H. FRASCH.

MINING SULFUR.

APPLICATION FILED FEB. 6, 1905.

1,008,319. Patented Nov. 14, 1911.

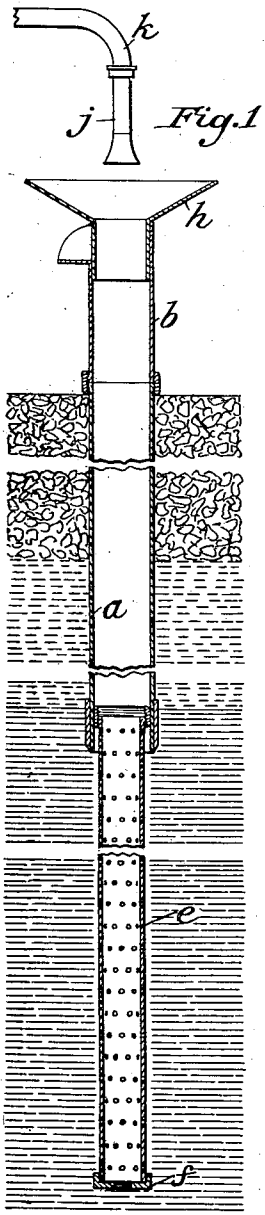

Fig. 1

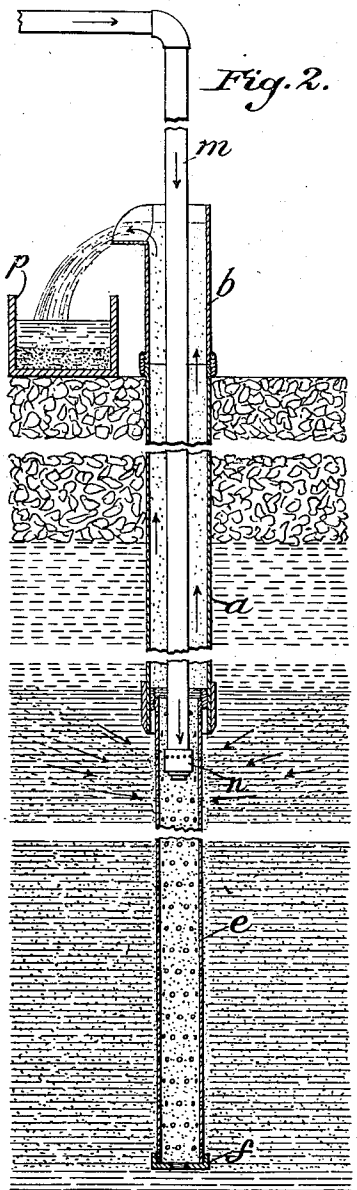

Fig. 2.

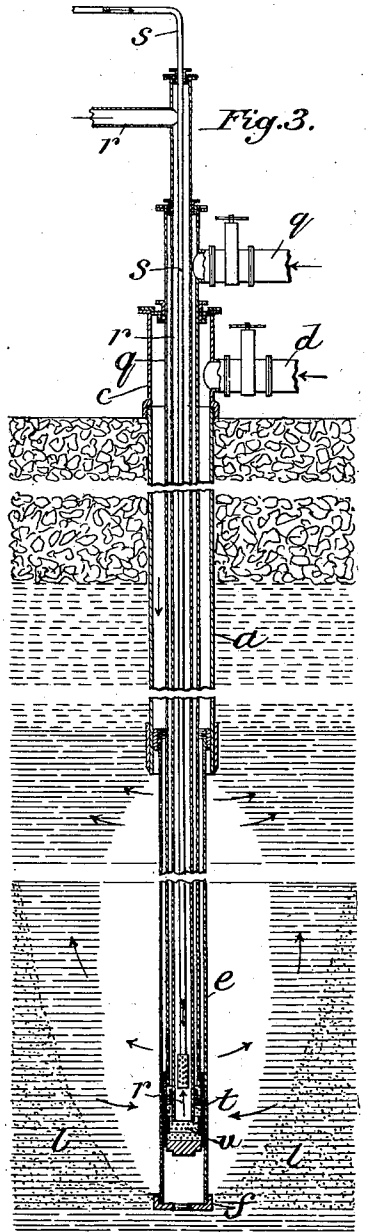

Fig. 3.

