

H. FRASCH.
MINING SULPHUR.

No. 461,431.

Patented Oct. 20, 1891.

FIG. I.

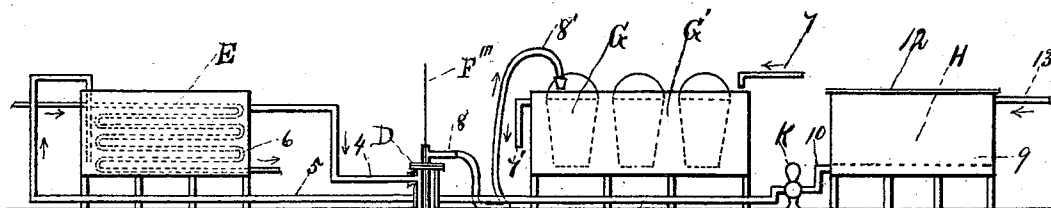


FIG. II.

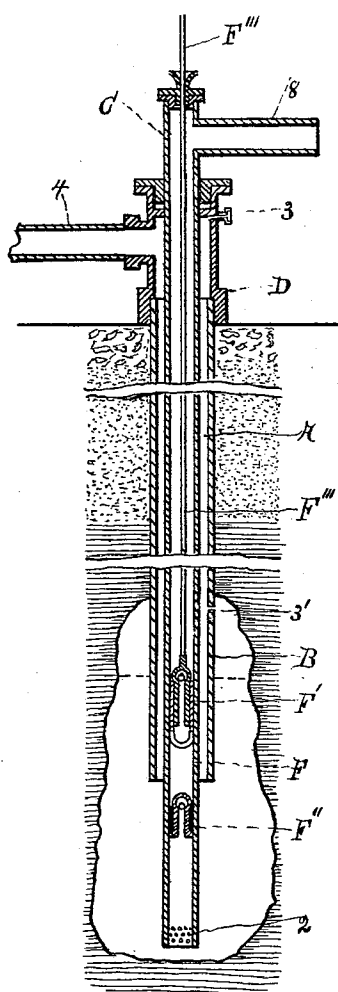


FIG. III.

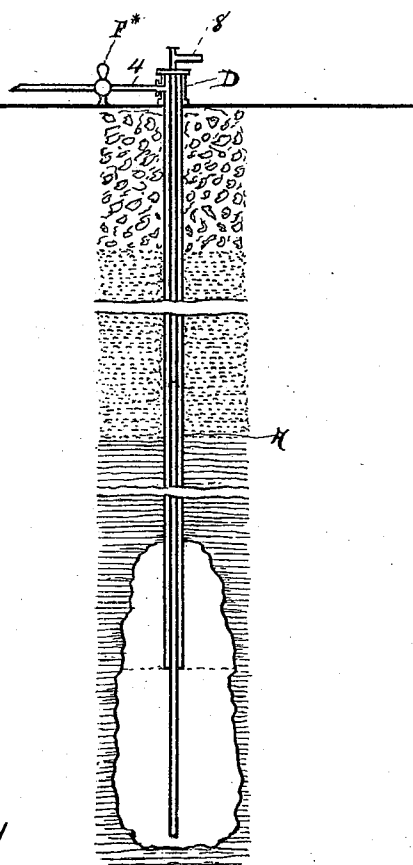
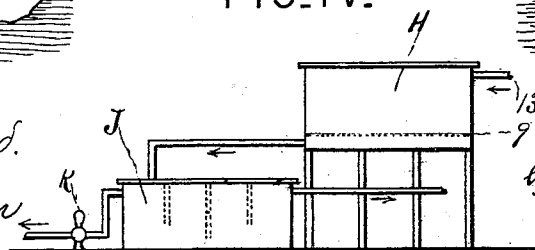


FIG. IV.



Witnesses

R. E. Auld.

Edw. A. Muir

Inventor

Herman Frasch

by Chas. J. Hedrick

his attorney

(No Model.)

