June 6, 1933. H. O. C. INGRAHAM 1,912,455

METHOD AND APPARATUS FOR ROASTING ORES

Filed Aug. 8, 1930

Fig. 1.

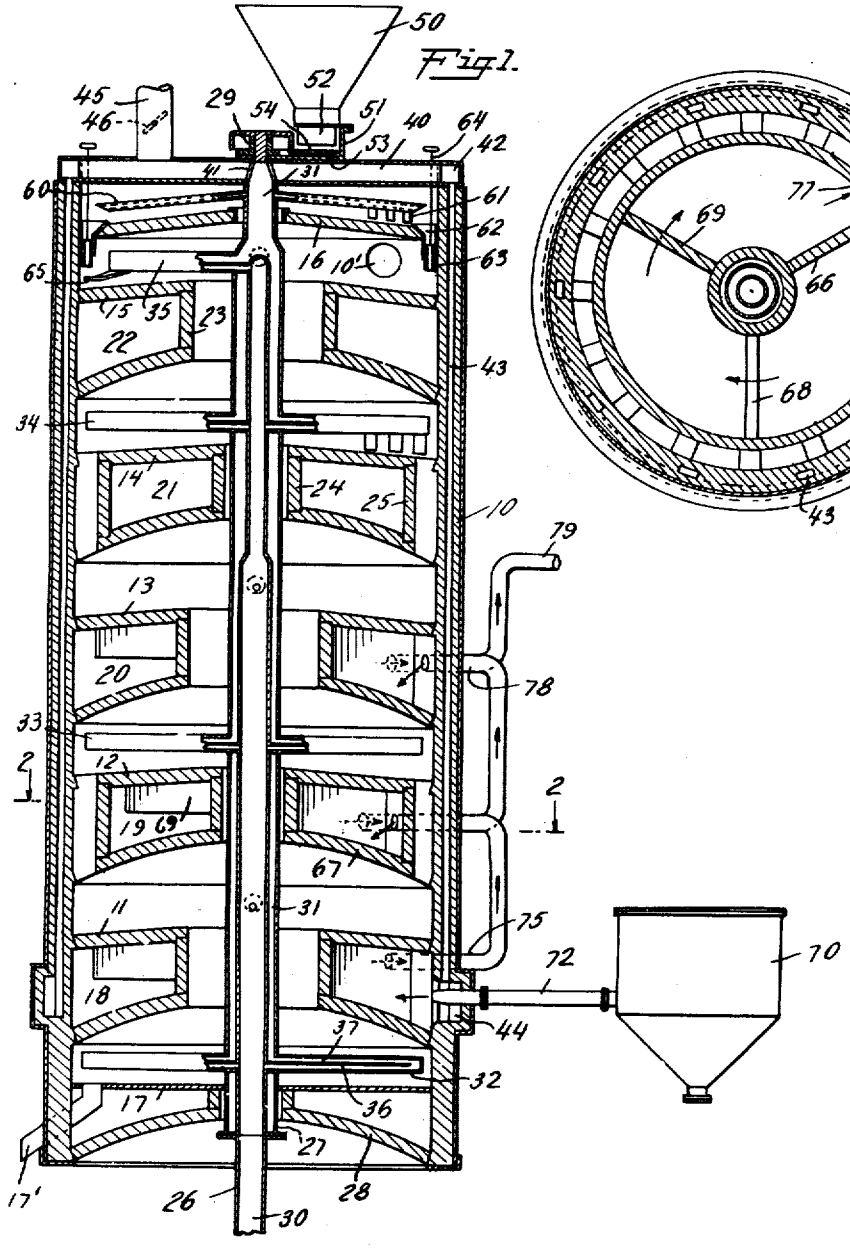


Fig. 2.

INVENTOR
H. O. C. Ingraham
BY
Fothergill
ATTORNEY

Patented June 6, 1933

1,912,455

UNITED STATES PATENT OFFICE

HAROLD O. C. INGRAHAM, OF GREENWICH, CONNECTICUT, ASSIGNOR TO GENERAL CHEMICAL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

METHOD AND APPARATUS FOR ROASTING ORES

Application filed August 8, 1930. Serial No. 473,837.