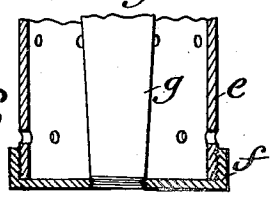

Fig. 4.

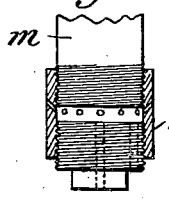

Fig. 5.

Witnesses

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MINING SULFUR.

1,008,319. Specification of Letters Patent. Patented Nov. 14, 1911.

Application filed February 6, 1905. Serial No. 244,509.

To all whom it may concern:

Be it known that I, HERMAN FRASCH, a citizen of the United States, residing at New York city, borough of Manhattan, and county of New York, in the State of New York, have invented new and useful Improvements in Mining Sulfur, of which the following is a specification.

This invention relates more particularly to mining sulfur by fusing the latter in its natural underground deposit and removing it to the surface while it is in the melted condition; but each of the improvements constituting the invention is intended to be secured for all the uses to which the same can be applied, with or without modification.

In my patents of October 20, 1891, Nos. 461,429 and 461,430, in which I have described and claimed, respectively, the process of mining sulfur by fusion and apparatus suitable for the purpose, the mode of effecting the fusion which was set forth consisted in the circulation through the deposit of a fusing fluid, water heated under pressure to above the melting point of sulfur being considered the best. It was returned to the surface of the ground while still above said melting point. In practically applying this process, a deposit of sulfur was encountered in rock which was both porous and flooded with naturally present water; and, while sulfur can be, and was, in fact, obtained by the introduction and return of hot water under pressure, I discovered that more sulfur could be obtained at less expense and that larger amounts thereof could be extracted from a well by dispensing with the return of the fusing fluid (except as some of it might accidentally or incidentally be brought back to the surface of the ground) and causing it to flow away through the porous deposit underground. This discovery forms part of the subject-matter of my applications of May 27, 1897, No. 638,357, and November 23, 1903, No. 182,359, on which patents respectively numbered 799,642 and 800,127 were granted on September 19, 1905. I have further discovered that water which is introduced to effect the fusion of the sulfur is liable to flow away underground without having served its purpose of melting sulfur, or at least of melting it in the vicinity of the well hole, whence the melted sulfur could be removed; and I have further discovered that the yield of sulfur can, in many cases at least, be improved by forming an artificial retaining wall about the lower part of the well hole by means of sand filling the spaces in the rock and so confining the fusing liquid in a species of kettle. The wall of this kettle I have discovered to be capable of shifting under the influence of currents of fusing water, so that the melting need not be confined to the space within said wall at the commencement of the fusing operation. Moreover, I have discovered that the operation of melting the sulfur out of porous rock is liable to detach masses of rock, which in falling will choke the inlet and outlet openings of the mine piping (or of one or more of such openings); and I have further discovered that this condition can be remedied or ameliorated by providing the well hole within the deposit with a perforated lining which will prevent detached masses of rock from reaching the interior mine piping. Such masses may close some of the perforations in the said lining; but these are, or may be, so numerous and so widely distributed that only a general cave in would be apt to close enough of them to shut off the inflow of the sulfur or the outflow of the fusing liquid. Moreover, when the lining is present, a mass of rock detached from the upper part of the deposit is apt to lodge there against the lining; whereas, without such lining it might fall to the bottom of the well hole, where it would be more objectionable. Again, a mass or rock lodging against the lining does not close the well hole; but it would do so to a greater or less extent if lodged against the interior mine piping.

So far reference has been made only to the mining of sulfur by the introduction of fusing fluid which flows away underground; but it is conceived that more or less advantage might be obtained by using some at least of the means herein specified in mining sulfur, especially when found in porous rock, by fusion with return of the fusing fluid or by liquefaction without fusion (see my patent of October 20, 1891, No. 461,431), or even in obtaining other substances from underground deposits, especially in porous rock, by the aid of wells, with or without a preliminary liquefaction of the same in their underground deposits.

