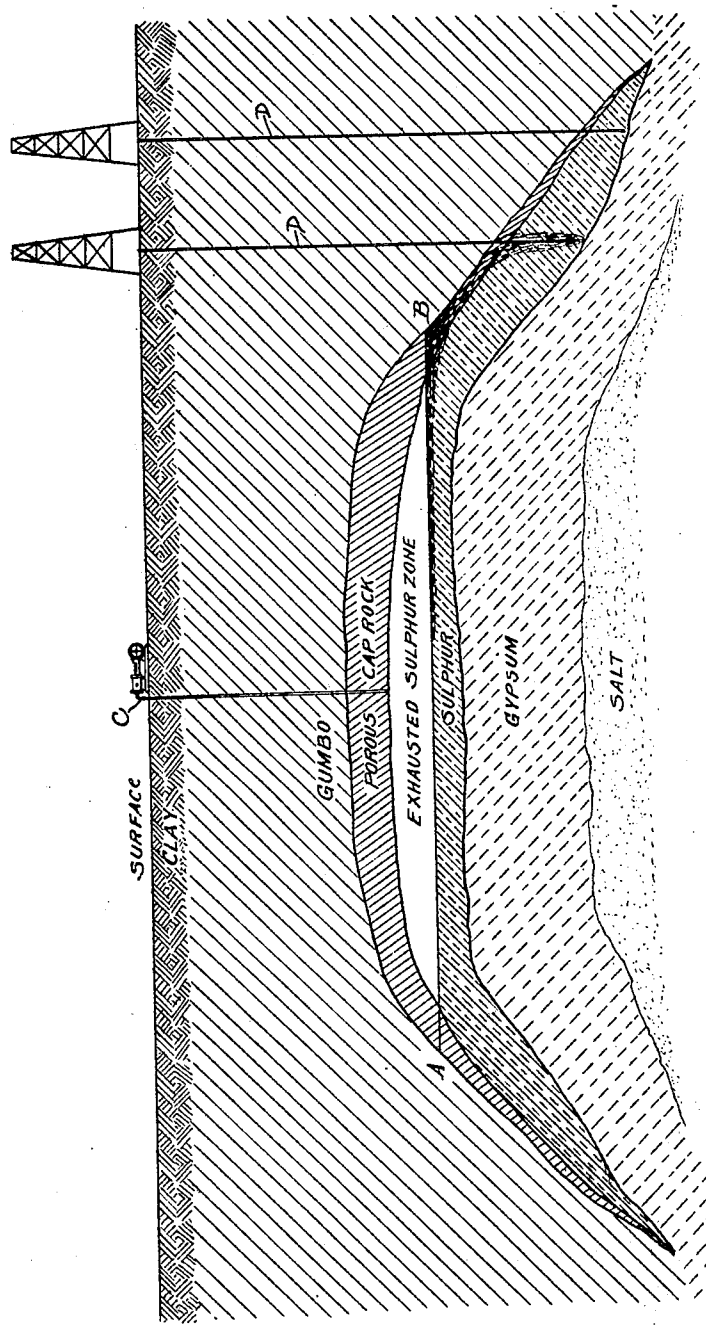
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PROCESS OF MINING SULFUR.

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PROCESS OF MINING SULFUR.

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To all whom it may concern:

Be it known that I, AUGUST T. DRACHENBERG, a citizen of the United States, residing at Gulf, in the county of Matagorda, State of Texas, have invented certain new and useful Improvements in Processes of Mining Sulfur; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to processes of mining sulfur and similar fusible minerals, and more particularly to processes of mining fusible minerals by underground fusion of the mineral such, for example, as the so-called Frasch process of sulfur mining.

In the mining of sulfur by underground fusion, in accordance with the Frasch process, a hole or well is drilled through the overlying strata to the bottom of the sulfur formation, which hole is usually cased with eight-inch or ten-inch pipe, and then, through a system of concentric pipes appropriately arranged within this casing, superheated water is pumped down to the foot of the hole or well where it is discharged into the sulfur formation and melts the sulfur. The melted and liquid sulfur enters one of the concentric pipes, usually through a strainer, and is raised to the surface of the ground, generally by means of an air lift. The well continues to operate and produce sulfur until the sulfur-bearing formation is exhausted locally or until the piping equipment is broken by subsidence of the ground due to the extraction of the sulfur content.