This invention relates to a method and apparatus for roasting ores, and is particularly directed to a method and apparatus for the roasting of those ores which require the employment of extraneous heat to effect the roasting operation.

Heretofore, furnaces employed for the roasting of ores such as zinc blend which require the application of extraneous heat to satisfactorily complete the roasting thereof have been customarily equipped with suitable muffles associated directly with the roasting hearths. Such furnaces employing muffled hearths have been heated by the burning of natural gas of other suitable fuel, and in many installations, it has been common practice to utilize producer gas as a source of heat. In the former instance, the utilization of natural gas or other hydrocarbon fuel is a direct charge against the roasting operation. In plants where the latter method is employed, it is necessary to provide producer gas generators and associated apparatus. The necessity for such equipment increases the cost of roasting not only in the capital investment, but in maintenance after installation.

This invention contemplates the combustion of sulfur with a combustion supporting gas, preferably preheated, in the muffles of such roasting furnaces, the utilization of the heat generated by the combustion of the sulfur to supply the extraneous heat necessary for efficiently effecting the roasting operation, and the subsequent employment in the arts of the sulfurous gases formed by the combustion of the sulfur in the muffles.

By employing the combustion of sulfur as the source of extraneous heat in accordance with the present invention, it becomes possible to supply the extra heat required at a much lower operating cost than heretofore since the sulfur dioxide gas produced is in itself a valuable product and may be used for example in the production of sulfuric acid by the contact process, or in accordance with the preferred method of practicing my invention, may be mixed with the sulfur dioxide gas stream produced by the roasting of the sulfide ore undergoing roasting in the furnace in which the sulfur is being burned to supply the extraneous heat required. By thus mixing the two steams of sulfur dioxide gas the volume of sulfur dioxide produced is of course greatly augmented and in addition is ordinarily enriched in SO_2 content by reason of the fact that the sulfur dioxide gas from the combustion of the sulfur will ordinarily be richer in SO_2 content than the gas from the ore roasting. A further advantage of the combustion of sulfur to provide the extraneous heat required is that the danger of leakage of air or inert products of combustion from the heating flues into the roaster hearths, or leakage of SO_2 gas from the roasting hearths into the muffles, with attendant dilution of the roaster gas or loss of valuable SO_2 into the waste products of combustion as necessarily occurs when carbonaceous fuels are used to supply the extraneous heat, is entirely obviated when sulfur is burned in the muffles because the sulfur dioxide gas produced is of substantially the same composition as the sulfur dioxide gas produced from the ore roasting. Operating and maintenance costs are thus reduced since the necessity heretofore of constructing and maintaining the furnaces tight against gas leakage, and extremely difficult accomplishment at the high temperatures existing in the furnace, is now largely reduced or eliminated.

A suitable furnace for practicing my invention is illustrated in the accompanying drawing, in which

Fig. 1 is a vertical section of a multi-hearth roasting furnace, and

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

The numeral 10 indicates generally a vertically disposed multi-hearth roasting fur-

nace of the general type known as the Herreshoff roaster. The furnace includes a plurality of superposed roasting hearths 11, 12, 13, 14 and 15. The top of the roasting chamber is closed off from the atmosphere by the drying deck 16, and the bottom of the roasting chamber is formed by the cinder floor 17. The roasting hearths each have associated therewith the muffles 18, 19, 20, 21 and 22. The top and bottom of each muffle are formed respectively by the floor of the next upper roasting hearth, and the arched top of the lower roasting chamber. The outer vertical walls of the furnace and the circular members 23 constitute the side walls of the muffles 18, 20 and 22, and the vertical walls of the muffles 21 and 19 are formed by the circular brick-work 24 and 25. As is usual in roasting furnaces of the kind described, alternate hearths are arranged with peripheral and central openings to facilitate the passage of the ore through the roaster from top to bottom.