So far as I am aware, the sanding of a well and the providing of the same with a

perforated lining of the foregoing description are each of them new broadly, as well as in the relations and combinations herein specified.

The following detailed description, in connection with the accompanying drawings, explains what is considered the best mode of carrying the invention into effect; but it will be understood that additions, omissions and modifications can be made indefinitely, within the limits of the invention, so long as the substance of any one or more of the hereinafter written claims is taken.

In said drawings: Figure 1 is a diagram in vertical section, illustrating means employed to fill a well with sand, the well hole shown having been previously provided with a perforated lining; Fig. 2 is a similar diagram, illustrating the removal of the sand from the well hole and its immediate vicinity; Fig. 3 is a similar diagram of a completed well; Fig. 4 is a detail view, showing means which can be used to aid in lowering the perforated lining into place; and Fig. 5 is a detail view of the lower end of the sand-removing instrument.

The well may be sunk in any suitable way. Ordinarily it would have to be cased in its upper part; and a cased well is shown.

At the upper end of the casing *a*, in Figs. 1 and 2, is a special head *b* having an open top and lateral spout; while in Fig. 3 the regular casing head *c* is shown having a stuffing box at the top and a lateral branch *d*. In all the figures, a perforated lining *e* for the well hole below the casing is shown. This lining can be lowered into place in any suitable way. As shown, it has a cap *f* at the bottom provided with a screw threaded opening in the middle. This cap can be engaged by a lowering rod or pipe *g* whose bottom end is threaded for the purpose. By making these threads opposite to those in the joints of the lowering rod or pipe, the latter can be unscrewed from the cap *f* after this has been lowered to the bottom of the well with the perforated lining *e* without danger of unscrewing said joints. Pipe sections are commonly put together by right hand threads; and left hand threads are, therefore, shown at the bottom of the lowering rod or pipe *g*. After the introduction of the perforated lining (or it might be before), the well is filled with sand. For this purpose the funnel *h* may be applied to the top of the head *b*. It is kept supplied with sand which is washed down into the well by water from the nozzle *j* of hose *k*. The nozzle *j* is shown with a flattened discharge end so as to deliver a wide jet. The water flows away through the rock and carries the sand with it for a certain distance. Gradually the spaces in the rock are filled, and the operation would best be continued until no more sand can be washed down the well. In Fig. 2 the space below the casing *a* is filled with dots to suggest the presence of the sand therein. Having thus filled the well with sand, the latter is next removed from the well hole and its vicinity, leaving the sand at a suitable distance from the well hole and thereby forming an artificial retaining wall *l* (Fig. 3) within which (as in a species of kettle) melting can be carried on.

In Fig. 2 is shown a water pipe *m*, provided at the bottom with a jet producer *n* (Fig. 5) in the form of a ring with a circle of upwardly inclined jet orifices, the bottom of the ring being closed by a plug through which extend two jet orifices (shown in dotted lines). Water being forced under pressure through the pipe *m* issues in the form of jets which stir up and loosen the sand, so that the particles of the latter will be carried up through the casing *a* by the return current of water. Below the spout on the head *b* is shown a trough *p* in which the sand may settle, while the water runs off. As the sand is displaced, the jet producer *n* is lowered, until at length it reaches the bottom of the well. As it is lowered, the jets are projected through the holes in the lining *e* and stir up the sand outside, so that it will be removed for a certain distance from the well hole. Naturally this distance will be greatest at the top and least at the bottom of the deposit, leaving a kettle-shaped space within the retaining wall formed by the unremoved sand; and in my experience there has been so complete a removal at the top as to allow the hot water which is subsequently forced into the deposit in order to melt the sulfur therein to flow away underground. When the sand-removing operation is finished, the pipe *m* and jet producer *n* are withdrawn; the regular casing head *c* is substituted for the special head *b*; and the interior mine piping is introduced.

The interior piping shown is the same which is set forth in my hereinabove mentioned patents of September 19, 1905, Nos. 799,642 and 800,127. So far as the present invention is concerned, the interior piping, when used, may be of any suitable description. That shown consists of an inner hot water pipe *q*, a sulfur-raising pipe *r*, and an air-injecting pipe *s*. The sulfur-raising pipe *r* terminates in a strainer *u*, which is attached to the interior hot water pipe *q*, but which is shut off therefrom by the plug *t*.

