slopes downwardly toward the shell of the furnace. Lying above the hearth are rabble arms 19 having downwardly projecting plows 20 pitched to work sulfides gradually toward the circumference of the drying hearth. Arms 19 are rotated by a motor 22 through a shaft 23 supported in bearings so as to maintain the lower ends of the plows 20 spaced with respect to the surface of the drying hearth 17. Fines are intermittently dropped from distributing platform 25 onto the center of hearth 17 by a sweep 27 rotating with shaft 23.

As shown more clearly in the enlarged detail of Fig. 2, attached to shell 11 by suitable brackets not shown are hoppers 30 covered by sloping screens 31. Cut through the shell 11 and also in the upper edge of lining 12 are downwardly sloping passages or conduits 34 through which fines are passed from drying hearth 17 into hoppers 30. Oversized material discharged by screens 31 is collected by receptacles 32 and conveyed by means not shown to a crusher, or used in a bed roaster or otherwise disposed of. It will be understood the number of conduits 34 and hoppers 30 used in conjunction with the burner correspond with the number of injectors employed. On rotation of rabble arms 19 the sulfide fines are gradually fed through opening 34 into hopper 30 which discharges fines into a downwardly sloping passage 36 which together with air inlet 37 constitutes part of an ore injector. For convenience in construction, fines passage 36 and air inlet 37 may be made in an individual block, several of which, in accordance with the number of injectors used, are peripherally spaced about the upper end of the burner. As will be seen from Fig. 2, sulfides fed into passage 36 from hopper 30 run down over sloping surface 40 at the bottom of which the fines are picked up by the air stream flowing through passage 37 and are carried into the furnace in a horizontal direction through fines inlet port 42. In some cases the axis of air inlet passage 37 may be upwardly directed at a relatively low angle with the horizontal. In the embodiment of the burner illustrated in Fig. 1 six injectors are employed.

The air used in the process to inject fines into the furnace and also to provide oxygen for the roasting operation is introduced into the roaster through pipe 45 opening into the bottom of an air preheating jacket 47 preferably made so as to surround the vertical walls of the burner. Near the top, the roaster is surrounded by a casing 50 formed so as to provide a secondary air inlet bustle 52 and a primary air inlet bustle 54 which communicates directly with the upper end of heating jacket 47. The casing 50 is attached to the shell in such a way that the outer ends of the air inlets 37 open into primary air bustle 54. Flow of air from bustle 54 into air inlet 37 is controlled by a suitable valve 56 operable by valve stem 57 from outside casing 50.

The major portion of the air used for oxidation of the fines is introduced into the top of combustion chamber 14 through ports 60 communicating through passages 62, Fig. 3, with secondary air inlet bustle 52. As will be seen from Figs. 2 and 3, the inner edge of the top side 64 of casing 50 abuts burner shell 11, with the exception of the modified portions formed to accommodate the lower ends of hoppers 30 as shown in Fig. 2. Flow of air from primary air bustle 54 into secondary air bustle 52 through a plurality of passages 66 is controlled by a corresponding number of suitable independently or simultaneously operated valves 67. Where it is desired to operate with unpreheated air, pipe 45 may be connected directly with bustle 54 and jacket 47 eliminated. Alternatively, some of the air may be introduced through pipe 45 as shown on the

drawing and the balance through a pipe 55 connected to inlet bustle 54 as shown in Fig. 2. In either case, the air may be supplied by a blower not shown.

In accordance with the invention, scarring or the building up of slag-like accretions on the inner walls of the roasting chamber is prevented by introducing at least some of the air consumed in roasting in such a way as to provide in effect a blanket or layer of air interposed between at least a portion of the inner walls of the roasting chamber and burning ore. To facilitate maintenance of the air blanket, there is provided in the burner walls a plurality of ports 70 communicating with the primary air inlet bustle 54 by means of passages 71. Ports 70 are spaced about the periphery of the roasting chamber at intervals suitable for the particular operating requirements. As shown in Fig. 2, ports 70 open into combustion chamber 14 underneath deflecting plate 72 having a depending vertical portion 73 long enough to insure downward passage of air along the inner wall of the combustion chamber for a substantial distance. Flow of air through all passages 71 may be controlled by valves 75 provided with operating stems 76.

The bottom of the combustion chamber 14 is formed by a hopper-shaped brick hearth 78 terminating in a cinder outlet pipe 79 emptying into a pit 80 from which cinder may be discharged by a conveyor not shown.