The shaft indicated generally at 26 is rotatably supported at its lower end by means not shown, and is arranged to revolve in the opening 27 in the lower arched wall 28 and in the upper bearing 29 which is properly secured against lateral movement by members, not shown, extending across the top of the furnace. The shaft 26 includes the central air passage 30, and the annular passage 31. The shaft 26 has associated therewith a suitable number of rabble arms indicated generally at 32, 33, 34, and 35. Each rabble arm is constructed in a manner known in the art, so that air under suitable pressure in the central passage 30 is conducted to the end of each rabble arm by a passage 36, and then returned to the main annular passage 31 in the shaft 26 through a passage as indicated at 37 on the rabble arm 32. Rabble arms 32, 33 and 34 are each provided with the customary plows or teeth arranged to work the ore toward the vertical passages adjacent the periphery of the furnace as the shaft 26 rotates and the roasting of the ore proceeds. The plows on the rabble arms associated with hearths 11, 13 and 15 are oppositely arranged so as to work the ore toward the central passages through the hearths of the furnace as the shaft 26 rotates.

The annular passage 31 in the shaft 26 is connected at its upper end to a cross conduit 40 through a series of slots indicated at 41. The conduit 40 is securely supported on the top of the furnace shell by members not shown. The ends of the conduit 40 open into the circular bustle 42 resting on the upper end of the furnace wall. The bustle 42 is in turn connected to a series of passages or ducts 43 in the vertical walls of the furnace, which passages terminate at their lower ends in a bustle 44 constructed about the lower end of the furnace surrounding the muffle 18. The conduit 40 is provided with an outlet 45 having a suitable control damper 46.

The ore hopper 50 is attached to and supported by a bracket 51 which is suitably secured and held in the position indicated by cross members not shown. The lower end of the hopper 50 is provided with a circular sleeve outlet 52 which is vertically adjustable with respect to the lower end of the hopper and a horizontal shelf 53 formed by the horizontal portion of the bracket 51. The wiper blade 54 is fixed to and rotates with the shaft 26. It will be understood that the space above the drying deck 16 is open except where interrupted by the conduit 40, and other cross members not shown which serve to support the bearing 29, bracket 51, conduit 40, and the hopper 50.

A rabble arm 60, constructed similarly to the other rabble arms, is attached to the upper end of the shaft 26 and includes plows 61 which, on rotation of the shaft, gradually work the ore outwardly over the top of the drying deck 60 and into the secondary ore feed hoppers 62. The hoppers 62 are each provided with an adjustable sleeve 63, the vertical position of which is controlled and regulated by the stem 64 threaded into and supported by suitable bracket attached to the furnace wall and not shown in the drawing. It will be understood that the rotation of the stems 64 changes the position vertically of the lower end of the sleeves 63 with respect to the surface of the hearth 15. Wiper members 65 are connected to the ends of each of the rabble arms 35 and are arranged to pass under the ends of the sleeves 63 on each rotation of the shaft.

The construction of the muffle 19 is shown in Fig. 2. The circular muffle is provided with a radial baffle 66 which extends vertically from the upper surface of the arch 67 of the lower roasting chamber upwardly to the under side of the hearth 12. The baffle 68 is similarly arranged except that the upper half of the baffle is cut off and its upper edge does not abut the lower side of the hearth 12. The baffle 69 projects downwardly from the under side of the hearth 12, its lower edge terminating approximately mid-way between the hearth 12 and the arch 67 as clearly shown in Fig. 1. In the present embodiment of the invention, muffles 18 and 20 are similarly constructed, and if desired, the same arrangement may be included in the muffles 21 and 22.

The numeral 70 indicates a sulfur sublimer. The sublimer is preferably of the type in which sulfur is vaporized by the combustion of a portion thereof, the small portion of the sulfur which is burned to SO_2 supplying the heat for vaporizing the remaining larger portion of the sulfur. A gas rich in sulfur vapor is thus generated. It will be understood that the sulfur for the sublimer 70 and

the necessary air for the burning and volatilization of sulfur therein may be supplied by any suitable means and I have not described the sublimer in detail since suitable sublimers are known in the art. The vapor chamber of the sublimer 70 is connected to the inlet 71 of the muffle 18 through a conduit 72. As shown in Fig. 1, the end of the pipe 72 passes into and through the bustle 44. At the inlet 71 air from the bustle 44 and gas from the sublimer 70 are mixed and introduced into the muffle 18. After passing completely around the muffle 18 the gases leave through the outlet pipe 75 and are introduced into the next higher muffle 19 through the inlet 76. In a similar manner the gases circulate through the muffle 19 and leave the muffle through the exit pipe 77, and are thence lead into the muffle 20 through the inlet 78. After passage of the gas through the muffle 20, the gases are discharged from the furnace through the outlet pipe 79 and are conducted to suitable conversion apparatus.