Hot water above the melting point of sulfur is forced down the pipes *a* and *q*. Its temperature may advantageously be that of ordinary steam under about ninety pounds of superatmospheric pressure per square inch or, in other words, about 335° F. Such temperature is set forth in my said patents of September 19, 1905, Nos. 799,642 and 800,127. The hot water which

passes down the exterior pipe or casing *a* enters the upper part of the deposit, being distributed over a certain vertical distance by the perforated lining *e*. It melts the sulfur in the upper part of the deposit and flows away underground over the top of the retaining wall *l*. The hot water which passes down the interior pipe *q* escapes near the bottom of the deposit through the openings in the wall of said pipe above the annular plug *t* and also through the openings in the perforated lining. It melts the sulfur within the retaining wall *l* and flows away underground over the top of the same. The melted sulfur collects at the bottom of the deposit and enters the pipe *q* below the annular plug *t;* from which space it is raised through the pipe *r* by the pressure of the water in the deposit, the column of melted sulfur having its gravity reduced sufficiently for the purpose by air injected into the same through the pipe *s*. Should any rock be loosened by the melting out of the sulfur, it falls against the perforated lining *e* and should not materially, if at all, affect the mining operation. The effect of the water entering from the pipes *a* and *q* and flowing away underground is, as I believe, to carry sand with it from the inner side of the retaining wall *l* and to deposit the same at a further distance from the well hole, the space within said wall being thus enlarged gradually as the melting operation progresses.

In the hereinafter written claims, the expression "substance to be mined" means sulfur primarily; and the words "mining" and "well" refer primarily to sulfur as the substance to be mined or the substance into or through a deposit of which the well is to extend; but said expression and words by extension include or refer to a substance in general capable of being mined by the aid of what is set forth in the respective claims wherein said expression and words (one or more of them) occur. The words "liquefaction" and "liquefying" refer primarily to fusion or melting; but by extension they include reduction in general to a liquid state.

I claim as my invention or discovery:

1. The process of mining by liquefaction underground of the substance to be mined, consisting in sinking a well into an underground deposit, forming a retaining wall in the deposit about the well hole by introduction of sand thereinto, liquefying said substance within said wall, and removing it in the liquid state, substantially as described.

2. The process of mining by fusion, consisting in sinking a well into an underground deposit, forming a retaining wall in the deposit about the well hole by introduction of sand thereinto, introducing hot water into the deposit and so melting the substance to be mined in the space inclosed by said wall, causing said water to flow away underground, and removing the melted substance, substantially as described.

3. The improvement in obtaining material from underground, consisting in forming by the introduction of sand through a well hole a retaining wall in the ground at a suitable distance from said well hole to leave between the latter and said retaining wall a space in which fluid can be contained, which space is open on the side of the well hole for passage of fluid between said space and the well, substantially as described.

4. The improvement in mining by liquefaction underground of the material to be mined, consisting in forming an artificial wall of sand in the deposit about the well hole and by such wall retaining liquefying fluid in the vicinity of the well hole, substantially as described.

5. The improvement in obtaining material which is found underground in self supporting rock, consisting in boring a well hole through the self supporting rock in which the material is found, inserting in such rock walled portion of the well hole a stout perforated lining which fills the well bore at least approximately and has a large number of widely distributed perforations and which thus serves to support masses of rock that may subsequently become detached from the originally self supporting well walls without closing communication between the interior and exterior of said lining through said perforations, and effecting the removal of said material by the aid of the so prepared well, substantially as described.

6. The process of obtaining a liquefiable substance which is found in self supporting rock, consisting in boring a well hole through the self supporting rock in which the substance is found, inserting in such rock walled portion of the well hole a stout perforated lining which fills the well bore at least approximately and has a large number of widely distributed perforations and which thus serves to support masses of rock that may subsequently become detached from the originally self supporting well walls without closing communication between the interior and exterior of said lining through said perforations, and effecting the liquefaction and removal in liquid state of the liquefiable substance by the aid of the so prepared well, substantially as described.

