Oct. 25, 1938.

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2,134,244

RETORT

Filed March 13, 1935

3 Sheets-Sheet 1

FIG. 1

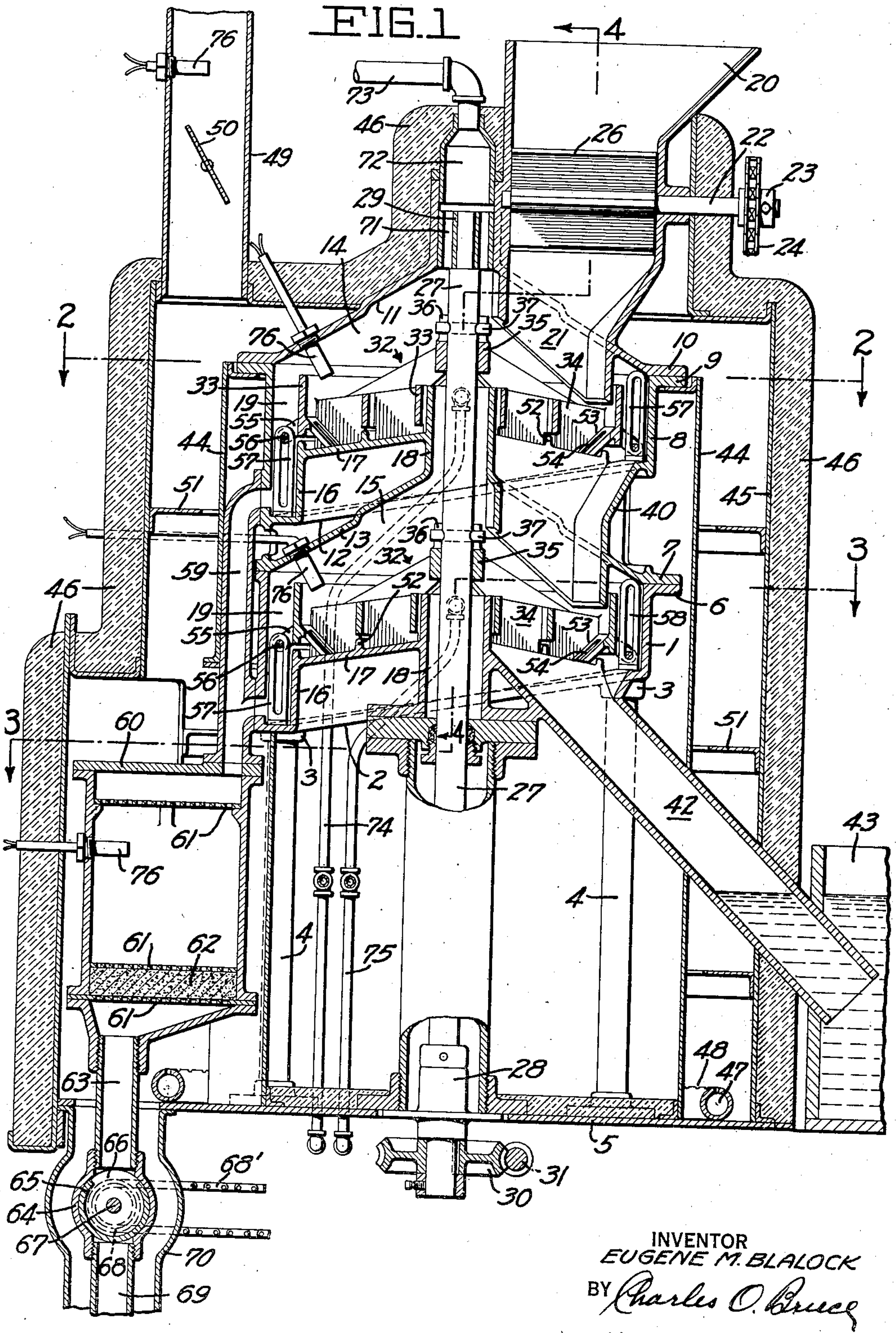

