United States Patent

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[54] **SULFUR RECOVERY**
4 Claims, 2 Drawing Figs.

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23/312 S, 23/270 R, 23/272.6 R, 23/229
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[50] **Field of Search** 23/267,
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ABSTRACT: Sulfur is continuously extracted from sulfur bearing ore, found or brought to the surface, by conveying said ore through a conduit containing a downstream sulfur extraction section. After sulfur is extracted, the residual trailings are further conveyed upstream through a second conduit to an exit point.

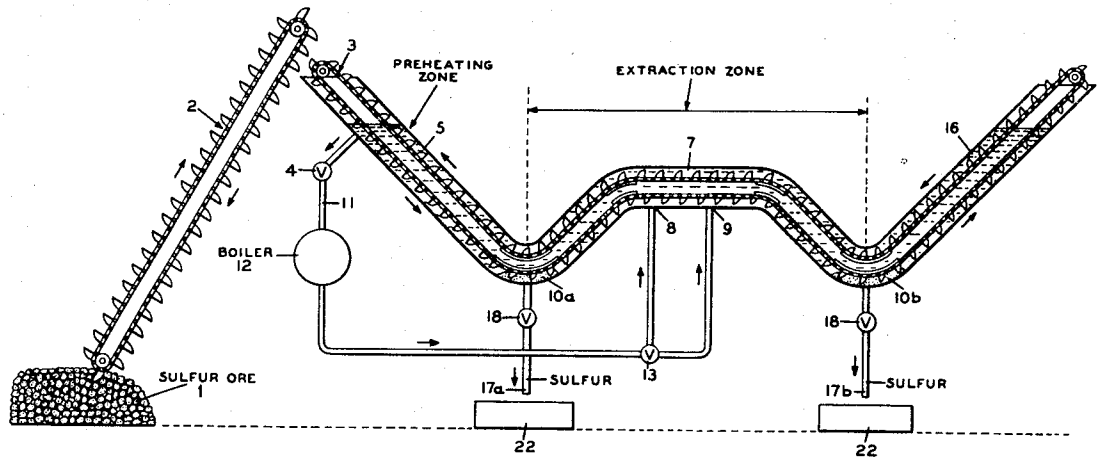
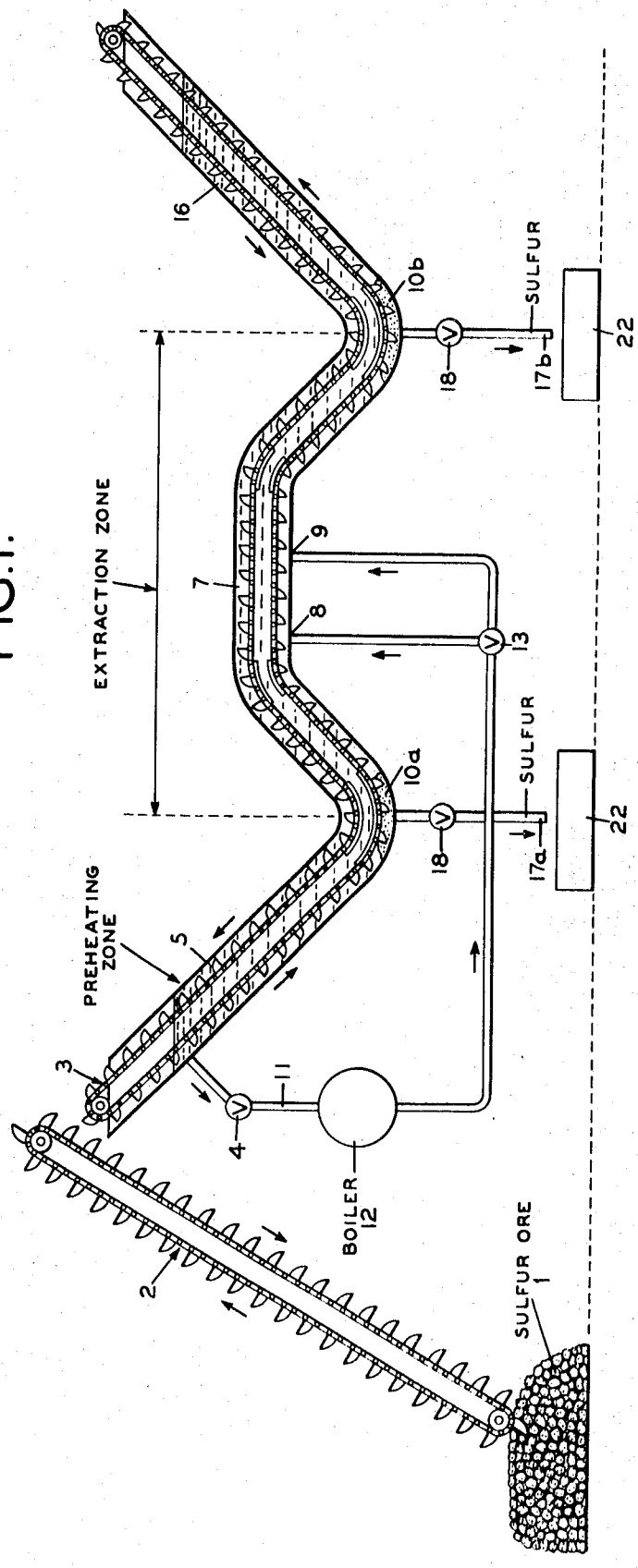