7. The process of mining by liquefaction underground of the substance to be mined, consisting in inserting in the deposit a stout perforated lining of approximately at least the diameter of the well bore, introducing liquefying fluid into the interior of said lining, causing it to flow out into the de-

posit through the perforations in said lining, which thus distributes the outflowing fluid over a greater depth of the deposit than it would occupy but for said lining and which also prevents the stoppage of said flow outward by the falling in of masses too great to be carried away by the current of said fluid, and removing the liquefied substance, substantially as described.

8. The improvement in obtaining material which is found underground in self supporting porous rock, consisting in boring through the porous self supporting rock in which said material is found, inserting in such rock walled portion of the well hole a stout perforated lining which fills the well bore at least approximately and which serves to support masses of rock that may subsequently become detached from the originally self sustaining well walls, forming by the introduction of sand through the well hole a retaining wall in the ground at a suitable distance from said well hole to leave between the latter and said retaining wall a space in which fluid can be contained, which space is open on the side of the well hole for passage of fluid between said space and the well, and effecting the removal of said material by the aid of the so prepared well, substantially as described.

9. The process of mining by liquefaction underground of the substance to be mined, consisting in sinking a well into an underground deposit, lowering a perforated lining for the well hole into said deposit, forming a retaining wall in the deposit about the well hole exterior to said lining by introduction of sand into said deposit, liquefying said substance in the space between said wall and said lining so that the liquefied substance flows into the space within said lining, and removing it in the liquid state from this latter space, substantially as described.

10. The process of mining by liquefaction underground of the substance to be mined, consisting in sinking a well into an underground deposit, lowering a perforated lining for the well hole into said deposit, forming a retaining wall in the deposit about the well hole exterior to said lining by introduction of sand into said deposit, inserting interior mine piping within said lining, liquefying said substance in the space between said wall and said lining so that the liquefied substance flows into the space within said lining, and removing it in the liquid state from this latter space through said interior piping, substantially as described.

11. The process of mining by liquefaction underground of the substance to be mined, consisting in sinking a well into an underground deposit, lowering a perforated lining for the well hole into said deposit, forming a retaining wall in the deposit about the well hole by first introducing sand and then washing out a part thereof next the well hole, inserting interior mine piping within said lining, introducing hot water into the deposit and so melting said substance in the space between said wall and said lining so that the melted substance flows into the space within said lining, and removing it in the liquid state from this latter through said interior piping, substantially as described.

12. The process of forming a retaining wall about a well hole by first introducing sand through the well hole and conveying it thence laterally under unremoved overlying strata and subsequently washing out a part of the sand outside of and next to the well hole, leaving the more remote sand to remain as a retaining wall in the well, substantially as described.

13. The method of preparing a well, consisting in forming by the introduction of sand through the well hole a retaining wall in the ground at a suitable distance from the well hole to leave between the latter and said retaining wall a space in which fluid can be contained, which space is open on the side of the well hole for passage of fluid between said space and the well, substantially as described.

14. The method of preparing a well which has been bored through self supporting rock, consisting in inserting in such rock walled portion of the well hole a stout perforated lining which fills the well bore at least approximately and has a large number of widely distributed perforations and which thus serves to support masses of rock that may subsequently become detached from the originally self supporting well walls without closing communication between the interior and exterior of said lining through said perforations, substantially as described.

15. The method of preparing a well which has been bored in porous self supporting rock, consisting in inserting in such rock walled portion of the well hole a stout perforated lining which fills the well bore at least approximately and which serves to support masses of rock that may subsequently become detached from the originally self sustaining well walls, and also forming by the introduction of sand through the well hole a retaining wall in the ground at a suitable distance from the well hole to leave between the latter and said retaining wall a space in which fluid can be contained, which space is open on the side of the well hole for passage of fluid between said space and the well, substantially as described.

16. A well having a retaining wall of artificially introduced sand in the ground under unremoved overlying strata at a distance from the well hole to leave between itself and the latter a space in which fluid can be contained, said space being open on the side of the well hole for passage of fluid

between said space and the well, substantially as described.

17. A well sunk into an underground porous deposit of naturally solid but liquefiable substance and having a retaining wall of artificially introduced sand about the well hole at a distance therefrom to inclose a body of said substance under unremoved overlying strata, substantially as described.