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FIG. 2

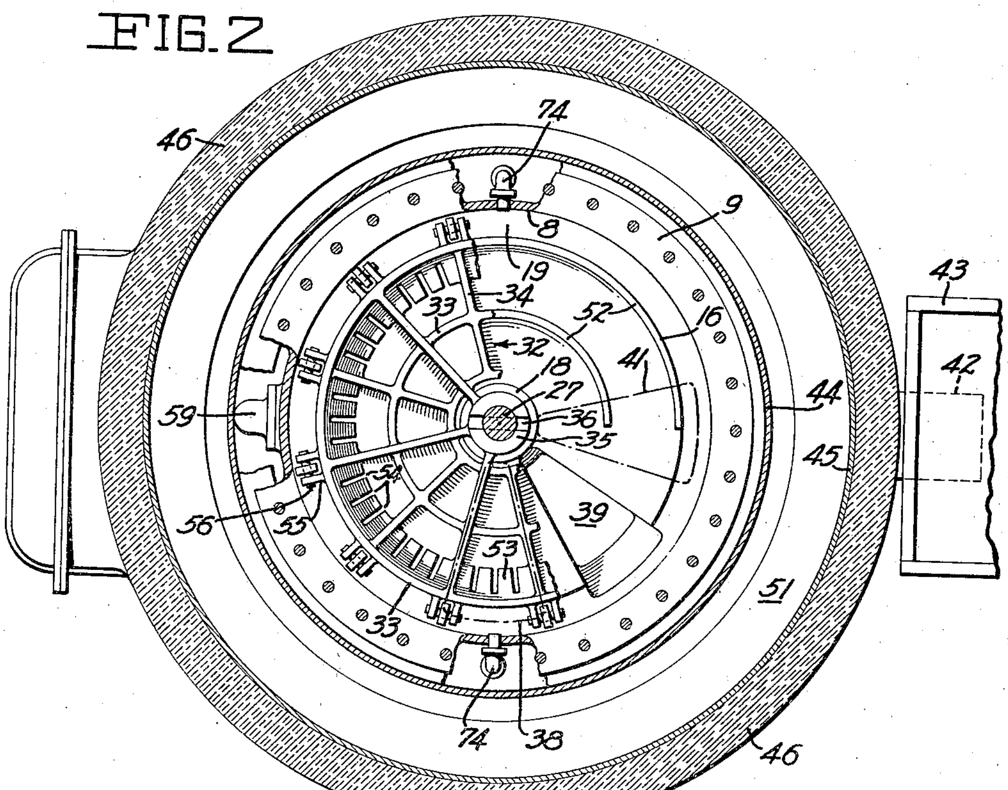
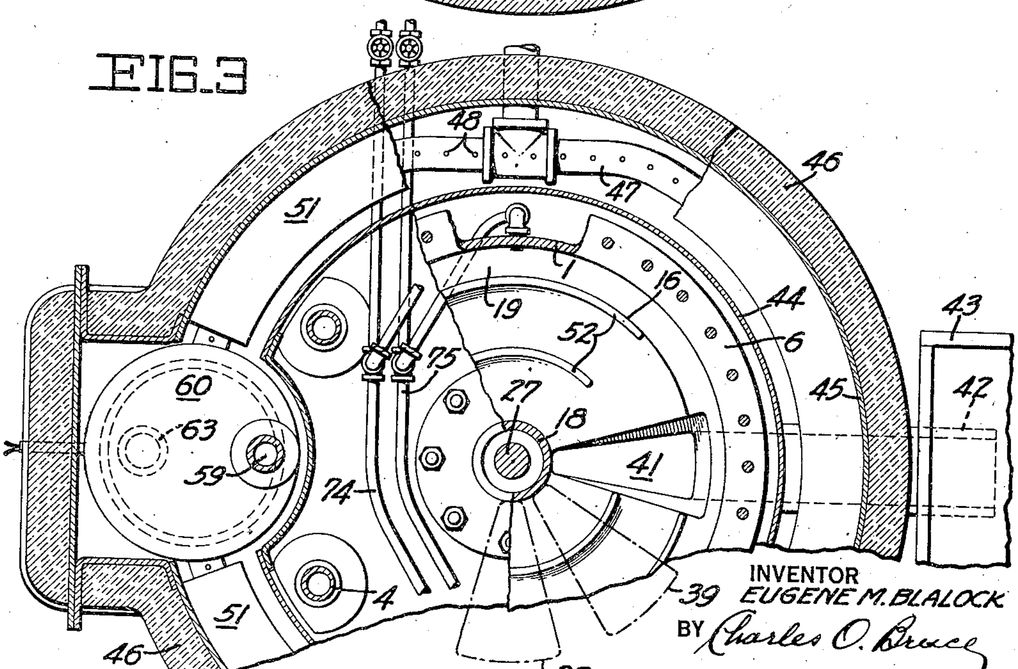