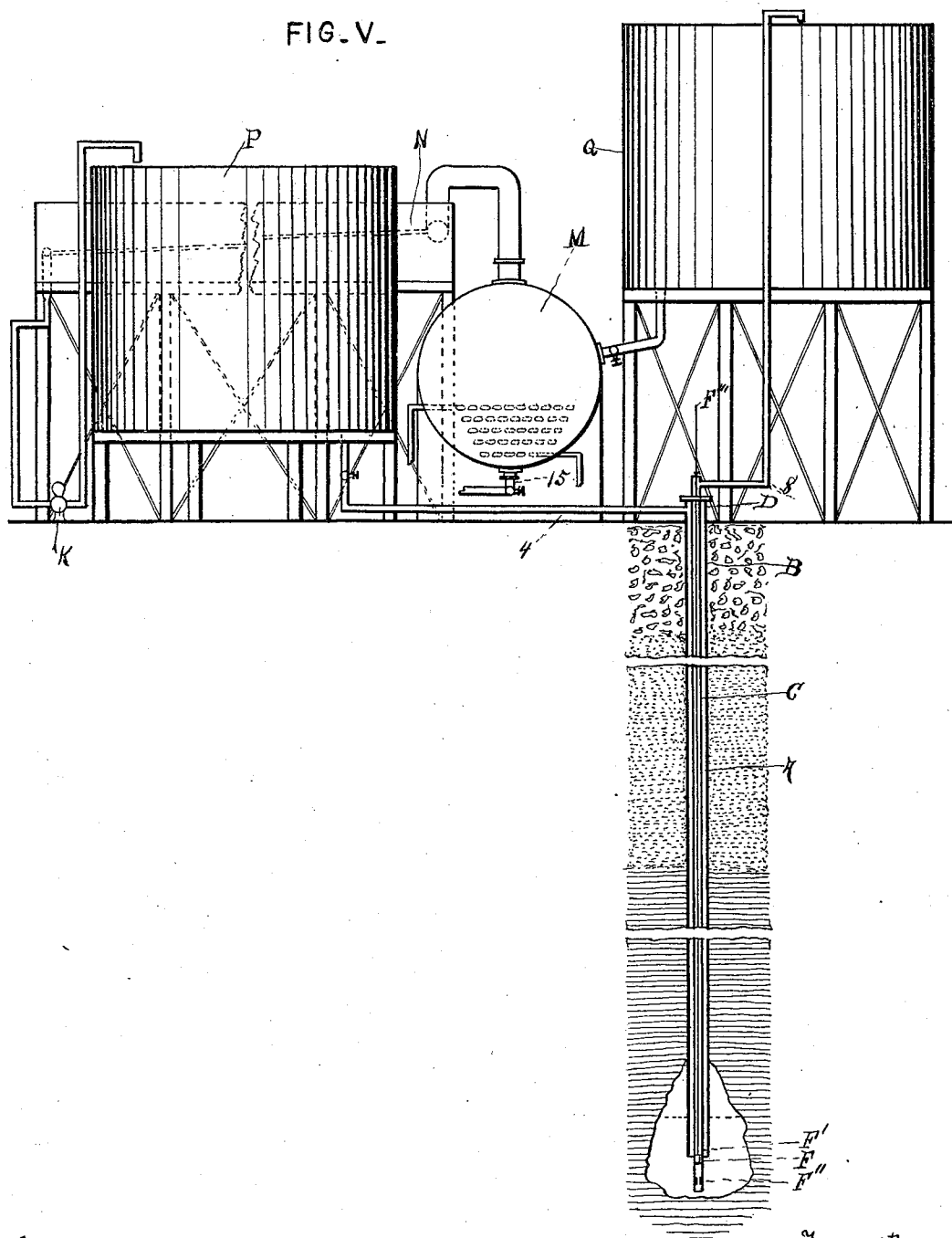
2 Sheets—Sheet 2.

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FIG. V.



Witnesses

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UNITED STATES PATENT OFFICE.

HERMAN FRASCH, OF CLEVELAND, OHIO.

MINING SULPHUR.

SPECIFICATION forming part of Letters Patent No. 461,431, dated October 20, 1891.

Application filed December 26, 1890. Serial No. 375,800. (No model.)

To all whom it may concern:

Be it known that I, HERMAN FRASCH, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Mining Sulphur, of which the following specification is a full, clear, and exact description.

This invention relates to the removal of sulphur from deposits in the earth which consist of or contain free sulphur, and is particularly useful in the removal of the sulphur from deposits which are overlaid with beds of quicksand and which therefore cannot be mined in the usual way by sinking a shaft; but each of the improvements constituting the said invention is included for all the uses to which it may be adapted. By means of the present invention, moreover, a refining of the sulphur is effected in the mining operation.

