R. E. CARMICHAEL.

METHOD OF AND APPARATUS FOR SULFUR MINING.

APPLICATION FILED APR. 20, 1918.

**1,308,929.**

Patented July 8, 1919.

2 SHEETS—SHEET 1.

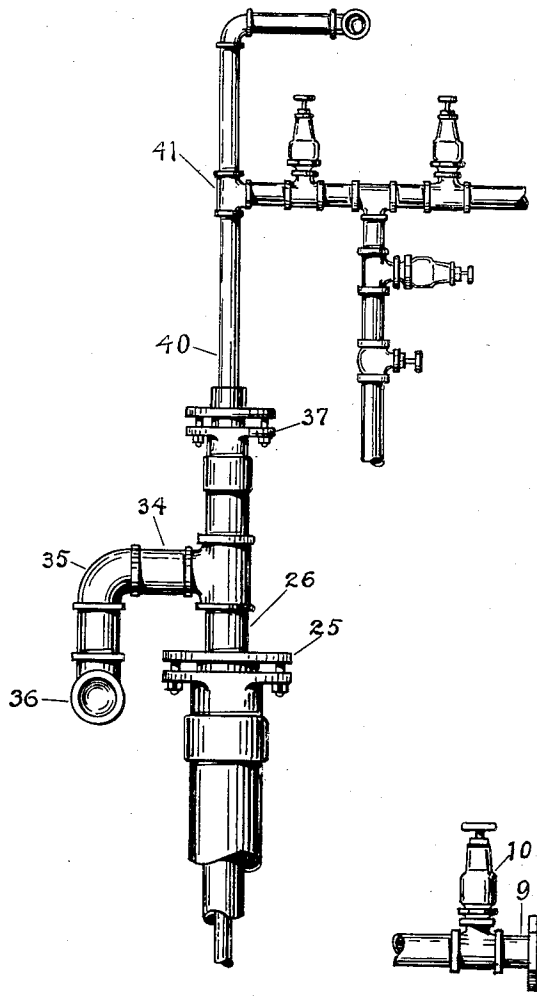



Fig. 1.