FIG. 3



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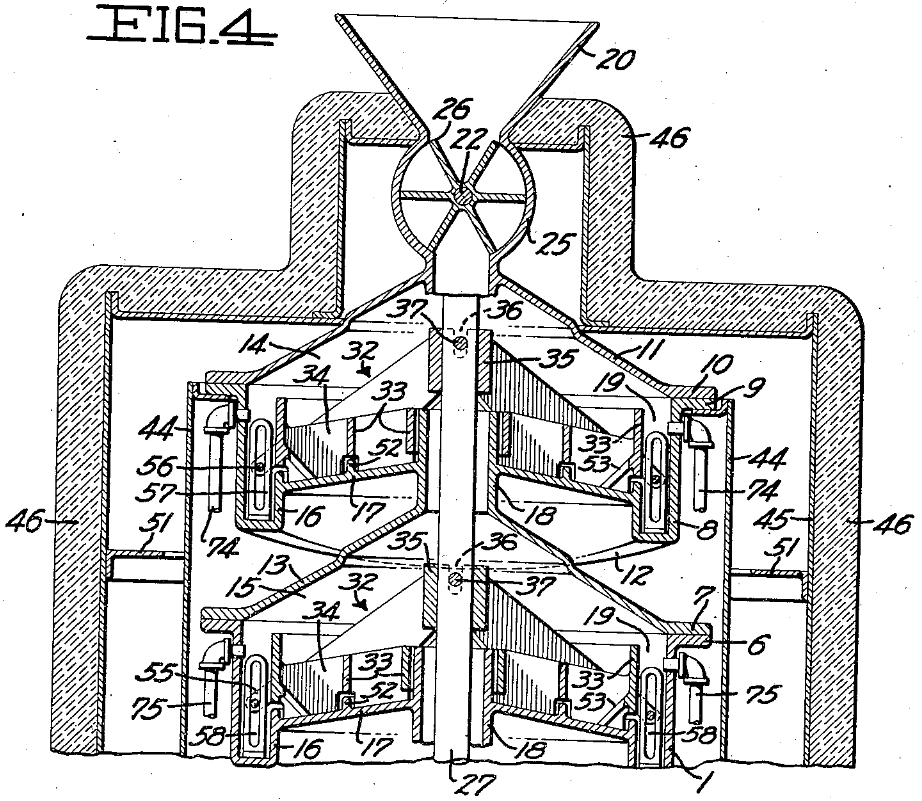
3 Sheets-Sheet 3

FIG. 4



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UNITED STATES PATENT OFFICE

2,134,244

RETORT

Eugene M. Blalock, Oakland, Calif., assignor of forty per cent to Richard Bates, seven and one-half per cent to C. C. Voglesong, seven and one-half per cent to William Pentecost, and five per cent to Harry B. Moore

Application March 18, 1935, Serial No. 11,674

7 Claims. (Cl. 23—280)

My invention relates to apparatus for effecting recovery of minerals from their ores.

An important object of my invention is the provision of apparatus of high efficiency capable of recovering a maximum of values from low-grade ores which heretofore were considered as not justifying commercial operation.