The invention consists in liquefying the sulphur in the mine or underground deposit by means of a solvent vehicle and lifting the solution to the surface by a pump or other known or suitable means of raising liquids. For the purpose of liquefying the sulphur the invention includes solvents in general of sulphur, (among which bisulphide of carbon, tar, petroleum, and other hydrocarbon or ethereal oils may be mentioned,) and the solvents may be used at any appropriate degree of temperature. The sulphur may be recovered from the solvent in different ways, as by distillation in case a volatile solvent is used, or by crystallization on cooling in case a hot solvent is employed for liquefying the sulphur in the mine. The nature of the solvent used, the temperature at which it is used, and the mode of recovering the sulphur therefrom are, however, matters of practical consequence; and the invention covers processes or improvements involving such matters as special features of invention. Thus, for example, the use of the solvent hot (or raised more or less above ordinary atmospheric temperature) constitutes a special feature; also, the recovery of the sulphur by separation on cooling; also, the use of petroleum as a solvent; also, the use of a solvent non-volatile at the melting-point of sulphur, and in particular petroleum intermediate in gravity between burning and

lubricating oils—say oil of 36° Baumé; also, in introducing and removing the solvent or in circulating it through the sulphur deposit without filling the cavity. These special features are each included separately, as well as in connection with one or more of the others.

Further, the invention consists in inducing a circulation of a solvent in the underground cavity (whether wholly or partly full) by introducing the fresh liquid near the bottom of the cavity or point at which the sulphur solution is removed. If the liquid be hot when introduced, the high temperature makes it specifically lighter than the liquid already in the cavity, so that it tends to rise, and thus induces a circulation of the whole fluid mass. The solution of the sulphur in the vehicle also makes the liquid in the cavity specifically heavier, and consequently increases the differences in density between the inflowing and the present liquid. This part of the invention extends to the circulation, as above indicated, of a liquid in general adapted to liquefying the sulphur. In this connection the word "liquefy" is used in the general sense of reducing to a liquid state irrespective of which of the known modes of effecting liquefaction is employed, the known modes of liquefaction being, first, solution, and, second, fusion. It is to be understood, however, that neither mode has been utilized in the removal of sulphur from underground mines prior to my invention.

In the accompanying drawings, which form part of this specification, Figure I is a diagram of a plant for mining sulphur in accordance with the invention. Fig. II is a diagram of the mine or well on an enlarged scale. Fig. III is a diagram of a somewhat different arrangement of well. Fig. IV is a view illustrating another mode of finishing the cleansing of the sulphur from solvent, and Fig. V is a diagram illustrating another form of plant.

A well A is drilled in the manner usual in making salt or oil wells to and into or through the underground sulphur deposit. As shown in Figs. I and II and also in Fig. V, a casing B, of, say, ten inches in diameter, is brought nearly to the bottom of the well. Tubing—say five inches in diameter—is introduced through the casing B until it projects slightly beyond. The lower part of this tubing may be provided with perforations 2 at the side,

or may be otherwise provided with a strainer, or it may be more or less open. The casing B may be provided with small openings 3 and 3' to act as air-vents. The opening 3' is shown as provided with a valve in the form of a screw-plug, so that it can be opened or closed at will. At the surface of the ground there is a casing-head D, having a lateral tube 4. The tubing C extends through the casing-head D, which is shown provided with a stuffing-box around the tubing. A lateral pipe 8 leads from the tubing. At the bottom of the tubing is the working barrel F of the pump, and at F' F'' are the piston and the check-valve. The piston is operated by the sucker-rod F''', extending through the tubing C and passing out through a stuffing-box at the top of the tubing to suitable means for reciprocating it. The whole arrangement is like the pumping means employed in oil-wells.

At E is a heater with steam-pipes 6 for raising the temperature of the solvent which is to be introduced into the mine. A pipe 5 conducts the hot fluid from the heater E and discharges it into the mine through the casing B. A feeding-pump could be interposed in this pipe (like the pump F* of Fig. III) instead of the solvent being allowed to run from the heater into the mine by gravity alone. The lateral pipe 8 from the tubing C delivers the sulphur solution into vessels for recovering the sulphur. These vessels, as shown in Fig. I, are coolers G, in the form of large frusto-conical buckets, which are set in a vat G', supplied with cooling medium, as cold water entering by pipe 7 and escaping by pipe 7'.

The pipe 8 is supplied with a flexible hose 8', such as used for oil, (petroleum,) by which the sulphur solution can be run into any cooler G in the vat G'.