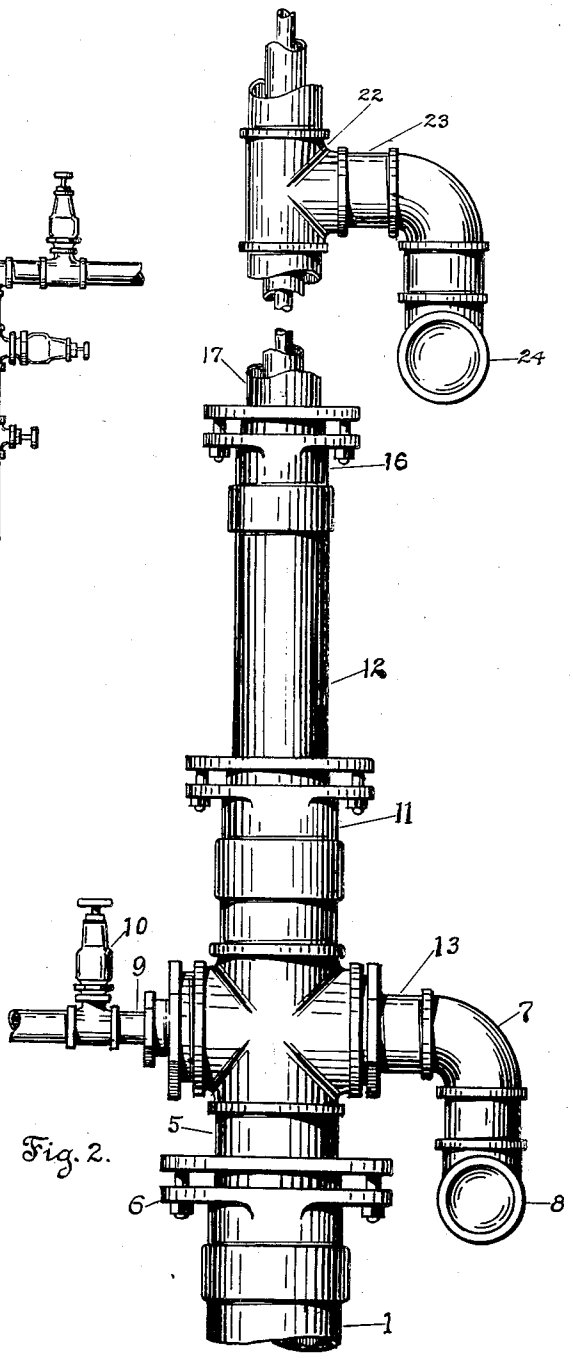



Fig. 2.

R. E. Carmichael, Inventor

By his Attorney Jesse R. Stone

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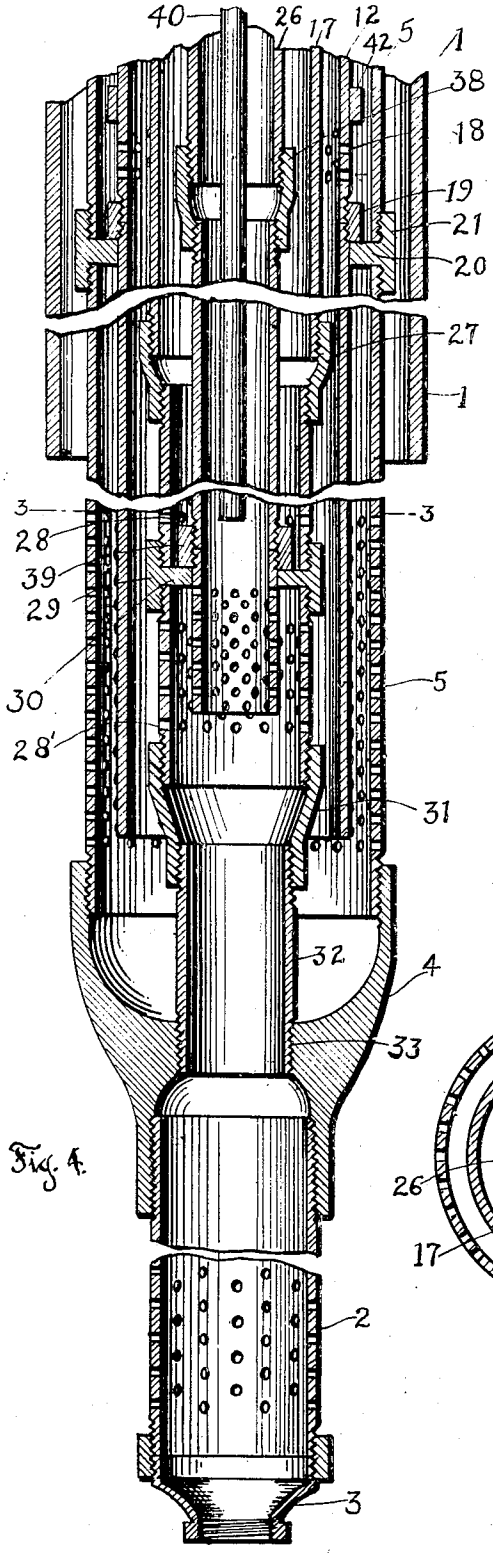



Fig. 4.