Other objects of my invention are to provide apparatus of the character described capable of handling a continuous flow of ore, and, due to this, produces refined products of consistant high quality; to provide means, in apparatus for the refining of mineral ores wherein the ores are passed through a plurality of zones heated from a common source, for individually regulating the heat of such zone; to provide, in apparatus for the refining of mineral ores, means for effecting recovery and segregation of minerals having different melting points from an ore during a single passage thereof through the apparatus; to provide an efficient and compact mechanism for the purpose set forth; to provide apparatus having such low first and maintenance costs as to permit fields of low-grade ore to be worked profitably; to provide apparatus of the character described having safety features included therein which permit safe handling of ores containing sulphur or other combustible minerals; to provide apparatus, for the refining of sulphur from its ore, in which losses, due to combustion of the sulphur during processing, are reduced to a minimum; to provide improved means, in apparatus of the character described, for removing to a maximum degree undesirable components of the recovered values prior to the introduction thereof into the final or filtering step of the process; and to provide an improved means and method for extracting minerals, such as sulphur, from their ores.

In terms of apparatus, my invention comprises broadly, a plurality of communicating chambers, each evacuated to a substantially constant pressure below atmospheric. Ore to be refined may be introduced into one of the chambers, preferably through means which, while permitting such introduction, prevents communication of the interior of the chamber with the atmosphere.

Means are provided for heating the ore to effect separation of the mineral values therefrom and means are provided for moving the ore in a horizontal plane through the first chamber to a point where it is deposited into a succeeding chamber.

Means cooperative with said first moving means are provided for moving the ore in a horizontal plane through each succeeding chamber and in substantially parallel paths until after passage of the ore through the last chamber it is discharged therefrom through means which functions to cool the ore and seal the interior of the chambers from the atmosphere.

Means are provided in each chamber for collecting the mineral values released from the ore, and means preferably operative with said ore moving means are provided in each chamber for removing a maximum of undesired components from the values before discharge thereof from the chambers.

Means are provided for withdrawing the values from the several chambers and passing them through filtering means common to all of the chambers. Means are also provided for withdrawing the filtered values without exposing the interior of the chambers to atmospheric pressure.

Means are further provided for governing the humidity of the gases in each chamber to preclude the possibility of combustion thereof.

Referring to the drawings:

Figure 1 is a vertical sectional view of sulphur refining apparatus incorporating my invention. Due to the complexity of the figure, the discharge spout of the hopper and that of the upper chamber are not shown in their true positions, these being clearly and accurately indicated in Figure 2.

Figure 2 is a horizontal sectional view of the apparatus of Figure 1. The plane in which the view is taken is indicated by the line **2—2** of the latter figure.

Figure 3 is a view similar to Figure 2 except that the plane of section is as indicated by the line **3—3** of Figure 1.

Figure 4 is a vertical sectional view of the device of Figure 1. The plane of section is indicated by the line **4—4** of the latter figure.

Sulphur is sufficiently concentrated at only a few points in the earth's crust to justify mining, although it has been estimated by experts that about .06 per cent thereof is composed of this mineral. These points of concentration are notably Sicily in Europe, and Louisiana and Texas in the United States. In Europe, although modern machinery has recently been introduced, the sulphur is mined and refined by primitive methods resulting in wide variation in the quality of the finished product.

In the United States the sulphur deposits lie at a level which prohibits open shaft mining, but, however, by means of the Frasch process, which is generally employed, recovery in sufficient quantities to warrant commercial operation is obtained. The Frash process takes advantage of the fact that sulphur has a fairly definite melting point at approximately 240 degrees and consequently by sinking a casing into the strata of sulphur bearing ore and releasing superheated steam or hot water at a temperature above the melting point of the mineral, thereinto, the sulphur is separated from the ore and collects in a pool adjacent the mouth of the casing. By piping compressed air down from the surface to a point below the level of the molten sulphur and by providing a conduit within the casing for the sulphur, it will be seen that the molten mineral will be forced to the surface, being forced upwardly by the pressure of the air.