In this system of mining sulfur by underground fusion, the water is a vehicle for conveying and transmitting heat to the sulfur, which absorbs heat from the water, its temperature thereby rising until it melts and flows as a liquid to the bottom of the well where it is pumped or otherwise appropriately raised to the surface of the ground. The heat efficiency of the hot water pumped into the sulfur formation is low for the reason that the hot water pumped into the formation (which is already full of water) tends to rise or diffuse upwardly in convection currents away from and above and over the bodies of sulfur. The course of these convection currents is generally toward the overlying porous rock formation, in which the hot water lodges and stores its major heat content until displaced downward by incoming newer and consequently hotter and and lighter water.

The dome sulfur deposits are usually overlaid by a porous cap rock formation of limestone which in turn is overlayed by gumbo, quicksand or clay. Where this porous rock formation is thick in the higher parts of the dome it constitutes a storage reservoir for the hottest water which is thus led away and kept remote from contact with the sulfur bodies until its heat content is depreciated by conduction through and dissipation in the enveloping lime-stone. Even after subsidence and caving has brought the lime-stone crown of the dome to lower levels as mining operations proceed, it still remains as a porous, non-sulfur-bearing skeleton rock mass having a large volume of space open to occupation by the hot water above the sulfur sought to be melted.

Furthermore, in mining sulfur by underground fusion, wheresoever the hot water is discharged into the deposit, it will tend to rise in convection currents by reason of the inferior density of such hot water compared with the water already *in situ*, conveying and transmitting its heat to and melting the sulfur bodies at the higher levels in the central part of the dome, thus establishing there as time goes on an extended area which must be heated and maintained hot with superheated water to a depth sufficient to extend to and reach the underlying bodies of sulfur.

The present invention contemplates certain improvements in mining sulfur and similar fusible minerals by underground fusion as a result of which the aforementioned difficulties are in large measure minimized. Thus, the invention aims to avoid in large measure the filling up of non-sulfur-bearing regions, such as the exhausted sulfur zone and the porous cap rock, with hot water with the consequent saving in water and fuel. It is a further object of the invention to bring the hotter portions of the hot water (which on account of their lesser density tend to rise) into more intimate contact with the sulfur deposit.

The objects of the invention are attained by filling, to the appropriate degree, the non-sulfur-bearing zones above the sulfur deposit, for example, the exhausted sulfur zone and the porous cap rock above the sulfur deposit, with a gas, such as air, under considerable pressure so as to form a gas or air cushion which prevents the rise of

hot water into these non-sulfur-bearing zones and which, therefore, tends to hold the hot water down in intimate contact with the sulfur bed. This gas cushion fills the porous cap rock, or other formation above the sulfur deposit as well as the exhausted sulfur zone, which regions in accordance with the heretofore customary practice had to be filled by hot water. The gas cushion is effectively sealed in by the formation overlying the cap rock which usually consists of gumbo, quicksand and clay.

In carrying out the invention compressed air or other appropriate gas is forced down or otherwise brought into the non-sulfur-bearing regions above the sulfur deposit, thus filling such regions with a gas cushion which operates to hold the hot water pumped into the sulfur deposit out of the large volume of porous space heretofore open to occupation by the hot water in such formation and out of the exhausted sulfur formation or any other skeleton formation above the sulfur-bearing formation heretofore open to the hot water. Once the pores, crevices, cavities and pockets in this cap rock or porous or open formation are filled with gas, such as air, at an appropriate pressure, the hot water can rise only to the bottom of the gas cushion and heat losses through the higher strata overlying the water will be largely reduced, since the heat-carrying capacity by conduction of a gas such as air bears to the heat-carrying capacity of lime-stone the ratio of 1 to 107. There was accordingly in the heretofore customary practice, a very considerable loss of heat by conduction through the cap rock into the overlying quicksand or gumbo, which loss of heat is practically eliminated in accordance with the present invention because of the very poor heat conductivity of the gas cushion.