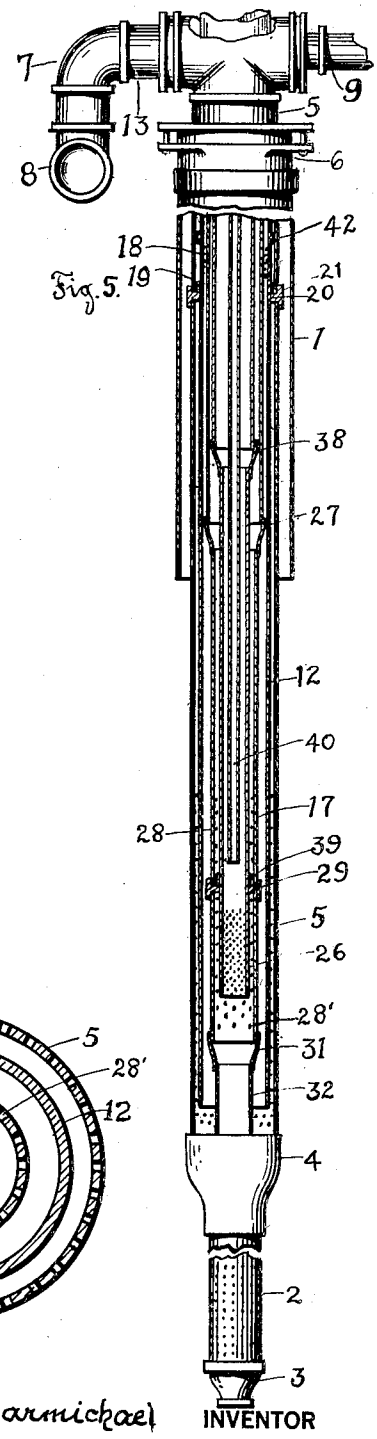



Fig. 5.

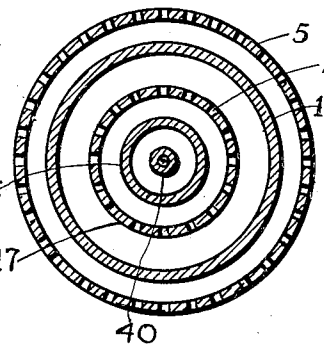



Fig. 3.

R.E. Carmichael INVENTOR

BY

Jesse R. Stone ATTORNEY

# UNITED STATES PATENT OFFICE.

ROBERT E. CARMICHAEL, OF DAMON, TEXAS, ASSIGNOR OF ONE-HALF TO GEORGE HAMMAN, OF HOUSTON, TEXAS.

## METHOD OF AND APPARATUS FOR SULFUR-MINING.

1,308,929. Specification of Letters Patent. Patented July 8, 1919.

Application filed April 20, 1918. Serial No. 229,859.

*To all whom it may concern:*

Be it known that I, ROBERT E. CARMICHAEL, a citizen of the United States, residing at Damon, Brazoria county, Texas, have invented a certain new and useful Improvement in Methods of and Apparatus for Sulfur-Mining, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to a method of, and apparatus for, sulfur mining and contemplates the use of a system of concentric cylindrical pipes. These pipes are adapted to extend down into the mine and are equipped with valves and means for circulating hot water, air and the melted sulfur therethrough. A well shaft is dug down through the sulfur bed by means of the usual well drilling apparatus. An anchoring pipe is then cemented to the bottom of the well and a system of perforated pipes is attached to this anchoring pipe. Hot water is circulated downwardly between the outer concentric pipes and through the perforations to the sulfur which is thus melted. In this melted state the sulfur is drawn through the lower perforations and circulated to the surface through a central pipe.

One object of my invention is to provide a novel means of regulating the hot circulating fluid so that it may be directed toward any desired point along the sulfur strata.

Another object is to so construct my circulating system as to form a plurality of entrances for the hot water so that if one of the pipes becomes clogged the others may serve to assist in maintaining a full circulation and open up the system.

Another object is to provide a sliding unperforated pipe adjacent the outer perforated pipe, so arranged as to properly regulate the discharge of the water.

Another object is to improve the old process of sulfur mining so that the hot circulating fluid may be directed in such manner as to obtain a constant and steady flow of sulfur from the mine.

Another object is the provision of a system of seats or valves so positioned as to direct the currents of circulating fluid into the proper channel and to prevent a back flow of the same at certain points.

Other objects and advantages of my invention will more clearly appear in the specification which follows and will be pointed out with more particularity in the claims.

With reference to the drawing forming a part of this specification and wherein like numerals refer to like parts throughout the different views:

Figure 1 is a broken side view showing the upper part of the pipe connections by means of which the water and air circulation is obtained in my invention.

Fig. 2 is a continuation of the system represented in Fig. 1.

Fig. 3 is a section on the line 3—3 of Fig. 4.