At H is a strainer for drawing off the solvent from the sulphur which has been separated by cooling in the buckets G. It consists of a vessel having a perforated false bottom 9, which is covered with a cloth. A pipe 10 connects the space under the false bottom with the inlet of a pump K, whose outlet is connected by the pipe 11 with the heater E. The straining-vessel H has a close-fitting removable cover 12, and a pipe 13 enters just below said cover for admitting into the said vessel a fluid for removing the last traces of solvent from the sulphur.

In order to carry out the process of the present invention with the apparatus described, the heater E may be filled with petroleum distillate of, say, 36° Baumé, which is then heated to, say, 250° Fahrenheit, at which temperature it is capable of dissolving one hundred per cent. of sulphur. When this oil has been raised to the proper degree of heat, it is introduced through the casing B into the bottom of the well. There it comes in contact with the sulphur or sulphur-containing walls of the cavity, which it dissolves, form-

ing a sulphur solution. This solution is pumped up by means of the pump F' F'' and discharged through the tubing C and pipe 8 into one or more of the vessels G. Here it is allowed to cool and deposit the sulphur. At 60° Fahrenheit the oil will contain about four per cent. of sulphur. When this temperature is reached, the buckets G are emptied into the strainer H. This oil, lightly charged with sulphur, passes through the false bottom 9 and is returned by a pump K into the heater E. When its temperature has been raised, it is again introduced into the well. As the cavity in the mine increases it is not necessary to increase the quantity of solvent used, since the solvent may be allowed to only partially fill the cavity, as indicated by the dotted lines. By introducing the hot solvent at or near the bottom of the cavity it naturally rises as soon as it escapes from the casing B and creates a circulation, which flows over and comes in contact with the sulphur, dissolving the same, so that it can be pumped out in a liquid condition. It is evident that the hot solvent could be introduced considerably above the bottom of the tubing C or at the upper part of the cavity in the mine; but in that case the advantage of obtaining a circulation, as just stated, would not be had. The solvent can be introduced continuously at the same time that the sulphur solution is pumped out, thus making a continuous operation, or the solvent can be introduced, allowed to stand, and then the sulphur solution be pumped out. Instead of raising the oil to the temperature indicated, it may be raised to a less temperature or to a higher temperature. The cooling also might be to a temperature other than 60° Fahrenheit. It is possible also to employ this petroleum solvent in a cold state; but this is not considered advantageous. The portion of the solvent which adheres can be removed by washing the sulphur with a volatile solvent of the oil, like bisulphide of carbon or benzine. The cover 12 can be closed when this is effected, the solvent being introduced through the pipe 13. It passes with the heavy oil through the false bottom 9, and may be allowed to pass through the pump K into the heater E. Only a small quantity is required. When the sulphur is removed from the straining-vessel H, any of the light solvent which may adhere passes off as vapor.

Instead of using a light solvent to wash off the heavy oil, this may be effected by the introduction of steam into the vessel H through the pipe 13. To separate the water of condensation from the oil, a separator or trap J, Fig. IV, may be inserted between the vessel H and the pump K. This is a common appliance in oil-refineries and needs no description here.

Instead of employing "petroleum-gas oil," as the product above-mentioned is called, aniline or phenol might be used or other appropriate solvent.

Instead of raising the solution of sulphur by means of a pump at the bottom of the well, a pump F*, (see Fig. III,) which discharges the solvent from the heater E into the casing B, may be utilized for that purpose by introducing enough solvent or other fluid to fill the cavity in the mine. By introducing the casing B into the cavity, as shown in dotted lines in this figure, air can be pumped in to fill the space (or part of the space) above the end of the casing, thus confining the solvent to the lower part of the cavity.

Instead of using a solvent non-volatile at the melting-point of sulphur, like petroleum-gas oil, aniline, or phenol, a volatile sulphur solvent, like benzol, (coal-naphtha,) benzine, (petroleum-naphtha,) or bisulphide of carbon, may be used. This would preferably be employed in the cold state, but may be heated. It can be introduced into the mine through the casing B either at the top or bottom of the cavity, and when it has become saturated or charged with sulphur is removed by the pump F' F'' (see Fig. V) and discharged into a suitable steam-heated still M, in which the solvent is evaporated from the sulphur. The temperature at the bottom of the still is preferably sufficient to melt the sulphur, so that it can be drawn off at 15 in a liquid state. The evaporated solvent is recovered in a condenser N and is reused for the liquefying of the sulphur in the mine. As shown, the pump K discharges the condensed solvent into the tank P, from which it flows into the well or mine, and the sulphur solution from the mine is discharged into tank Q, from which it is drawn into still M. The volatile solvent could be made to fill the cavity in the mine; but preferably it would be introduced so as to only partially fill the same, as described, for the non-volatile solvent. It can be forced into and out of said cavity by a pump at the surface of the ground, as exhibited in Fig. III.