The layers of water at and immediately below the floor of the gas cushion (provided in the practice of the present invention) will, within the reach of the heat, be the best melting media, since the hotter and consequently lighter water in diffusing upwardly will seek the higher levels. As a result of the provision of the gas cushion of the invention, the hot water will spread out uniformly over a larger area horizontally than in the heretofore customary practice, and will have no opportunity to rise to and occupy the pores, crevices and pockets of the cap rock, thereby eliminating a large area of conducting surface and increasing the heat efficiency of the hot water, with resulting higher sulfur production at lower cost.

It has been estimated that only about one-half of one per cent. of the heat sent down a sulfur well by the superheated water is actually utilized in melting the sulfur. Most of the heat is wasted in heating up the rock, quicksand and ground water. Any process, therefore, looking toward an economy of heat is of pronounced importance in mining sulfur by underground fusion and the present invention involves primarily such a saving of heat.

The present invention is further illustrated in the single figure of the accompanying drawings representing a cross section through a typical dome formation sulfur mine.

In such a mine as represented in the accompanying drawing, the sulfur deposit is usually overlaid by a cap rock formation of limestone, above which is gumbo, quicksand and clay. Below the sulfur deposit there are usually bodies of gypsum and salt. In the drawing, there is represented a region marked "Exhausted sulfur zone," from which it is assumed the sulfur has been extracted. It is, of course, apparent that further mining of the sulfur necessitates the filling of this exhausted sulfur zone and the filling of the pores of the cap rock and in accordance with the heretofore customary practice these regions were necessarily filled with hot water in order that the required pressure and temperature of the hot water for melting the sulfur might be maintained. In accordance with the present invention, a cushion of compressed air, or other appropriate gas, is formed in the non-sulfur-bearing regions or zones above the sulfur deposit; two such regions being represented in the accompanying drawing and designated "Exhausted sulfur zone" and "Porous cap rock."

The air or other gas employed for the formation of the gas cushion of the invention may, if desired, be preheated, but this is not necessary. On account of its low specific heat conductivity, the gas in contact with the superheated water when once heated to the temperature of the water will not thereafter take any appreciable amount of heat therefrom.

In the practice of the present invention, air may be forced down through drill holes in any part of the dome. Thus, as indicated in the accompanying drawing, air may be pumped down through a pipe C into the non-sulfur-bearing regions above the sulfur deposit. The air will find its final lodgement above the water, regardless of where it may be injected and regardless of temperature. By reference to the accompanying drawing, it will be noted that the spaces represented by the legends "Porous cap rock" and "Exhausted sulfur zone" if not filled with gas in accordance with the present invention remain open to occupation by the hot water, thus constituting a "heat reservoir" where the water cools before its major heat content can be transmitted to

the sulfur, and thereby involving great losses which result in low heat efficiency for the hot water. When practising the present invention, the junction of the gas cushion and underlying water may, by adding or withdrawing gas, be established at any elevation at the will of the operator, this junction of gas and water where the water is hottest being the horizon of most effective melting power.

In the accompanying drawing, the lower edge of the gas cushion is indicated as substantially co-extensive with the line A—B representing the top of the residual sulfur bed. The upper surface of the hot water is thus at about the level of the upper surface of the sulfur bed, the gas pressure being preferably maintained at such a point that no substantial part of the hot water is allowed to go up into the non-sulfur-bearing regions above the sulfur bed. Due to the fact that the hotter portions of the hot water are lighter, these hotter portions rise to the surface where they are held by the gas cushion in intimate contact with the sulfur bed. This represents a distinct improvement over the heretofore customary practice where such hotter portions of the hot water would rise up into the cap rock.

The strata overlying the cap rock or porous formation consisting usually of gumbo, quicksand, and surface clay, are relied upon to seal the gas cushion and to prevent escape of gas therefrom to the surface of the ground. Other suitable and appropriate precautions should be taken in carrying on mining operations in accordance with the present invention to guard against and prevent the loss of gas.