Fig. 4 is a transverse section of my underground series of pipes showing details of construction.

Fig. 5 is an assembly view partly in transverse section showing the relative position of the parts of my invention.

My invention is adapted to be used particularly in mining sulfur where the sulfur is located several hundred feet below the surface. In this method a well is dug deep enough to reach far into and through the sulfur strata, passing some distance beyond the bed to be mined. An outer casing 1, is fitted into this well for a portion of its depth. This casing is unperforated and is used to close up the upper end of the shaft or well as will appear. This outer casing may be a pipe of about 12 inches in diameter or any desired dimensions. A smaller perforated pipe 2 of about one-half the diameter of the outer pipe is then introduced into the bottom of the well. This pipe 2 is partially closed at the bottom by means of a bushing 3 and extends from the bottom of the well up to the lower side of the sulfur bed, where it is screwed into the threaded lower end of a compound coupling or swage 4. The perforated pipe is then filled with fresh Portland cement which is forced through the perforations in the pipe and fills up the lower end of the well, firmly cementing the pipe into position. The upper end of the coupling 4 is of larger diameter and is threaded to receive the outer pipe 5 which is perforated for a distance equal to the full depth of the sulfur bed to allow the hot water to be projected outwardly against the sulfur.

The outer casing 1 is connected at its upper end to a stuffing box 6 within which stuffing box is fitted the pipe 5. This pipe

5 has a laterally extending inlet 13 joined to an elbow 7 which in turn is connected with the T 8. This furnishes the inlet for the hot circulating fluid which is projected downwardly inside the pipe 5. Opposite the inlet 13 and connected with the pipe 5 is a smaller pipe 9 having thereon a relief valve 10. This provision is made in order to take up any excess pressure inside the pipe 5.

Pipe 5 terminates at its upper end in the stuffing box 11 which receives a pipe 12 of smaller diameter which is slidable within the stuffing box 11, in a vertical direction. The pipe 12 terminates at its upper end in the stuffing box 16, which receives a pipe of still smaller diameter 17 on which the stuffing box 16 and pipe 12 are slidable.

The slidable pipe 12 is extended downwardly in the well concentric with the outer pipe 5 and is not perforated except at a point, somewhat below the surface, indicated at 18. Immediately below the perforations 18 is an outer coupling ring 19 which is adapted to be seated, at its lowest position, upon an inwardly extending flange 20. This flange 20 forms an integral part of the coupling 21 upon the outer pipe 5 and extends inwardly so as to contact with the outer surface of the pipe 12 and completely close the annular space between these pipes. It will thus be noted that when the water is circulated in through the inlet 8, by means of the pipe 13, and downwardly between the two pipes 5 and 12, the seating of the collar 19 upon the flange 20 will bar further progress downward of the circulating fluid. The fluid will thus be forced through the perforations 18 and into the space inside of pipe 12.

The pipe 17 extends downwardly for some distance into the well and is threaded into a reducing swage 27 by which the diameter of the pipe is somewhat reduced thereby accelerating the force of the downwardly flowing current. This pipe is perforated toward its lower end as at 28 and, immediately below the perforations, a coupling 29 is provided, said coupling having an annular inwardly extending flange 30 similar to the coupling 21 previously described in relation to pipe 5. Below this coupling 29 the pipe is further perforated as shown at 28'. The lower end of the pipe 17 is threaded into another reducing swage 31 by which it is attached to the short length of pipe 32 which is screwed at its lower end into the threaded opening 33 in the coupling 4 previously described.

The pipe 17 is also extended longitudinally upward for some distance above the surface and has, toward its upper end, a coupling 22. Said coupling has thereon a laterally extending pipe 23, terminating in an inlet T 24 through which water may be introduced into the space within the pipe 17. The pipe like the preceding ones terminates at its upper end in the stuffing box 25 which receives within it a pipe 26 of smaller diameter.