A gas main 81 for withdrawing gaseous products of combustion from the burner connects the bottom of the burner with the lower end of a preliminary gas cooler 82. As shown on the drawing, the cooler is constructed generally similar to burner 10 and comprises chiefly a steel shell 84 and a lining 85 of refractory material forming an elongated cylindrical gas cooling chamber 86. The upper surface 87 of top 88 of the cooling chamber 86 forms a drying or preheating hearth which is slightly cone-shaped and slopes downwardly toward shell 84. Above the hearth 87 are rabble arms 90 carrying downwardly projecting plows 91 pitched to work sulfides gradually toward the circumference of the drying hearth. Arms 90 are rotated by a motor 93 through shaft 94 supported in bearings so as to maintain the lower ends of the plows spaced with respect to the surface of hearth 87. A bin 95 mounted on framework 96 discharges fines onto a platform 97 from which the fines are intermittently dropped onto hearth 87 by a sweep 98, rotating with shaft 94. The upper edge of cooler shell 84 and also the upper edge of lining 85 are provided with a passage 100 through which material is fed into chute 101, the outlet end of which is arranged to discharge fines onto platform 25 on the top of burner 10.

The lower end of chamber 86 is made hopper-shaped and terminates in an outlet pipe 102 connecting with an air-lock 104 by means of which dust and cinder may be discharged from chamber 86 without admitting air into the system. Sulfur dioxide gases leave the top of gas cooling chamber 86 through a pipe 105.

The invention is applicable to roasting of finely divided metal sulfides such as iron pyrites, pyrrhotite, zinc sulfide or arsenopyrite, and for convenience the operation of the process may be described in connection with roasting of iron pyrites.

The supply of sulfide fines is maintained in bin 95 by a suitable conveyor or elevator mechanism not shown. Before the roasting operation is begun, the combustion chamber 14 is preheated to temperatures above the ignition point of the particular fines to be roasted as by means of oil burners inserted through conveniently located work-holes not shown. After an initial supply of fines has been provided on burner hearth 17 and the desired degree of preheat obtained in combustion chamber 14, motors 22 and 93 are started and rabble arms 19 and 90 may be rotated at a rate of say one revolution per minute. The fines run continuously out of bin 95 onto platform 97 and on each revolution of shaft 94 a regulated quantity of fines is swept off platform 97 onto approximately the center of the gas cooler drying hearth 87. On rotation of rabble arms 90, sulfide fines are gradually worked across the surface of hearth 87 and into outlet passage 100 opening into chute 101 which carries the more or less dried fines on the platform 25 from whence such fines are intermittently dropped onto the center of drying hearth 17 on top of the burner. By rotation of the rabble arms 19, the fines are worked outwardly across the surface of hearth 17 and into the several passages 34 each of which communicates with a hopper 30. The dry or dry and partly preheated fines are run onto sloping screen 31, which removes lumps and thence into hopper 30 and injector feed passages 36.

In accordance with the invention, only a relatively small amount, say less than about 10%, of the total air used in the roasting operation is employed to inject the fines into the top of the roasting chamber. Steam or any gas not adversely affecting oxidation of the sulfite may be employed to charge the fines into the combustion chamber. However, it is preferred to use air which may be maintained in bustle 54 at a pressure of for example about 5 pounds per square inch. Since the air is brought into the process through jacket 47, the air in bustles 52 and 54 may be preheated to say 300–400° F. by absorption of heat from the burner walls. Fines run continuously down through passage 36 and are picked up by the air stream passing through injector inlet passage 37. The quantity and velocity of air flowing through any given passage 37 is controlled by adjustment of a valve 56, and in practice, the valve is adjusted so that the primary air flows through passage 37 in quantity and at velocity great enough so that the bulk of the fines particles are carried substantially horizontally over a substantial distance through the upper end of the combustion chamber before descending under the influence of gravity. In Fig. 1 dotted line 107 indicates the approximate path of an ore particle of average size. Further, the air pressure in passage 37 is regulated preferably so that substantially none of the fines particles will be carried far enough across the furnace horizontally so as to contact the opposite wall of the combustion chamber. Inasmuch as several injectors are employed, it will be understood that by this method there is formed in the upper end of the burner a dispersion of fines covering a major portion of the top of the combustion zone. This dispersion is formed in such a way that contact of fines with the combustion chamber walls is avoided. This is particularly important since the fines containing an appreciable proportion of sulfur are in a state conducive to scar formation. Horizontal or slightly upwardly inclined injection of fines also has the advantage of effecting heating up of the fines to the ignition point before vertical drop of the fines commences, in this way decreasing the nec-

essary length of the vertical drop for desulfurization of the fines and cutting down the vertical dimension of the burner.

