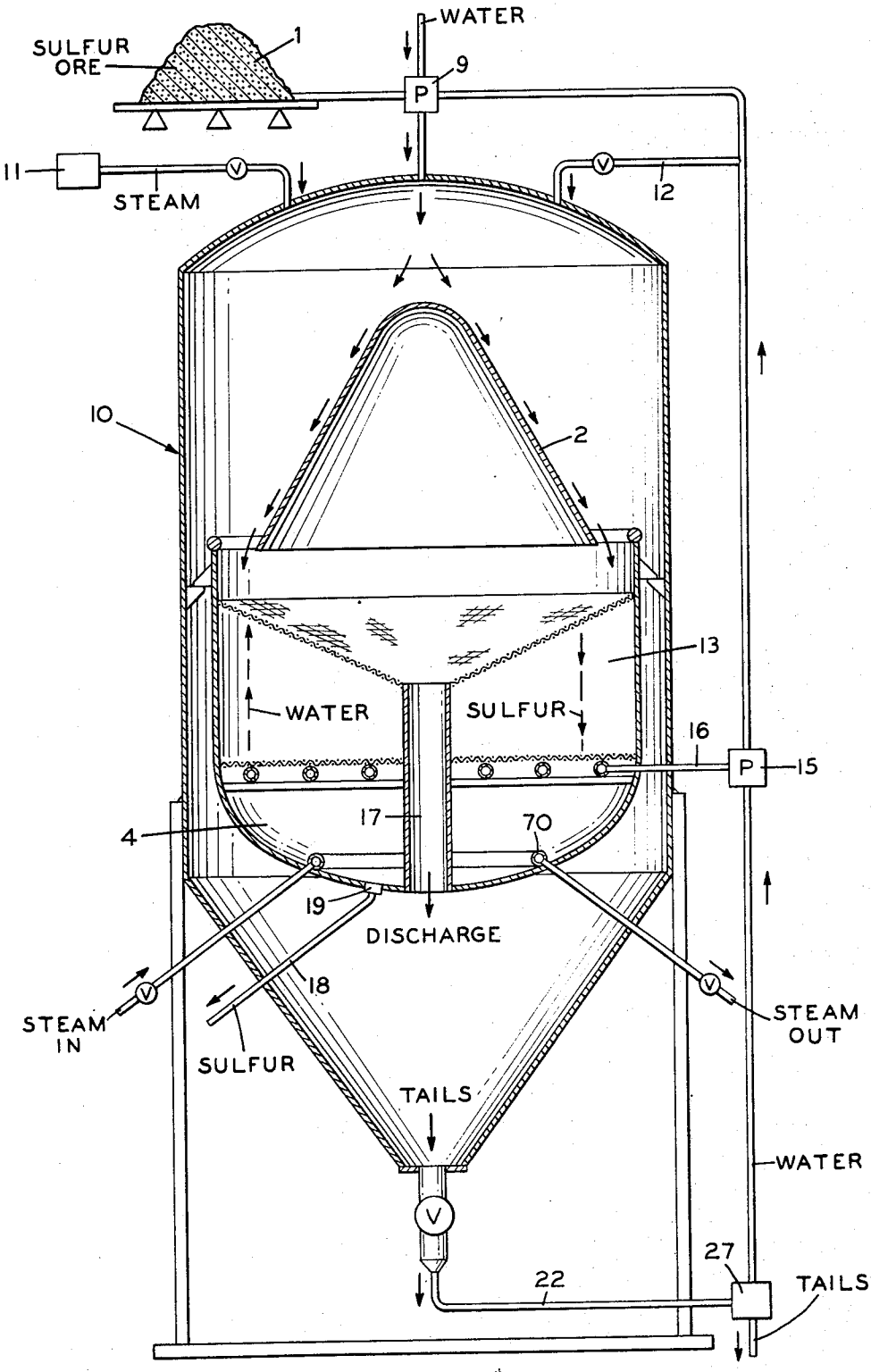
Sept. 5, 1972 X. T. STODDARD 3,689,226

SULFUR EXTRACTION APPARATUS

Filed March 3, 1971



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United States Patent Office 3,689,226 Patented Sept. 5, 1972

3,689,226

SULFUR EXTRACTION APPARATUS

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Filed Mar. 3, 1971, Ser. No. 120,414
Int. Cl. C01b 17/02, 17/08, 23/00
U.S. Cl. 23—280 4 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for the extraction of sulfur from ore at or near ground level in which the molten sulfur is passed through a filtering bed in opposing direction to the flow of hot water.

This invention relates to an apparatus for recovering sulfur from ore.

More particularly this invention relates to an apparatus for recovering sulfur from ore which is located at or near ground level in which low grade ore having a high percentage of fine gangue is found naturally or as a result of grinding, as will be described in more detail hereinafter.

The mining and extraction of sulfur from ore (1) substantially below the ground and (2) located at or near ground level have been historically two separate problems of sulfur recovery.