The pipe 26, as in the other pipes 5 and 17 previously described, has a laterally extending pipe 34 connected by an elbow 35 to a T 36 which may serve either as an inlet or an outlet as will be seen. This pipe furnishes the exit for the sulfur forced upwardly from the bottom of the well. It is extended upwardly to terminate in the stuffing box 37. It extends downwardly within the pipe 27 and is reduced in diameter at some distance below the surface by a reducing swage 38. At a point within the pipe 17 adjacent to and above the inwardly extending flange 30 I have provided a coupling ring 39, which, when seated upon the annular flange 30, acts to prevent any further progress downward of the water within the space between the two pipes 17 and 26. Water which is circulated downwardly between these two pipes meets the obstruction formed by the flange 30 and the coupling 39 and finds an exit outwardly through the perforations 28 of the pipe 17 into the space provided between the pipe 17 and the slidable pipe 12. Within the stuffing box 37 is received a pipe of smaller diameter 40 which furnishes an inlet for air under pressure which is introduced by means of a series of connecting pipes shown generally as connected with the coupling 41 which connect the same with an air compressor not shown.

Thus in the operation of my invention, superheated water and steam under pressure is forced inwardly through any or all of the inlet pipes 13, 23 or 34 and finds a passage downwardly inside the slidable pipe 12. It will be noted that no matter by which inlet the water is introduced into the pipes, its passage downwardly will be prevented between the pipes 5 and 12 by means of a flange 20 and be directed inwardly inside of the slidable pipe 12. Or if the water is introduced between the pipes 17 and 26 its passage downwardly will be prevented by the flange 30 and it will be directed outwardly through the perforations 28 into the space within the slidable pipe 12. Thus any water introduced into the well will be directed downwardly around the lower end of the pipe 12 and outwardly through the perforations in the pipe 5 against the strata of sulfur to be melted.

If it is desired to melt the sulfur adjacent to the lower end of pipe 5, the slidable pipe 12 is lowered to the position shown in Fig. 4 and the heated water and steam, escaping around the lower end of pipe 12, will be directed outwardly through the perforations in pipe 5 against the sulfur at that point. If, however, these perforations become somewhat clogged or, a larger or different

portion of the bed is to be attacked by the heated fluid, the slidable pipe 12 is raised up so as to direct the heated fluid against the point desired and the said fluid, escaping around the lower end of the pipe 12, will be directed outwardly through the perforations in pipe 5 to a point higher up in the sulfur stratum. The raising and lowering of pipe 12 is accomplished by the means ordinarily used in a pumping derrick. This comprises a block and tackle attached to the upper part of the derrick and having at its lower end an elevator which is adapted to grip the slidable pipe 12 and raise the same upwardly, the pipe 12 sliding within the stuffing box 11 and over the pipe 17 in an obvious manner.

To prevent the pipe 12 from being elevated to the extreme height whereby it may be pulled entirely out of the stuffing box 11, a lug or flange 42 is provided on the outer periphery of the pipe 12 which is adapted to contact at its extreme upper position with the inside of the stuffing box 11 and prevent further upward movement.

The sulfur melted by the hot fluid runs downwardly and through the perforations in the lower part of the outer pipe 5 and fills the lower end of the pipes. It is forced up through the perforations in pipe 17 inside the smaller perforated pipe 26 by the pressure of the pumps on the hot circulating water. The compressed air pumped downwardly through the pipe 40 causes the pressure at this point to be about that of the atmosphere. This air bubbles up within the passage between the pipes 40 and 26 assisting greatly in the elevating of the melted sulfur to the upper part of pipe 26 where it finds an outlet through the pipe 34 and its connections.

The pipe 34 may be used, during the preliminary heating and washing of the well, as an inlet pipe also. Steam forced downwardly through this pipe is directed toward the bottom of the pipes and melts the sulfur adjacent to that part of the well. When, however, the well is cleared and the flow of sulfur is ready, the pipe 34 is used as an exit for the molten material.

The advantages of my system lie in the greater efficiency obtainable through the use of my slidable pipe 12. Without this pipe the steam and hot fluid pumped into the well escapes outwardly through any or all the perforations in the outer pipe 5. If large crevices or cavities occur in the stratum, some sulfur may be melted and fill the lower end of the pipes but, due to the escape laterally of the steam through the crevice, the melted sulfur will soon harden and clog the pipes. By means of my adjustable pipe 12 I can direct the steam at some point removed from the crevice and continue the operation without the loss of the heated fluid and obtain a constant flow of the molten sulfur.