By this method substantially pure sulphur is obtained; however, due to the cost of drilling the well and sinking the casing, a considerable quantity of sulphur must be recovered before any profit is realized on the investment.

There are, in the United States, numerous surface deposits of sulphur bearing ore, which, however, were heretofore considered as having such a low percentage of sulphur as to render commercial operation unprofitable. This was due, in part, to the methods used, for the most part these being attempts to recover values in furnaces in which from 25 to 30 per cent. of the sulphur in the ore was wasted due to combustion. Others have tried processes in which quantities of the ore were enclosed in a sealed cylinder and steam was then admitted to melt the sulphur. These methods failed due to the time required to charge and discharge the cylinders, and furthermore, due to the non-uniformity of the heat applied, the color of the resulting product varied considerably. Of greatest importance was the fact that ores comparatively rich in values were required before a return was had which justified operation.

I have provided a furnace which overcomes to a great extent all of the difficulties inherent in the previously known devices and one which effects a maximum and profitable recovery from ores of such low grade as heretofore did not warrant refining.

In greater detail, my invention comprises a cylindrical casing 1 having a slanting bottom 2 provided with bosses 3 which are adapted to receive a plurality of supporting stanchions 4 mounted on a base plate 5.

The casing 1 is provided at its upper edge with a flange 6 which is adapted to receive a flange 7 formed integrally with a second casing 8 also provided with a flange 9 which connects with the flange 10 of a conically shaped cover plate 11, and a sloping bottom 12. The lower portion of the casing 8 is so formed as to provide a cover plate 13 for the casing 1 so that the various parts, when assembled provide an upper chamber 14 and a lower chamber 15. It is, of course, obvious that by adding additional casings, as many chambers as are desired may be provided; however, to simplify the drawing and description, but two chambers will be considered.

Each of the casings 1 and 8 is provided with vertical walls 16 rising parallel to and spaced from the outer casing walls and these vertical walls join a slanting deck 17 which rises slightly toward the center of the chamber to a point where it joins a tubular neck 18. It will be seen that the positioning of the walls 16 with respect to the outer wall of the casings provides a circular channel 19, which, due to the sloping bottom of the casings, is deeper at one side and gradually rises to a point diametrically opposite where it is flush with the surface of the decks 17.

Means are provided for admitting ore to be refined to the upper chamber and the construction of said means is such that the ore will be admitted without exposing the interior of the chamber to the atmosphere. Formed integrally with the cover plate 11 is a charging hopper 20 provided at its lower end with a discharge spout 21 positioned directly above the upper deck 17. As will best be seen in Figure 4, a shaft 22 is provided, journaled in the side walls of the hopper, which shaft is provided with a sprocket 23 carrying a chain 24 which may be connected to any suitable source of power for rotating the shaft 22. About the shaft 22 the hopper is formed to provide a cylindrical portion 25 in which is adapted to rotate a shutter wheel 26 carried by the shaft 22. It will be observed that the vanes of the shutter wheel at all times seal the chamber 14 from the atmosphere although they offer, when the shutter wheel is rotating, no resistance to the passage of ore from the hopper 20 into the chamber.

Means are provided for moving the ore in a horizontal plane through the upper chamber and depositing it into the next succeeding chamber. Disposed axially of the chambers is a shaft 27 journaled in a bearing 28 at its lower end and at its upper end in a bushing 29. A worm gear 30 is suitably keyed to the lower end of the shaft and is driven by means of a worm 31 which may be connected to any suitable source of power to effect rotation of the shaft.

Mounted for rotary movement with the shaft 27, and adapted to contact the upper surface of each deck 17, are a pair of conveyors 32 comprising a plurality of concentric rings 33 joined by radial ribs 34, several of which extend upwardly and terminate at a boss 35 which is provided with a transverse slot 36 adapted to engage a drive pin 37 secured in the shaft 27. Rotation of the shaft 27 will cause rotation of the conveyors over the upper surfaces of the decks 17.