In accordance with the invention the major part of the air used to support roasting is introduced through the air ports **60** communicating with the secondary air inlet bustle **52**. By adjustment of the several valves **67**, the air pressure in secondary air bustle **52** and the velocity and quantity of air entering the combustion chamber through ports **60** may be regulated. To obtain the best results, it is preferable to maintain the pressure in bustle **52** at say around 3 pounds per square inch, appreciably less than the pressure in bustle **54** so that the velocity of the air entering the combustion chamber through ports **60** is substantially less than the velocity of the air flowing through injector inlets **37**. The horizontal plane of ports **60** is located adjacent the underside of combustion chamber crown **15** substantially above the horizontal plane of ports **42** through which the fines are injected. By reason of this arrangement and the relatively low velocity of the air entering the combustion chamber through ports **60**, the relatively large amount of air needed for roasting can be introduced into the upper end of the combustion chamber just beneath the crown **15** without immediately contacting and disturbing the fines dispersion formed approximately in the plane of inlets **37**. In this way, the setting up within the upper end of the roaster of turbulent conditions tending to carry the fines against the roasting chamber walls while in a state conducive to scarring is avoided. Separate introduction of the fines and of the bulk of the air used in the roasting operation makes possible the introduction into the top of a relatively short furnace of all the fines and of all the air needed to support roasting without causing fines to contact with the inner walls of the combustion chamber.

On introduction of the fines and air (preheated or not) into the combustion chamber in the manner described, ignition of the fines takes place almost instantaneously. 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 of the furnace, no auxiliary heat is required. In operation the temperature is high throughout the chamber, and in the production of say an approximately 10% SO_2 gas from iron pyrites, the temperature of the roasting chamber as a whole may be around 1800–2000° F.

In the upper end of the roasting chamber, the reaction is most intense and temperatures are high on account of the relatively high sulfur content of the ore. Accordingly, in the upper end of the combustion zone there is a greater tendency toward scar formation than farther down. By introducing the fines and the major portion of the air used to support oxidation into the upper end of the roasting chamber in the manner described, the tendency toward causing contact of fines with the roasting chamber wall is minimized, but to insure substantial absence of scarring in the roasting operation in accordance with the present invention a relatively small portion of the primary air is introduced into the top of the combustion chamber through ports **70** beneath deflecting plate **72**. The pressure of the air flowing through passages **71** is adjusted by valves **75** so that there is maintained between the roasting chamber walls and the burning fines an air blanket extending down at least a substantial distance toward the bottom of the combustion chamber. As roasting of the fines progresses, scar formation tendency decreases and usually it is not necessary to maintain an air blanket between the roaster chamber walls and the burning fines all the way to the bottom of the combustion zone. In practice, the lower edge of the zone in which scar formation tends to take place may be determined by observation through work-holes, and the air pressure in passages **71** adjusted accordingly so as to cause the air blanket to extend downwardly at least throughout the zone in which scar formation tends to take place. Only a relatively small amount, say about 5%, of the total quantity of air required for roasting need be used to maintain the air blanket.

The fines and the oxidizing gas stream pass downwardly co-current through the combustion chamber and roasting of the fines progresses to completion. It is preferred to use an unobstructed combustion chamber of relatively large cross-section and having a horizontal dimension approximating and preferably a little less than the height. The co-current roasting operation may be carried out satisfactorily when fines and air are introduced into the burner in the manner described and the combustion chamber is proportioned about as indicated.

A free-flowing iron oxide cinder collects on hearth **78** and is discharged from the apparatus into pit **80**. The hot sulfur dioxide gases at temperatures around 1800–2000° F. pass through connection **81** and thence upwardly through chamber **86**. Entrained dust drops out of the gas stream while the latter flows upward through chamber **86** and collects in the bottom. The horizontal dimension of cooler **82** corresponds generally with that of burner **10**, although the height of the cooler is preferably sufficient to make possible gravity flow of fines through chute **101**. In view of the large area presented to the atmosphere by the surface of the cooler, substantial cooling of the gas is effected, and the sulfur dioxide gas stream is discharged through pipe **105** at temperatures of about 1200–1400° F. and is conducted thence to a gas purification system or to a suitable waste heat boiler or auxiliary gas cooler and suitable auxiliary dust collector prior to the usual gas purification system. In accordance with the invention, at least a substantial portion of the surface, for example the top, of the cooler is employed to subject the fines to a preliminary drying. Sulfide fines, especially flotation concentrates, are received in wet or damp condition and drying is necessary before the fines may be satisfactorily injected into and dispersed in the combustion chamber. The amount of drying surface of a single burner unit is relatively limited, and the capacity of a single burner unit depends more or less upon the amount of relatively dry fines available. By the present arrangement, the area of the fines drying surface is substantially doubled, and by utilizing heat of the hot sulfur dioxide gases recovered during cooling of the gases after discharge from the burner, the capacity of a burner unit may be substantially increased without providing additional fines drying equipment.

I claim:

1. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises in-

jecting sulfide fines into one end of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber in a direction having an initial horizontal component and at an initial velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to disperse the fines in the combustion zone and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing into said end of the combustion chamber at a point adjacent introduction of the fines a stream of oxidizing gas containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity less than that of the initial injection velocity of the fines and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas and while passing the fines through the combustion chamber co-current with the stream of oxidizing gas, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products therefrom.

2. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises injecting sulfide fines into one end of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber in a direction having an initial horizontal component by means of a stream of gas at superatmospheric pressure and having velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to disperse the fines in the combustion zone and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing into said end of the combustion chamber at a point adjacent introduction of the fines a stream of oxidizing gas containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity less than that of the fines injecting gas and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas and while passing the fines through the combustion chamber co-current with the stream of oxidizing gas, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products therefrom.

3. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises injecting sulfide fines into the top of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber in a direction having an initial horizontal component by means of a stream of gas at superatmospheric pressure and having velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to form a dispersion of fines in the upper end of the combustion chamber and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing into the top of the combustion chamber at a point adjacent introduction of the fines a stream of oxidizing gas containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity substantially less than that of the fines injecting gas and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas and while passing the fines downwardly through the combustion chamber co-current with the stream of oxidizing gas, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products from the bottom of the combustion chamber.

4. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises injecting sulfide fines peripherally into one end of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber by means of a stream of gas at superatmospheric pressure and having velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to disperse the fines in the combustion zone and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing peripherally into said end of the combustion chamber, at a point adjacent but spaced from the point of introduction of the fines, a stream of oxidizing gas containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity substantially less than that of the fines injecting gas and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products therefrom.

5. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises injecting sulfide fines peripherally at the top of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber by means of a stream of air at superatmospheric pressure and having velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to form a dispersion of fines in the upper end of the combustion chamber

and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing peripherally and at the top of the combustion chamber, at a point adjacent but spaced from the point of introduction of the fines, a stream of air containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity substantially less than that of the fines injecting air and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas and while passing the fines downwardly through the combustion chamber co-current with the stream of oxidizing gas peripherally introducing into the top of the combustion chamber a stream of air and maintaining a layer of said air between the walls of the combustion chamber and the burning ore while the latter is in a state conducive to scar formation, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products from the bottom of the combustion chamber.

6. Apparatus for roasting metal sulfide fines comprising a combustion chamber having a large horizontal dimension relative to the height, a fines feeding conduit in the periphery of the combustion chamber at the top thereof, means for feeding fines into the inlet end of the feed conduit, means for injecting gas into the fines to charge the same into the combustion chamber and cause fines to travel across the combustion chamber a substantial distance in a horizontal direction and form a dispersion of fines in the top of the combustion chamber, a plurality of air ports in the periphery of the combustion chamber at the top thereof for introducing into the top of the combustion chamber a stream of oxidizing gas to support oxidation of the fines, means for discharging cinder from the bottom of the combustion chamber, and a gas outlet for withdrawing gaseous combustion products from bottom of the combustion chamber.

7. Apparatus for roasting metal sulfide fines comprising a combustion chamber having a large horizontal dimension relative to the height, a plurality of fines feeding conduits in the periphery of the combustion chamber at the top thereof, means for feeding fines into the inlet ends of the feed conduits, means for injecting gas into the fines to charge the same into the combustion chamber and cause fines to travel across the combustion chamber a substantial distance in a horizontal direction and form a dispersion of fines in the top of the combustion chamber, a plurality of air ports in the periphery of the combustion chamber at the top thereof for introducing into the top of the combustion chamber a stream of oxidizing gas to support oxidation of the fines, means at the upper end of the combustion chamber for maintaining a layer of gas between at least the upper part of the combustion chamber walls and the burning ore therein, means for discharging cinder from the bottom of the combustion chamber, and a gas outlet for withdrawing gaseous combustion products from the bottom of the combustion chamber.

8. The method for roasting metal sulfide fines to produce sulfur dioxide which comprises injecting sulfide fines peripherally at the top of a combustion chamber heated to temperatures above the ignition point of the fines and having a large transverse dimension relative to the height, said fines being injected into the combustion chamber by means of a stream of air at superatmospheric pressure and having velocity such as to cause at least a portion of the fines to travel horizontally across the combustion chamber a substantial distance and to form a dispersion of fines in the upper end of the combustion chamber and low enough to prevent initial contact of any substantial quantities of incoming fines with the heated combustion chamber walls at points approximately opposite the point of introduction of the fines, separately introducing peripherally and at the top of the combustion chamber, at a point adjacent but spaced from the point of introduction of the fines, a stream of air containing sufficient oxygen to effect substantially complete roasting of the fines and moving at a velocity substantially less than that of the fines injecting air and low enough to avoid setting up turbulent gas currents in the combustion chamber and to avoid causing fines contacting the hot walls of the combustion chamber, roasting the fines while in suspension in the oxidizing gas and while passing the fines downwardly through the combustion chamber co-current with the stream of oxidizing gas, separating gaseous combustion products from oxide cinder, discharging cinder from the bottom of the combustion chamber, and separately withdrawing gaseous combustion products from the bottom of the combustion chamber.

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