I have described a longitudinally adjustable pipe for regulating the point of discharge of the heated fluid but it is obvious that the pipe might be adjustable in other ways without departing from the spirit of my invention.

By anchoring my pipes at the bottom I avoid the loss of my system of pipes due to a sinking of the material and maintain a firm and secure foundation for operations.

Having thus described my invention what I claim as new and desire to protect by Letters Patent is:

1. A device for sulfur mining comprising a casing, a pipe projecting below said casing and perforated toward its lower end, a slidable pipe within the first pipe, means to close the passage between the two said pipes; a third pipe within said slidable pipe, perforated toward its lower end, a fourth pipe within the third pipe, a closure toward the lower end thereof and closing the passage between the third and fourth pipes, an inner air pipe in the system and fluid connections at the upper ends of each of the pipes except the slidable pipe, whereby heated fluid may be directed around the lower end of said slidable pipe.

2. In a system of concentric pipes for sulfur mining, an outer stationary pipe perforated at its lower end adjacent the sulfur bed, a slidable pipe inside said stationary pipe, separate means to direct a downward current of heated fluid inside said slidable pipe and means for adjusting said slidable pipe.

3. In a device for sulfur mining, an outer perforated pipe, an inner fluid circulating pipe, a longitudinally slidable, regulating pipe between the two first mentioned pipes, means for directing circulating fluid between the different pipes into the space within the slidable pipe and around its lower end, an inner sulfur conveying pipe, and means, including an air pipe, to force the sulfur in an upward current through the sulfur conveying pipe.

4. In a device for sulfur mining an outer pipe perforated at its lower end adjacent the sulfur bed, an inner slidable regulating pipe, and an annular closure for the space between said pipes, said regulating pipe being perforated immediately above said closure to direct fluid from between the pipes to the space within the regulating pipe for the purpose described.

5. In a device for sulfur mining an outer pipe perforated for a part of its length adjacent the sulfur bed, an inner fluid circulating pipe, a slidable pipe between the two first mentioned pipes, said slidable pipe be-

ing non-perforate adjacent the sulfur bed and means to direct the circulating fluid around the lower end of the slidable pipe.

6. In a device for sulfur mining an outer pipe perforated adjacent the sulfur bed, an inner fluid circulating pipe, a slidable pipe between the two first mentioned pipes, means to direct the circulating fluid around the lower end of the slidable pipe and means to conduct the molten sulfur upwardly inside the fluid circulating pipe.

7. In a system of concentric pipes for sulfur mining, an outer perforated stationary pipe, a longitudinally slidable pipe inside said stationary pipe, means for closing the passage between the two pipes, said slidable pipe being perforated above said means, and perforated pipes within said slidable pipe adapted to conduct steam or other heated fluid under pressure around the lower end of said slidable pipe and an exit pipe for the molten material.

8. In a system of concentric pipes for sulfur mining, an outer stationary pipe perforated toward its lower end, a longitudinally slidable pipe within said stationary pipe, fluid circulating pipes within said slidable pipe, sulfur lift pipes within said circulating pipes, and means for anchoring said system in the bottom of the well.

9. In a system of concentric pipes for mining sulfur by means of heating fluid, the improvement consisting of a pipe, imperforate adjacent the sulfur strata and longitudinally adjustable, means for directing the heating fluid within and around the lower end of said adjustable pipe, and means to discharge the fused sulfur from the well.

10. In a device for sulfur mining the combination of a series of concentric pipes for circulating heated fluid to the sulfur beds, and an anchoring and supporting means for said pipes, at the lower end of the well, to which a plurality of said pipes are secured, said means comprising a perforated pipe adapted to be filled with cement and a compound coupling between said anchoring pipe and said circulating pipes.

11. In a device for sulfur mining an outer pipe perforated adjacent the sulfur bed, an inner fluid circulating inlet pipe and a slidable pipe between the two first mentioned pipes for the purpose described.