Referring now to Figure 2, ore is admitted to the upper chamber 14 through the spout 21 and deposited in that area of the upper deck defined by the dot and dash line 38. Rotation of the conveyor clockwise will carry the ore in a circuitous path over the surface of the deck until an opening 39 therein which leads to the spout 40, is reached. The ore is discharged into this spout which deposits it on the deck of the next succeeding chamber 15 in an area directly below the spout opening, whereupon the conveyor of the chamber 15 moves it over the deck surface as before and conveys it to the opening 41 whereupon it is deposited in the discharge duct 42. It will be noted that the end of the discharge duct is submerged under water contained in a tank 43 positioned externally of the mechanism; this being done to seal the interior of the chambers from the atmosphere as was the case at the intake mechanism adjacent the hopper 20.

Means are provided for heating the ore in the chamber to effect removal of the minerals therefrom. Secured to the casing members and surrounding them is a tubular inner shell 44 which extends from the base plate 5 to a position adjacent the upper surface of the flange 9, and spaced from this shell and concentric therewith is an outer shell 45 provided with suitable lagging 46 secured to the outer surface thereof for heat insulation purposes. A gas burner comprising a ring 47 of pipe is positioned on the base plate 5, within the space between the two shells, and is provided with apertures 48 spaced at intervals along the upper surface thereof. A mixture of gas and compressed air is used as fuel so as to create an intense heat in the inter-shell space and a flue 49 fitted with an adjustable damper 50 is provided for carrying away the products of combustion. Baffles 51 are positioned at intervals in the path of the hot gases to direct them against the outer surface of the inner shell 44.

The heat created in the inter-shell space is radiated inwardly and raises the temperature of the ore in each chamber to a point, preferably about 240 degrees F., where the sulphur in the ore becomes fluid and flows downwardly and outwardly over the face of the decks 17 to be collected in the troughs 19. The sulphur acts as a binder of the other components of the ore in its cold state prior to introduction into the chamber and as soon as the heat liquifies the mineral it is natural for the ore to break up. This causes a release of a considerable quantity of "fines" which if allowed to accumulate in the mechanism would cause serious stoppages.

Means are provided for removing, to a great extent, these "fines" from the molten mineral. Arranged concentrically on the surface of each deck are a plurality of ridges 52 over which the molten sulphur must flow in order to reach the trough 19, allowing the heavier particles of ore to be trapped behind the ridges and carried around to the discharge openings. Additional means are provided for preventing these undesirable components from escaping from the decks. Formed integrally with the outer ring 33 of each conveyor structure is a strainer comprising an inwardly sloping plate 53 provided with spaced slots 54 narrow enough to trap ore particles of very small size and at the same time wide enough so as to not seriously impede the flow of the molten minerals.

Should there be particles of such size as to pass all of these traps and into the trough, additional means are provided therein for removing them. Disposed in spaced relationship about the periphery of the outer ring 33 are a plurality of lugs 55 provided with pins 56 which provide guides for paddles 57 provided with slots 58 in which the pins are disposed. It will be seen that, as the conveyors rotate, any sediment, or particles of ore, which may be carried into the troughs 19 by the molten minerals, is carried upwardly in the troughs by the paddles until it reaches the highest point thereof whereupon it is discharged into the spouts 40 or 42 as the case may be.

The molten minerals are drawn off from the troughs through a conduit 59 (see Figure 1), the lower end of which is bolted to and opens into a filter 60. The interior of the filter is provided with a plurality of perforated plates 61, the upper one of which is designed to trap any large particles of ore which might possibly find their way past the several traps above mentioned, and the two remaining plates being spaced apart adjacent the bottom of the filter, the space therebetween being filled with a suitable filter material 62, preferably shreded asbestos or mineral wool. Since the purity of the molten minerals, up to the point of entrance thereof into the filter, is of a high order, care should be exercised in the choice of a filter material of high quality. It has been found that a substance such as grade A mineral wool, which is substantially free of acids or other chemical substances which will adversely affect the quality of the finished product, is desirable. The presence of any such substance will discolor the resultant product and seriously impair its market value.