In the case of mining and extraction of sulfur from ore mined substantially below ground level, a great deal of research and experimentation has taken place, with the Frasch process, as disclosed for example in U.S. Pat. 1,628,843, issued May 17, 1927 providing a basis for such sulfur extraction. On the other hand, in extraction of sulfur from ore located at or near ground level, a number of uneconomic or impractical, processes heretofore have been devised, usually because of mechanical complication or inefficiency in the amount of sulfur extracted as compared to the amount of sulfur present in the ore. The extraction of sulfur from ore located at or near ground level has therefore been the subject of continued research.

The Frasch process of mining sulfur where it occurs in deposits substantially below ground level is discussed in detail in the patent to which we have previously referred. Generally, that process relies on the fact that agglomerating molten sulfur, which has become molten below the ground in the deposits in which it occurs (as a result of heat exchange with a super-heated fluid which has been forced through those deposits), travels through the deposit under the action of gravity in a direction opposite to the movement of the lighter ore flushing water moving from the well bore through the deposit. The agglomerating or fusing molten sulfur arrives through the deposit at the point in the well bore where it can be carried up, as a result of the pressure differential, to an above ground location. I have devised a similar process for mining sulfur from ore which is located at or near the surface.

Generally speaking, our apparatus for extracting sulfur from ore at or near the ground surface is as follows:

Sulfur bearing ore located at or near ground level is usually stockpiled for sulfur recovery therefrom; such sulfur from deposits usually of, but are not limited to, the surface sulfur, spring, volcanic, hydro-thermal fumarole or solfataric types, including the presently poorly regards, low-yield (5–10%) variety. The ore is then crushed and ground and then pumped (for example, as a slurry in hot water) or moved by a conveyer to a position for further treatment, to be discussed in detail hereinafter. The crushed and ground ore is mixed with hot water and, preferably, steam to commence melting of

the sulfur deposited in the ore. The slurry of water and sulfur containing ore is then introduced into a fusion chamber under pressure and directed into a conical distributor which increases the velocity of the slurry centrifugally as it descends. 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 elevated pressure in the chamber. The agglomerating molten sulfur passes downward from the distributor onto a bed in the chamber under the influence of gravity. Hot water is passed through said bed in a counter-current direction to the direction which the gangue (ore depleted of sulfur) and sulfur tends to move. Since the molten sulfur is heavier than the water, the sulfur passes through the bed in a downward direction while the water is passing upward through the bed counter-currently. The bed is angled downward toward the center. As a result of preferential wetting, and the surface tension of the upwardly moving water, the gangue, even though heavier than water, is floated by the upwardly moving water and separated, up to 100% separation from the sulfur and moved out of the area through a hole in the center of the bed. The molten sulfur passes through the bed counter-current to the water and is then collected at a point below the bed for transmission to a storage area. The gangue, the ore from which the agglomerated molten sulfur has been extracted, is carried by the water to be filtered therefrom from the chamber. The water may then be re-circulated to be reused in the process just described. Because of the mass of the molten sulfur as compared to the crushed gangue, the sulfur moves further to the outside of the vessel, off the conical distributor under centrifugal force, then the gangue, aiding in separation of the sulfur from the gangue with the least amount of water being used.

As needed, additional hot water may be added to the process.

The invention will now be described in more detail with relation to the following drawing in which is shown a schematic illustration of the apparatus for carrying out the invention.

Ore bearing sulfur **1** is shown at the extreme upper 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, already described. The ore is crushed to, for example, ¾" size, and ground to, for example, pass a 28 mesh screen, again by the use of conventional structure.

The ore preferably is mixed with water to form a slurry, said water at a temperature in the range of 175°–200° F., and preferably of about 200° F. It may be necessary to increase the wettability of the gangue as compared to the sulfur contained therein by introducing an acid, and to simultaneously neutralize the acidity of the slurry by the addition of a base, not shown, such as lime.

The slurry of water and crushed ore, under pressure, is then moved by pump **9** into a fusion chamber **10**. Recirculating hot water, through line **12**, and, preferably, steam from the steam generator **11**, introduced into the chamber serve to continue the melting of the sulfur deposited in the ore. As a result of the introduction of the hot water, and preferably the steam, and the fact that the slurry is under pressure in the chamber the temperature within the fusion chamber reaches about 260° to 280° F., and preferably about 270° F.

At this temperature, substantially all of the sulfur deposited in the crushed and ground ore slurry becomes molten and as a result of its affinity for itself, as previously discussed, tends to agglomerate or fuse.

Sulfur bearing ore in a slurry of water is deposited on conical distributor **2**. In the course of moving down the distributor **2** in the chamber **10** the sulfur melts, tending to agglomerate. Sulfur globules are thrown out and off of the conical distributor by centrifugal force, because of their mass relative to the crushed gangue fines which accompany them.

The agglomerated sulfur sulfur passes through the porous filter bed **13** under the action of gravity. Contemporaneously, hot water from the separator **27** is, preferably, directed by pump **15** through line **16** upwardly through said bed **13**.