FIG. 1.



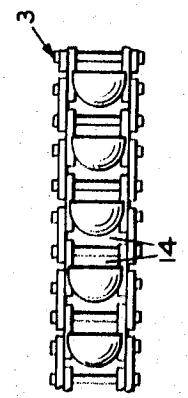


FIG. 2.

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SULFUR RECOVERY

BACKGROUND OF THE INVENTION

This invention relates to a continuous process for recovering sulfur from sulfur bearing ore found at or brought to the surface. It is specially advantageous, but not limited, to mine sites located in mountainous regions. More particularly, sulfur is extracted from ore deposits, at or near the surface, by conveying said ore downwardly through a conduit containing a downstream sulfur extraction section. After sulfur is extracted from the ore, the residual trailings are further conveyed upwardly through a second conduit to an exit point preferably contiguous with the mining site if used in such a location.

Heretofore known methods of extracting sulfur contained in low-grade ores found at or near the surface, for example in mountainous regions, have been expensive, wasteful and therefore of peripheral utility. Such methods could not, in general, compete effectively with subsurface extraction processes employing Frasch-type techniques. A further impractical feature of prior surface recovery techniques is the extent to which they rely on batch or semibatch processing methods.

The present invention provides for a continuous flow of preheated ore to and through an instream sulfur extraction section and with continuous deposit of residual trailings, in close proximity to the mine site where said trailings can be used for backfill. Other, and more distinct, advantages of the present process will become apparent upon examination of the following detailed disclosure.

SUMMARY OF THE INVENTION

In accordance with the instant invention, crushed sulfur bearing ore is moved, by conventional means, to the lip of a downwardly projecting, inlet conduit and conveyed downwardly through said conduit, preferably through water. The water in said inlet portion is of such temperature as to preheat the sulfur contained in said ore. The ore is then conveyed into a convoluted sulfur extraction section wherein the temperature exceeds the melting point of sulfur. Upwardly moving superheated water is injected into the sulfur extraction section to maintain the flow of ore fragments and water in the desired direction. Sulfur is extracted from the ore and deposited in the lower portions of the convolutions. The extracted sulfur is removed from the convoluted portions of the sulfur extraction section and residual ore fragments are conveyed upwardly through an upwardly projecting, tubular outlet conduit. More particularly, in the present invention, sulfur is extracted from surface, or near surface, ore deposits by a process which utilizes the physical properties of elemental sulfur. Solid sulfur undergoes transition to the molten state at temperatures above 245 F. and in such molten state exhibits a tendency to agglomerate or coalesce excluding substantially all impurities. When the transition state environment is created by superheated water, it is found that the water serves as a lubricant, and flushes sulfur from the residual ore (commonly referred to as gangue).

Generally, in the present process, a course sulfur bearing ore is conveyed downwardly through a conduit, comprising a barometric column, connected at the lower periphery to a lateral, convoluted section, wherein sulfur is extracted, said convoluted section also being connected at its other end to the lower periphery of a second conduit, comprising a barometric column, through which residual ore is coursed upwardly to a deposit site. The present invention is particularly suited, but not limited to processing ore extracted from mountainside mining sites. Ores suitable for processing include materials wherein sulfur is found in an uncombined form, such as volcanic, hydrothermal fumarole and solfataric bearing materials. Even ores containing a low sulfur content, such as about 5–10 percent by weight, may be advantageously processed.