The operation of the improved method and apparatus is as follows:

Sulfide ore such as zinc blend is fed into the hopper 50 by any suitable mechanism. By proper adjustment of the sleeve 52, a pile of ore is maintained on the horizontal shelf 53. On each revolution of the shaft, a predetermined quantity of ore is swept off the shelf 53 by the wiper 54 and dropped onto the drying deck 16. On further rotation of the shaft 26, the ore is gradually worked outwardly over the drying deck and into the feed hoppers 62. The ore drops from the hoppers 62 through the sleeves 63 to the surface of the hearth 15, and is deposited thereon in small piles similar to those formed on the shelf 53 under the primary hopper 50. On rotation of the shaft 26, the wipers 65 on the ends of the arms 35 sweep small portions of ore out from under the sleeves 63, at which time such portions are picked up by the plows of the rabble arm 35 and are gradually worked toward the center of the hearth 15. As the roasting of sulfide ores in furnaces of the type described is well understood, further detailed mention of the roasting operation per se is unnecessary. It is sufficient to say that the gases formed by the roasting of sulfides contain sulfur dioxide as the principal useful constituent. The gaseous products are drawn off from the furnace through the outlet indicated at 10'. After the ore has passed successively over the roasting hearths, it is discharged from the furnace through the cinder outlet 17'.

During the roasting operation, air under suitable pressure is introduced into the center conduit 30 of the shaft 26, and, in the manner well known in the art, is circulated through the rabble arms and back into the annular passage 31 of the shaft 26. It will be understood that such circulation of air through the shaft 26 and the rabble arms maintain the rabbling mechanism at a sufficiently low temperature to prevent damage thereto on account of excessive heating, and at the same time effects a heating of the cooling air. The heated air leaving the upper end of the annular conduit 31 passes into the transverse pipe 40 through the slots 41, and is conducted through the conduit 40 into the bustle 42. The heated air then passes downwardly through the several vertical passages 43 and is thus introduced into the bustle 44 surrounding the lower muffle 18. It will be apparent that as the air passes downwardly through the ducts 43, its temperature will be further increased by the amount of heat extracted from the walls of the furnace. In the event that more air is needed to effect proper cooling of the rabble mechanism than is necessary for the combustion of the gases in the muffles as hereinafter described, the surplus heated air can be discharged from the conduit 40 through the outlet 45 by suitable manipulation of the damper 46.

As mentioned, according to the preferred mode of operation of the invention, the sublimer 70 is of the type in which sufficient quantities of air are introduced to effect combustion of a small quantity of the sulfur and a vaporization of a large amount of sulfur by the heat generated by the combustion of the smaller portion. The resulting gas mixture rich in sulfur vapor is introduced into the muffle 18 through the muffle inlet 71. At the inlet, the gases from the sublimer are mixed with preheated air from the bustle 44 to effect a complete combustion of the sulfur in the gases, during the passage of the gas mixture through the several muffles of the shaft furnace. On admission of the preheated air and sulfur containing gases, combustion of the resulting gas mixture is initiated in the muffle 18 and proceeds as the mixture is circulated through the muffle with the consequent generation of large quantities of heat. The combustion of the sulfur and the generation of heat continues as the gas mixture passes successively through the muffles 18, 19 and 20. By the time the combustion of the sulfur is complete, as will be the condition after the gas passes through the muffle 20, the resulting gas, containing sulfur dioxide, is discharged from the roaster through the outlet 79, and may be conducted to a contact sulfuric acid plant designed for the use of brimstone burner gas. It will be noted that the burning gas mixture enters each muffle on one side of a full baffle 66 and passes completely around the circumference of the furnace and is discharged from the muffle on the opposite side of the full baffle. Thus the full benefit of the heating effect of the burning gases is obtained

and imparted to the roasting ores on the adjacent hearth.