Upon passing through the filter 60, the minerals pass into a conduit 63 in which is disposed a rotary valve comprising a housing 64 containing a cylindrical rotor 65 provided with an open portion 66. The rotor is mounted on a shaft 67, fitted with a sprocket 68 which carries a drive chain 68' which may be connected to a suitable power source, preferably to that which drives the worm 31 and the chain 24, so that the former may be driven in synchronism with these two parts of the mechanism. It is obvious how the rotary valve operates, the function thereof being, of course, to permit discharge of the minerals into the conduit 69 without exposing the interior of the chambers to atmospheric pressure. To insure that the contents of the discharge conduit are fluid at all times, it is mounted within a flue 70 through which a current of heated gases from a burner, not shown, may be discharged into the inter-shell space of the main mechanism.

Having thus described how the values are discharged from the apparatus, let us now consider how the spent ore is disposed of. Since the ore in passing through the several chambers has been heated to a high degree, the arrangement of the end of the chute 42 positioned below the level of the water in the tank 43, to effect an air seal, as described above, also serves to quench the heated ore before it comes in contact with the atmosphere. This prevents the ore from giving off obnoxious sulphur-dioxide fumes.

During the processing of the ore in the chambers a considerable quantity of combustible gas is released, and means are provided for carrying this gas off. The bushing 29 for the upper end of the shaft 27 is provided with marginal passages 71 which open into the chamber 14 at their lower end, and into a chamber 72 at their upper end. This latter chamber is provided with a conduit 73 which may be connected to the suction opening of a suitable blower, not shown. Thus the pressure within the chambers is maintained at a point below that of atmospheric and as fast as gases are released from the ore they are drawn off from the chambers, the danger of their combustion being greatly lessened.

Means are provided for further lessening the danger of combustion of the gases, said means also functioning to control the temperatures of the several chambers. Conduits 74 and 75 are provided, the former of which open into the chamber 14 and the latter into chamber 15 (see Figure 4). Steam is admitted to the chambers through these conduits and serves to blanket the combustible gases if the temperature thereof dangerously approaches the "flash" point.

It will be seen that the steam admitted to the chambers may be made to control the temperature thereof. In the operation of the apparatus, it is desirable that a temperature gradient exists whereby the upper chamber is maintained at say 240 degrees and each succeeding lower chamber is a few degrees hotter. This is done to effect separation of any sulphur which may be located deep within the lump of ore and was not released in the first chamber. To produce this heat gradient, the flame of the burner 47 is adjusted so that the ore removed from the final discharge spout will show little or no sulphur content. This means that the heat of the lowest chamber is sufficient to drive out all of the entrapped minerals. However, the temperature of the upper chambers is entirely too great and vaporization of the minerals would probably occur. Consequently to reduce the temperature at these points, steam at a temperature sufficiently cool with respect to the temperature of the chamber in question is admitted thereinto and as a result the desired degree of heat is thus obtained. It is, therefore, possible within limits to vary the temperature of the several chambers independently of the temperature of the burner flame.

Ores containing several minerals having different melting points may be treated in the apparatus of my invention and, in addition to this, segregation of the various minerals may be had without materially disturbing the set-up of the apparatus, all during a single passage of the ore therethrough. It will be seen that, by regulating the temperature of each successive chamber to a value corresponding to the melting point of a particular mineral contained in the ore, the mineral having the lowest melting point will be recovered in the first chamber, that having the next higher melting point in the second chamber, and so on. It is also obvious that the ore may be subjected to a constant temperature during passage through the apparatus to effect recovery of a certain one of the minerals, and the others of the minerals may be recovered by subsequent passages of the ore under the influence of different temperatures. The only change in the apparatus required to effect this segregation of the minerals is that the chambers be provided with individual discharge conduits for withdrawing the different values therefrom.

To insure that proper working temperatures are being maintained at all times in the several parts of the mechanism, thermocouples **76** are provided in the flue **49**, the several chambers, and in the filter **60**. By concentrating the leads from these instruments to suitable indicating devices at a central control board a workman may tend a battery of mechanisms.