12. In a device for sulfur mining, an outer perforated pipe, an inner slidable regulating pipe and sulfur lift pipes within said slidable pipe for the purpose described.

13. In a device for sulfur mining, the combination of a perforated pipe for the discharge of heated fluid to the sulfur stratum, and an adjustable pipe adjacent thereto for regulating the point of discharge of the said heated fluid, and means within said adjustable pipe to convey the fused sulfur from the well.

14. In a device for sulfur mining, the combination of a perforated pipe for discharge of heated fluid to the sulfur and a longitudinally adjustable pipe coöperating therewith to regulate the point of discharge of the heated fluid, a closure for the passage between said pipes, said adjustable pipe being perforated to allow ingress of the heated fluid from said passage to the space within the adjustable pipe.

15. In a device for sulfur mining, an anchoring means for same comprising a longitudinal pipe perforated, and adapted to be cemented to the bottom of the well, and means at the top of said pipe for support and attachment of the sulfur mining apparatus.

16. A method of mining subterranean sulfur comprising the establishing of a plurality of concentric conduits to the sulfur bed, forcing the heated fluid under pressure through certain of said conduits, regulating the discharge of said fluid as desired to any level, and so regulating the pressure of said heated fluid on the molten sulfur as to cause an upward current of the same through one of said conduits to the surface of the ground.

17. A method of mining subterranean sulfur comprising, forcing the heated fluid under pressure into the well to a point adjacent the sulfur stratum; so regulating the discharge of the heated fluid as to project the same at various points on the stratum as desired; so regulating the pressure upon the molten sulfur as to cause an upward discharge of said sulfur to the surface of the ground.

18. In an apparatus for sulfur mining, a system of concentric pipes comprising an outer, perforated, heating fluid inlet pipe, an inner sulfur exit pipe, and a means for adjustably regulating the discharge of said heating fluid at any level desired.

19. In an apparatus for sulfur mining, a system of concentric pipes comprising a longitudinally slidable pipe imperforate toward the lower end adjacent the sulfur bed, means for discharging heating fluid within said slidable pipe, and an inner sulfur lift pipe for discharging the sulfur from the well.

20. In a device for subterranean sulfur mining, means for conducting heating fluid into the well, means, adjustable during the operation of the device, for regulating the point of discharge of said fluid, and means to convey the fused material to the surface.

21. In a device for subterranean sulfur mining, means for conducting a heating fluid into the well, adjustable means to regulate the point of discharge of said fluid, means to convey the fused material to the surface and detachable means for anchoring the device in position.

22. In an apparatus for sulfur mining, a

system of four concentric pipes comprising an outer water inlet pipe, an inner sulfur outlet pipe, an intermediate slidable pipe imperforate toward its lower end, and a central air inlet pipe for the purpose described.

23. Apparatus for introducing hot water into a sulfur mine comprising a pipe extending down to a point adjacent the sulfur-bearing rock and having a telescoping lower end adjustable as to height, means for introducing hot water into said pipe, and means under the control of the operator for raising and lowering said telescoping end so as to control the point of delivery of hot water, and means for removing the melted sulfur.

24. Apparatus of the kind described comprising a pipe extending to a point adjacent the top of the sulfur formation a lower telescoping section extending into the sulfur formation, and means for adjusting said lower section vertically for the purpose described.

25. Apparatus for introducing hot water into a sulfur mine comprising a pipe extending to the sulfur forma ion, means for forcing hot water into said pipe, and a section of pipe adjustably supported and controlled at the surface of the ground, and forming a continuation of said first-mentioned pipe and means for removing the melted sulfur.

26. Apparatus of the kind described comprising a casing extending from the surface of the ground to or adjacent the sulfur to be mined, a pipe inside said casing, means for delivering water heated to such a temperature as to fuse sulfur through said pipe into the mine, and means controlled from the surface of the ground for raising and lowering said pipe so as to deliver the hot water at the desired level and means for removing the melted sulfur.

In testimony whereof, I hereunto affix my signature this the 15th day of April, A. D. 1918.

ROBERT E. CARMICHAEL.