Although the present invention is applicable to the roasting of all types of sulfide ores in which extraneous heat is required, the invention particularly contemplates the roasting of zinc sulfide, for the efficient roasting of which a temperature of about 1600° F. should be maintained in the furnace, particularly on the lower hearths thereof. By the use of preheated air, it is possible to maintain temperatures of 2000°-2200° F. in the muffles 18, 19 and 20, with the consequent maintenance of a temperature of at least 1600° F. on the roasting hearths of the furnace.

It will be understood that instead of passing the sulfur gases through the muffles 18, 19 and 20 in series as described, it is possible to divide the gas stream from the sublimer into two or more portions and burn part of the gas in each muffle. In some instances, it may also be desirable to conduct the burning of sulfur gases in a greater or lesser number of muffles than described in the specific embodiment of the invention set forth.

A modified mode of operation of the invention contemplates the utilization of the gases from the roaster, discharged from the outlet 10′, and the gases discharged from the muffle through the outlet conduit 79 in separate apparatus. This procedure may be adopted where for any reason it is not desired to mix the gases from the outlet 79 with the gases issuing from the roaster through the outlet 10′.

I claim:

1. The process of roasting sulfide ores requiring the application of extraneous heat to effect an efficient roasting thereof which comprises initiating the roasting operation, generating a sulfur containing gas mixture, adding a heated combustion supporting gas to such mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ores.

2. The process of roasting sulfide ores requiring the application of extraneous heat to effect an efficient roasting thereof which comprises initiating the roasting operation, generating a sulfur containing gas mixture, preheating a combustion supporting gas, adding such preheated gas to the sulfur containing gas mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ores undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ores.

3. The process of roasting sulfide ores requiring the application of extraneous heat to effect an efficient roasting thereof which comprises initiating the roasting operation, generating a sulfur containing gas mixture, circulating a combustion supporting gas in heat exchange relation with the ores undergoing the roasting operation, adding such preheated gas to the sulfur containing gas mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ores undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

4. The process of roasting a zinc sulfide ore which comprises initiating the roasting operation, and burning sulfur in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

5. The process of roasting a zinc sulfide ore which comprises initiating the roasting operation, generating a sulfur containing gas mixture, and burning sulfur in such mixture in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

6. The process of roasting a zinc sulfide ore which comprises initiating the roasting operation, generating a sulfur containing gas mixture, adding a heated combustion supporting gas to such mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

7. The process of roasting a zinc sulfide ore which comprises initiating the roasting operation, generating a sulfur containing gas mixture, preheating a combustion supporting gas, adding such preheated gas to the sulfur containing gas mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

8. The process of roasting a zinc sulfide ore which comprises initiating the roasting operation, generating a sulfur containing gas mixture, circulating a combustion supporting gas in heat exchange relation with the ore undergoing the roasting operation, adding such preheated gas to the sulfur containing gas mixture, and burning the resulting gas mixture in indirect heat exchange relation with the ore undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

9. The process of roasting sulfide ores requiring the application of extraneous heat to

effect an efficient roasting thereof which comprises initiating the roasting operation, and burning sulfur in indirect heat exchange relation with the ores undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ores.

10. Apparatus for roasting ores comprising a furnace including a roasting chamber, means for feeding ore into said chamber, wherein the roasting of such ore is initiated, a sulfur sublimer for generating a sulfur containing gas mixture, a gas connection between the sublimer and the roasting chamber for introducing said mixture into the furnace and initiating the burning of such gas mixture therein, so that the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ore.

11. Apparatus for roasting ores comprising a roasting hearth, a muffle associated therewith, means for generating a sulfur containing gas mixture, and means for burning sulfur in such mixture in the muffle.

12. Apparatus for roasting ores comprising a roasting hearth, a muffle associated therewith, means for generating a sulfur containing gas mixture, means for preheating a combustion supporting gas, means for mixing the first mentioned gas and the preheated combustion supporting gas, and means for introducing the resulting gas mixture into the muffle and initiating the burning of such gas mixture therein.