From the foregoing description of my invention, it will be seen that I have provided apparatus whereby it is possible to recover sulphur from low-grade ore economically without the use of expensive equipment; the cost of the apparatus above described being but a fraction of the cost of sinking a well as is done in producing sulphur by the Frasch method; that I have provided for a continuous process in the processing of sulphur ore which results in a finished product of consistent quality and free from variations in color, and that I have provided a simple and safe apparatus which is extremely flexible as to adjustment of temperatures to provide for maximum operating efficiency.

While my invention is particularly effective in the recovery of sulphur from its ore, it is to be understood that it is not limited to such use alone, for it is obvious that it may be employed in the recovery of any mineral susceptible of separation from its ore by the application of heat.

Although I have described, for the purposes of illustration, the apparatus shown by the drawings, it is apparent that such apparatus may assume different forms within the scope of the following which I claim as my invention.

I claim:

1. In apparatus for the extraction of a mineral from its ore by heating the ore to melt the mineral, a casing providing a plurality of superimposed circular chambers having fixed bottoms each provided with a sector-shaped discharge opening and having a conically tapered upper face whereby the molten mineral may flow to its periphery, a rotary conveyor coaxial with said chambers and providing radial arms for moving the ore over said bottoms, and webs connecting said rotor arms whereby the ore is arranged to be moved in solely circular lines over the chamber bottoms by the operation of the rotor, each said opening being offset from the opening above it circumferentially of the chambers in such manner that ore discharged from the upper opening upon a given chamber bottom must be moved substantially through a full circle before it is discharged from the opening of that bottom.

2. In apparatus for the extraction of a mineral from its ore by heating the ore to melt the mineral, a casing providing a plurality of superimposed chambers having fixed circular bottoms each provided with a radial discharge opening and having a conically tapered upper face whereby the molten mineral may flow to its periphery, a rotary conveyor coaxial with said bottoms and providing laterally closed compartments over the bottoms for moving charges of the ore therein in solely circular lines over the bottoms for the discharge of said charges at the deck openings, each said deck opening being offset from the opening above it circumferentially of the chambers in such manner that ore discharged from an opening upon an underlying chamber bottom must be moved through a predetermined arc before it is discharged from the opening of the bottom.

3. In an oven for roasting divided material to extract a fusible substance therefrom by melting the same, a fixed circular material-supporting deck provided with a radial discharge opening, said deck having a conically tapered upper face sloping downwardly to its periphery whereby the molten substance may flow to the periphery and from the deck, a rotary conveyor coaxial with said deck and providing radial arms for moving the material over said deck face to said opening while the molten substance flows gravitally therefrom to the deck edge, and an annular member coaxial with the deck in close adjacency thereto and carried by said arms and defining therewithin the material-carrying zone of the deck.

4. A structure in accordance with claim 3 wherein the annular member is provided with slits extending upwardly from its bottom to provide for a screened escape of the molten substance from within it.

5. A structure in accordance with claim 3 wherein the upper deck face is provided with a series of circular ridges providing lips defining horizontal planes, and the annular member is operative between the outer pair of said ridges.

6. In an oven for roasting comminuted material to extract a fusible substance therefrom by melting the same, a fixed circular material-supporting deck provided with a radial discharge opening, said deck having a conically tapered upper face sloping downwardly to its periphery whereby the molten substance may flow from the deck, a rotary conveyor coaxial with said deck and providing radial arms for moving the material over said deck face to said opening while the molten substance flows gravitally to the deck edge, means providing a trough in fixed relation to said deck and below its rim and encircling

the same for receiving the molten substance flowing from the deck, the bottom of said trough defining a plane which is oblique to the horizontal whereby it is arranged to discharge the molten substance at its lowest point.

7. A structure in accordance with claim 6 characterized by the provision of an overflow spout at the lowest point of the trough and a bottom outlet at the uppermost point of the trough, and a paddle member gravitally engaged with the trough bottom and attached to the conveyor for movement through the trough as the conveyor rotates for moving solid particles in the trough along the bottom thereof for discharge at the upper trough outlet.

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