More specifically, course ore stockpiled for sulfur recovery therefrom is moved continuously to the lip of the tubular conduit and continuously drawn through said conduit by a conveyor or system of conveyors The conduit contains a standing supply of hot water, replenished as necessary and kept sufficiently hot in a manner as will be further described. The temperature of the environment surrounding the ore fragments is above the melting point of sulfur in the convoluted sulfur extraction section due to the injection of hot water and/or steam and the pressure of the standing water columns in the barometric legs. The molten sulfur, because of its tendency to agglomerate (as a result of the physical fact that it, like mercury, has an affinity for itself) tends to join together as it melts at the elevated temperature, which has been reached in the extraction section. Under the influence of gravity, the agglomerating molten sulfur passes downwardly through the moving conveyor and the diameter of the extraction section and collects in the convolutions therein. The gangue remains on the conveyor. Sulfur is continuously tapped from the convoluted portions of the extraction section. It is found that up to 100 percent of the sulfur is separated from the ore.

The processing unit used in the instant procedure is easily adaptable to differing mining situations. The unit comprises in combination two substantially coextensive tubular conduits, in spaced relationship, and a lateral conduit section containing therein a convolution at each end section; a conduit being demountably connected at its lower periphery to each end portion of the lateral conduit section. The axes of the ore inlet and outlet conduits usually form an angle of between 25° and 75°, but not limited thereto, with a horizontal plane passing through the lateral conduit section. Preferably the apparatus is placed such that the ore inlet is situated adjacent to the mining site with the extraction section at some point below the site and the residual ore outlet is situated at a point adjacent the mining site. The unit may also be at a remote location where gangue may be used for other commercial purposes, such as providing road building materials. A conveyor or system of conveyors passes the ore through the unit, as will be described with relation to the drawing.

This processing unit may be formed from one continuous length of piping material or alternatively, the unit may be constructed form sections of piping materials that are demountably connected, as desired. The diameter of the piping materials comprising the ore inlet and outlet may also differ from the diameter of the material forming the sulfur extraction site.

BRIEF DESCRIPTION OF THE DRAWING

The drawing shows in FIG. 1 a schematic illustration of the process and a "W" shaped apparatus for carrying out the invention and in FIG. 2 a detail of conveyor structure used in FIG. 1. The invention will now be described in more detail with relation to the afore-mentioned drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, ore bearing sulfur is shown at the extreme left awaiting processing for extraction of the sulfur deposited therein. Said ore has been mined at or near the surface, or in such a manner as to not allow for mining by the conventional Frasch process or its equivalent (or where the Frasch process is not as desirable), such as an ore body insufficiently buried to create sufficient mine pressure or an ore body situated in an arid region where there is an insufficient water supply, although the ore body is deep enough to mine by the Frasch process. In the embodiment shown in FIG. 1, ore fragments are lifted by conventional conveyor to column 5 containing water therein. It may be desirable to increase the wettability of the gangue as compared to the sulfur contained therein by introducing an acid, not shown, and to simultaneously neutralize the acidity to minimize corrosion by the addition of a base, not shown, such as lime, downstream of the acid addition.

In the illustrated embodiment, the pressure at the bottom of the column 5 is about 53 p.s.i.g. This pressure is induced in the embodiment shown by positioning the water column such that it upstands about 125 ft. from ground level as ore enters the

water column. The ore fragments are moved through water column 5 on the conveyor 3, the water temperature at the top of said water in said column 5 being about 200° F., for example. The conveyor 3 moves the ore through sulfur extraction section 7, either a single conveyor (as shown) or a multiplicity of conveyors being used. As the ore moves through water column 5 toward the extraction zone under increasing back pressure, sulfur begins to melt from the ore.

In the embodiment shown, preheat water is tapped from water column 5, through line 11, carried to boiler 12 and distributed therefrom as hot water and preferably superheated water or steam, into the extraction zone at one or more points near the inlet portion of said sulfur extraction section, such as for example points 8 and 9, causing continued melting of the sulfur deposited in the ore. Valves 4 and 13 regulate, respectively, the flow to boiler 12 and the distribution from said boiler to points 8 and 9. As a result of introducing hot water, and preferably superheated water, the temperature within melting zone 7 reaches about 240° to 320° F., and preferably 275° F., under the influence of the static pressure created by water columns 5 and 16. Alternately, the source of the water injected into the extraction zone may be completely independent of the unit. If the water for extraction zone injection is taken as shown in FIG. 1, however, this results in a useful flow of heat towards the preheat zone (leg 5) in a closed circuit.