13. Apparatus for roasting ores comprising a roasting hearth, a muffle associated therewith, means for generating a sulfur containing gas mixture, means associated with the hearth for preheating a combustion supporting gas, means for mixing the first mentioned gas and the preheated combustion supporting gas, and means for introducing the resulting gas mixture into the muffle and initiating the burning of such gas mixture therein.

14. Apparatus for roasting ores comprising a multi-hearth roasting furnace, a muffle associated with each hearth, means for generating a sulfur containing gas mixture, means for introducing the gas mixture into one muffle and initiating the burning of the gas mixture therein, and means for circulating the burning gas through another muffle.

15. Apparatus for roasting ores comprising a multi-hearth roasting furnace, a muffle associated with each hearth, means for generating a sulfur containing gas mixture, means for preheating a combustion supporting gas, means for mixing the first mentioned gas and the preheated combustion supporting gas, means for introducing the resulting gas mixture into one muffle and initiating the burning of such gas mixture therein, and means for circulating the burning gas through another muffle.

16. Apparatus for roasting ores comprising a multi-hearth roasting furnace, a muffle associated with each hearth, means for generating a sulfur containing gas mixture, means associated with a hearth for preheating a combustion supporting gas, means for mixing the first mentioned gas and the preheated combustion supporting gas, means for introducing the resulting gas mixture into one muffle and initiating the burning of such gas mixture therein, and means for circulating the burning gas through another muffle.

17. Apparatus for roasting ores comprising a multi-hearth roasting furnace, a muffle and rabbling mechanism associated with each hearth, means for generating a sulfur containing gas mixture, means for circulating a combustion supporting gas through the rabbling mechanism, whereby such mechanism is cooled and the gas preheated, means for mixing the first mentioned gas and the preheated combustion supporting gas, means for introducing the resulting gas mixture therein, and means for circulating the burning gas through another muffle.

18. Apparatus for roasting ores comprising a plurality of superposed roasting hearths and associated supporting walls, a muffle associated with each hearth, rabbling mechanism for moving the roasting ores successively over the several hearth, means for circulating a combustion supporting gas through the rabbling mechanism whereby the mechanism is cooled and the gas preheated, a bustle adjacent a muffle, means for conducting the preheated gas to the bustle including passages arranged in the wall of the furnace, a sulfur sublimer, a connection between the sublimer and the bustle, means for introducing a mixture of the gas from the sublimer and the preheated combustion supporting gas from the bustle into the adjacent muffle, whereby the combustion of the gas mixture is initiated, means for circulating the burning gas through a plurality of muffles, and means for withdrawing the gas from the last muffle of the series, whereby the sulfur in the gas mixture burned in the muffles is converted to sulfur dioxide and the heat of combustion imparted to the roasting ores in the associated hearths.

19. The process of roasting sulfide ores requiring the application of extraneous heat to effect an efficient roasting thereof which comprises initiating the roasting operation, generating a sulfur containing gas mixture, and burning sulfur in such mixture in indirect heat exchange relation with the ores undergoing roasting, whereby the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting of the ores.

20. The process of roasting sulfides requiring the application of extraneous heat to effect efficient roasting thereof which comprises initiating the roasting operation in a

roasting zone, separately generating a gas mixture rich in free sulfur vapor at a point outside of the roasting furnace, then introducing the gas mixture into the roasting zone, and therein burning sulfur vapor of such mixture in conjunction with the roasting operation so that the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting operation.

In witness whereof, I have hereunto set my hand.

HAROLD O. C. INGRAHAM.

CERTIFICATE OF CORRECTION.

Patent No. 1,912,455. **June 6, 1933.**

HAROLD O. C. INGRAHAM.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 15, for "of" second occurrence read "or"; page 5, line 88, claim 17, after "mixture" insert the words "into one muffle and initiating the burning of such gas mixture"; and line 96, claim 18, for "hearth" read "hearths"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of August, A. D. 1933.

M. J. Moore.

(Seal) **Acting Commissioner of Patents.**

roasting zone, separately generating a gas mixture rich in free sulfur vapor at a point outside of the roasting furnace, then introducing the gas mixture into the roasting zone, and therein burning sulfur vapor of such mixture in conjunction with the roasting operation so that the heat generated by the burning of the sulfur furnishes extraneous heat for the roasting operation.

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