It will be understood that the various modes described are all within the invention and are embraced by some one or more of the following claims, special claim being also made to that mode which employs a heated solvent and separates the sulphur by cooling or being so made as to apply to such mode and one or more of the other modes or to their substantial equivalents.

I do not herein claim the apparatus described; but the same forms part of the subject-matter of my application of even date, Serial No. 375,799.

I claim as my invention or discovery—

1. The process of mining sulphur, consisting in introducing a sulphur solvent into the mine or underground deposit and removing the sulphur solution formed thereby, substantially as described.

2. The process of mining sulphur, consisting in sinking a well through overlying strata to and into or through the sulphur or sulphur-bearing deposit to be mined, introducing into the cavity and in contact with the sulphur a

sulphur solvent, and removing the solution of sulphur formed thereby, substantially as described.

3. The process of mining sulphur, consisting in liquefying the sulphur in the mine by means of a solvent and removing the sulphur solution through a pipe or conduit from the cavity of the mine, substantially as described.

4. The process of recovering sulphur from underground deposits and at the same time effecting a refining of the sulphur, consisting in liquefying the sulphur in the mine or underground deposit by bringing in contact therewith a solvent of sulphur, removing the sulphur solution, and separating the solvent and sulphur from each other, substantially as described.

5. The process of mining sulphur, consisting in introducing a sulphur solvent into the mine, removing the sulphur solution, separating the solvent and the sulphur from each other, and returning the solvent into the mine, substantially as described.

6. The process of mining sulphur, consisting in liquefying the sulphur in the mine by a solvent, removing the sulphur solution, and recovering sulphur therefrom by cooling said solution, substantially as described.

7. The process of mining sulphur, consisting in dissolving the sulphur in the mine by means of a heated solvent and removing the sulphur solution, substantially as described.

8. The process of recovering sulphur from underground deposits, consisting in bringing into contact with the sulphur in the mine a hot solvent of sulphur, removing the sulphur solution, and separating the sulphur from the solvent by cooling, substantially as described.

9. The process of mining sulphur, consisting in introducing a heated solvent into the mine and removing the sulphur solution in a continuous manner, substantially as described.

10. The process of mining sulphur, consisting in partially filling the cavity in the mine with a solvent liquid and removing the sulphur solution from the cavity, substantially as described.

11. The process of mining sulphur, consisting in dissolving the sulphur in the mine by means of a heated solvent non-volatile at the melting-point of sulphur and removing the sulphur solution, substantially as described.

12. The process of mining sulphur, consisting in dissolving the sulphur in the mine by petroleum, removing the solution, and separating the sulphur, substantially as described.

13. The process of mining sulphur, consisting in dissolving the sulphur in the mine by hot petroleum, removing the solution, and separating the sulphur by cooling, substantially as described.

14. The process of mining sulphur, consisting in introducing into the mine heavy petroleum, like gas-oil, in a heated state, removing the solution, and separating the sulphur, substantially as described.

15. The improvement in mining sulphur by means of a liquid adapted to liquefy the sulphur, consisting in introducing the said liquid below the level of the liquid in the cavity and withdrawing the liquefied sulphur and vehicle from a lower point, substantially as described.

16. The improvement in mining sulphur by means of a liquid adapted to liquefy sulphur, consisting in introducing the said liquid in a heated state below the level of the liquid in the cavity and withdrawing the liquefied sulphur and vehicle from a lower point, substantially as described.

17. The improvement in mining sulphur by means of a liquid adapted to liquefy the sulphur and introduced into the cavity in the

mine, consisting in introducing a solvent liquid into said cavity below the level of the liquid therein and withdrawing the sulphur solution from a lower point, substantially as described.

18. The improvement in mining sulphur, consisting in introducing a hot solvent liquid into the cavity in the mine below the level of the liquid therein and withdrawing the liquefied sulphur and solvent from a lower point, substantially as described.

In testimony whereof I have signed this specification in the presence of two witnesses.

HERMAN FRASCH.

Attesting witnesses:

G. W. BOUDINOT,

F. W. LOTHMAN.