At this temperature, substantially all of the sulfur deposited in the crushed ore slurry becomes molten, and as a result of its affinity for itself, as previously discussed, tends to agglomerate or fuse. Molten sulfur passes through the conveyor, which is slotted or otherwise provided with openings 14, into convolutions or depositories 10*a* and 10*b* and is tapped therefrom. The conveyor 3 then carries the gangue from the extraction zone upwardly through water column 16, which forms the pressure balance on the opposite side of the "W" necessary for sulfur melting. Of course, other means for providing for such pressure situation in the exit column 16 than the existence of a water column, such as use of a pressure seal, may serve as an alternative, if desired.

Molten sulfur collected at the bottom of convolutions 10*a* and 10*b* passes through lines 17*a* and 17*b*, which are valved at 18, to a collection pan 22, for example, for further filtering thereof or storage.

The gangue carried through column 16 may be drawn off through line 14 by means of pump 15 to desanders and desilters (not shown) and removed by suitable means to a place where it may be dumped or used as backfill at the mining site or as road building material.

As a result of employing apparatus as described, the present sulfur extraction process has a high thermal efficiency. The static pressure condition created in the melting chamber by use of water columns 5 and 16 results in the high temperatures achieved in said chamber and allows a minimization of the amount of water to be used in the system since water can be recirculated. Furthermore, the use of the conveyor system to move the ore through standing water columns allows for extremely low utilization of water, which is especially useful in arid regions where sulfur may occur. Furthermore, the process is continuous, without internal moving parts in the melting chamber, and provides for a high recovery of sulfur from the ore, as much as 99 percent of the sulfur deposited in the ore being extracted, and is particularly adaptable to low grade sulfur ores. Since it is continuous process, relying on the physical principles utilized in the Frasch Process for separation of the agglomerating sulfur from the ore, it is highly economical and efficient.

A particular advantage of the "W" shaped embodiment in the drawing is the facility with which it permits extraction of sulfur from sulfur bearing ore found on hillside mining sites. The oblique section of the "W" comprising the sulfur extraction section can rest at ground level while the arms of the "W" comprising the inlet and outlet conduits upstand to the hillside site.

As previously mentioned, the continuous autoclave herein employed to extract sulfur is extremely flexible in the sense that it can be readily modified to meet changing production needs. The lengths and diameters of the water columns and melting chamber can be varied to accommodate different sulfur bearing materials and different extraction time periods.

While the present invention has been described in detail with respect to specific embodiments thereof, it is not intended that these embodiments circumscribe the invention except as it is limited by the claims.

I claim:

1) A process for extracting sulfur from sulfur bearing ore comprising moving crushed sulfur bearing ore to the upper end of a downwardly projecting, cylindrical inlet conduit; conveying the ore downwardly through water in said conduit by a mechanical conveying means; conveying the ore on said conveying means into and through an upwardly inclined cylindrical conduit section having a lowest part, then conveying the ore on said conveying means into and through a horizontal cylindrical conduit section of substantial length, then conveying the ore on said conveying means into a downwardly inclined cylindrical conduit section having a lowest part; said last three sections comprising the sulfur extraction section wherein the temperature is above the melting point of sulfur; injecting from an inlet line upwardly moving superheated water into said horizontal conduit section immersing said ore throughout the section in said water to melt the sulfur, extracting sulfur from the ore and depositing said extracted sulfur in said lowest parts of said extraction section; removing sulfur substantially from the bottom of the lowest part of each inclined section, and conveying residual ore fragments on said conveying means upwardly through a second upwardly inclined cylindrical outlet conduit.

2) The process as set forth in claim 1, wherein the upwardly moving superheated water is injected into the extraction section at a plurality of points in said extraction section.

3) A process as set forth in claim 1, further comprising withdrawing water from said downwardly projecting section, heating said water, and employing said heated water as at least a part of the upwardly moving superheated water.

4) The process for extracting sulfur from sulfur bearing ore as described in claim 1, wherein a temperature is maintained within said sulfur extraction section of between 240° and 320° F.

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