The sulfur wells embodying the usual series of concentric pipes for conducting hot water or other appropriate fusing medium into thermal relation with the sulfur deposit and for carrying the melted sulfur out of the mine are indicated diagrammatically in the accompanying drawing by reference letter D. Such wells may be of any approved construction, the details of which form no part of this invention.

From the foregoing discussion, it will be seen that the principal aim of the present invention is to keep the hottest water which will be at the floor of the gas cushion as near as possible to the bodies of sulfur, and in this manner eliminate or largely reduce heat losses in porous rock and exhausted sulfur regions at the higher levels of the mine where the presence of the hot water is of no benefit so far as melting sulfur is concerned. While the process of the invention has been more particularly described in connection with the mining of a partially exhausted sulfur deposit, it is of course applicable to a fresh sulfur deposit, the air or other gas in this instance being used to fill the porous cap rock or other non-sulfur-bearing formation above the sulfur deposit, thus eliminating the necessity of filling up this non-sulfur-bearing formation with hot water.

While I now regard air as the most satisfactory gas to employ in the practice of the invention, it is evident that other gases, simple or compound, may be used. Thus, mixtures of air with another gas or gases, carbon dioxid gas, and the like, may in the practice of the invention be pumped or otherwise appropriately introduced into the non-sulfur-bearing zone above the sulfur deposit for forming the desired gas cushion. Moreover, sulfuric acid, which can be manufactured at relatively low cost at a sulfur mine, may be introduced into the non-sulfur-bearing region, where the acid will react with the lime-stone of the cap rock with the generation *in situ* of carbon dioxid gas, which thereby serves to provide the gas cushion contemplated by the invention.

I claim:—

1. The improvement in the method of mining sulfur by underground fusion, which comprises conducting an appropriate fusing medium into the formation containing the sulfur deposit and thereby melting the sulfur, and appropriately regulating the flow of said fusing medium upwardly through the formation by compressed gas forced into the formation above the discharge into the formation of said fusing medium.

2. The improvement in the method of sulfur mining by underground fusion, which comprises forming a cushion of compressed gas above the sulfur deposit and bringing an appropriate fusing medium into thermal relation with the sulfur deposit, the gas cushion serving to prevent the rise of the fusing medium into the non-sulfur bearing region above the sulfur deposit.

3. The improvement in the method of sulfur mining by underground fusion, which comprises forcing compressed gas into the region immediately above the sulfur deposit, and bringing an appropriate fusing medium into thermal relation with the sulfur to melt it, the pressure and amount of the gas being sufficient to prevent the rise of the fusing medium into the non-sulfur bearing zone above the sulfur deposit.

4. The improvement in the method of sulfur mining, which comprises forming a gas cushion above the sulfur deposit, and bringing an appropriate fusing medium into thermal relation with the sulfur to melt it, the gas pressure being such as to keep the upper surface of the fusing medium substantially co-extensive with the upper part of the sulfur deposit, thereby preventing any substantial amount of the fusing medium rising into the non-sulfur bearing region above the sulfur deposit.

5. The method of mining sulfur by underground fusion from partially exhausted sulfur deposits, which comprises forcing compressed gas into the zone above the residual sulfur deposit from which sulfur has been mined and into the zone of earth or rock formation above the sulfur deposit, and bringing an appropriate fusing medium into thermal relation with the residual sulfur deposit to melt it, the pressure of the gas being such as to prevent the rise of the fusing medium into the exhausted sulfur zone and into the earth or rock formation overlying the sulfur.

6. The improvement in the method of mining a fusible mineral by underground fusion, which comprises introducing into the mine an appropriate gas and thereby forming a gas cushion above the fusing medium in contact with the mineral deposit.

7. The improvement in the method of mining a fusible mineral by underground fusion, which comprises melting the mineral by means of a fusing medium in thermal relation with the mineral deposit, and forming an underground cushion of compressed gas above said fusing medium and thereby regulating the passage upwardly of the fusing medium.

8. The improvement in the method of mining sulfur by underground fusion, which comprises conducting superheated water into the sulfur deposit to melt the sulfur, and forcing air under pressure into the formation containing the sulfur deposit for appropriately regulating the upward flow of said superheated water.

In testimony whereof I affix my signature.

AUGUST TOBY DRACHENBERG.