Because the molten sulfur is heavier than the water, the sulfur tends to pass through the bed in counter-current direction to the movement of the water. The water floats and entrains the gangue (which is not passed through the bed) and removes it from cell **10** through line **17**. Sulfur passing through the bed is collected at the bottom **4** of cell **10** and directed through line **18**, which is valved at **19** for further filtration or storage. The molten sulfur may be kept molten by heated coil **70**, for example.

The gangue, moved by the water out of the cell **10** through line **17** may be removed by suitable means, for example line **22**, to a place where it may be separated from the water and dumped. The gangue fines float to the center exit point on the angled bed (angled so as to be higher with relation to the horizontal along the outside of the vessel than at the center so that flow of water and gangue fines (or tails is toward the center opening and of increasing velocity)), with a minimum amount of water needed to float the gangue.

Pump **15** draws the water from separator **27** and preferably directs it through line **16** for re-circulation to the fusion cell. Details of the bed, for example, may be found in copending application Ser. No. 718,143, filed Apr. 2, 1968.

As a result of the recirculation of the water described, our sulfur extraction process has a high thermal efficiency. Heat added to the water in the fusion chamber, for example by steam injection results in the high temperature in the chamber, which is under pressure, and allows the water to be re-circulated without additional re-heating. Furthermore, the process is continuous, without moving parts in the fusion chamber, and provides for a high recovery of sulfur from the ore, as much as 98% of the sulfur deposited in the ore being extracted, and is particularly adaptable to low grade sulfur ores. Particularly, it allows for separation of sulfur from the fines in such low grade ore with a minimum amount of water employed. Since it is a continuous process, relying on the principles of the Frasch process for separation of the agglomerating sulfur from the ore, it is highly economic and efficient.

Although we have described, for the purpose of illustration, several embodiments of our invention it is not our intention to be limited by such description but rather it is intended that the invention may assume many different embodiments within the scope of the following claim protection.

I claim:

1. Sulfur extraction apparatus including means for introducing a slurry of crushed ore containing sulfur with hot water into the top portion of a vessel under pressure, downwardly outwardly extending conical distributor means in the upper portion of said vessel for deflecting said crushed ore and sulfur melting therefrom under centrifugal force toward the outer portion of the vessel, an open topped container means in the middle portion of said vessel for receiving said deflected crushed ore and sulfur melted therefrom, a porous bed in said container means, means for introducing steam into the upper portion of said chamber, said molten sulfur agglomerating from said ore and passing under the action of gravity downwardly through said bed, chamber means in the lower portion of said container including means introducing water into the chamber to upwardly through said bed counter-currently to the downward of the sulfur through said bed separating the sulfur from the spent ore from which it was extracted, said chamber means collecting molten sulfur that has passed downwardly through said bed and having a sulfur outlet connected to the lower portion thereof, the upper portion of said porous bed having a downwardly inwardly extending top surface for floating the spent ore from which the sulfur has been extracted to the center of the vessel, and a conduit extending from the central portion of said top surface downwardly through said bed and chamber for discharging the spent ore and water to the bottom of said vessel for discharge therefrom, the counter-currently moving water moving with increasing velocity for exiting through said conduit.

2. Apparatus as set forth in claim **1**, including means for separating water from spent ore, and means for re-circulating water after separation from the spent ore.

3. Apparatus as set forth in claim **2**, further including means for crushing and grinding ore containing sulfur, and means for mixing the crushed and ground ore with hot water before introduction of the ore into the chamber.

4. Apparatus for separating molten sulfur from crushed ore in a pressure vessel comprising means for introducing a slurry of crushed ore containing sulfur with hot water into the top portion of said vessel, a downwardly outwardly extending conical distributor in the upper portion of said vessel for deflecting said ore and sulfur melting therefrom under centrifugal force toward the outside of the vessel, an open topped container means in the middle portion of said vessel for receiving said deflected crushed ore and sulfur melting therefrom, a filter bed in said container means, chamber means in the lower portion of said container means below said filter bed including, means for introducing hot water into said chamber for flow upwardly through said bed against the action of gravity means for introduction of steam into said vessel, said molten sulfur agglomerating from said ore and passing under the action of gravity downwardly through said filter bed, said chamber means collecting molten sulfur that has passed downwardly through said filter bed and having a sulfur outlet connected to the lower portion thereof, the top surface of said filter bed being angled at its upper surface so that the center thereof is depressed and apertured with relation to the sides thereof so that the gangue of the ore from which sulfur has melted which is floated by said water will exit from said center depressed aperture with said water after floating toward said center with increasing velocity while the agglomerating sulfur passes through said bed counter-current to the flow of water for collection, and a conduit extending from the depressed aperture downwardly through said filter bed and said chamber for discharging the spent ore and water to the bottom of said vessel for discharge therefrom.

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U.S. Cl. X.R.

23—308 S, 312 S, 293 S, 229, 270; 210—265, 456