18. A well sunk into rock at its lower part and having at such part walls which are naturally self supporting and also having at such part a stout perforated lining adapted to support the pressure of detached masses of rock, which lining fills the well bore at least approximately and has a large number of widely distributed perforations, substantially as described.

19. A well sunk into rock at its lower part and having walls at such part which are naturally self supporting and also having each of the two features following, namely, first, a stout perforated lining in the lower part of the well adapted to support the pressure of detached masses of rock and filling the well bore at least approximately, and, second, interior piping extending from the surface of the ground down into said lining, substantially as described.

20. A well sunk into porous rock and provided in such rock with a stout perforated lining and also with a retaining wall of artificially introduced sand, said lining filling the well bore at least approximately and being adapted to support the pressure of detached masses of rock, and said retaining wall being located under unremoved overlying strata at a distance from the well hole to leave between itself and the latter a space in which fluid can be contained, and said space being open on the side of the well hole for passage of fluid between said space and the well, substantially as described.

21. A well having a retaining wall of artifically introduced sand in the ground under unremoved overlying strata at a distance from the well hole to leave between itself and the latter a space in which fluid can be contained and also having interior piping which extends from the surface of the ground to below the top of said wall, said space being open on the side of the well hole for passage of fluid between said space and the well, substantially as described.

22. A well sunk into a deposit of naturally solid but liquefiable substance and provided with a stout perforated lining in said deposit of approximately at least the diameter of the well bore and with means for introducing liquefying fluid into the interior of said lining, so that the delivery of said fluid into the deposit is modified by the passage of the fluid through said lining and is by the presence of said lining protected against stoppage by the falling in of solid matter of the deposit, substantially as described.

23. A well sunk into a deposit of naturally solid but liquefiable substance and having a stout perforated lining in said deposit and an overlying fluid conveying portion of the well bore of which said lining forms a continuation and also a pipe connection for introducing liquefying fluid into said overlying portion of the well bore to be thence delivered into the deposit through said lining, so that the delivery of the fluid from said well bore into the deposit is modified by the passage of said fluid through said lining and is by the presence of said lining protected against stoppage by the falling in of solid matter of the deposit, substantially as described.

24. A well sunk into a deposit of naturally solid but liquefiable substance and provided with a stout perforated lining in said deposit of approximately at least the diameter of the well bore and with means for introducing liquefying fluid into the interior of said lining, and also with an interior pipe for raising the liquefied substance, so that the delivery of said fluid into the deposit is modified by the passage of the fluid through said lining and is by the presence of said lining protected against stoppage by the falling in of solid matter of the deposit, while said interior pipe is protected by said lining from injury by such falling matter, substantially as described.

25. A well sunk into a deposit of naturally solid but liquefiable substance and having each of the four features following, namely, a stout perforated lining in said deposit, an overlying fluid conveying portion of the well bore of which said lining forms a continuation, an interior fluid delivery pipe with outlet below a large part of the perforations of said lining, and means for supplying liquefying fluid to the upper part of said lining through the said overlying portion of the well bore and to said interior pipe, substantially as described.

26. A well sunk into a deposit of naturally solid but liquefiable substance and provided with each of the three features following, namely, a stout perforated lining in said deposit of approximately at least the diameter of the well bore, an interior fluid delivery pipe with outlet below a large part of the perforations of said lining, and means for supplying liquefying fluid for delivery into the deposit in part after delivery into said lining above the outlet of said interior pipe and passage through perforations in said lining and in part after conveyance through said interior pipe to a lower level, substantially as described.

27. The process of mining by liquefaction underground of the substance to be mined, consisting in inserting in the deposit a stout

perforated lining of approximately at least the diameter of the well bore and an interior pipe for raising the liquefied substance, introducing liquefying fluid into the interior of said lining, causing it to flow out into the deposit through the perforations in said lining, and raising the liquefied substance through said interior pipe, so that the delivery of said fluid into the deposit is modified by the passage of part at least of the fluid through said lining and is by the presence of said lining protected against stoppage by the falling in of solid matter of the deposit while the raising of the liquefied substance through said interior pipe is also protected by said lining, substantially as described.

28. The process of mining by liquefaction underground of the substance to be mined, consisting in inserting in the deposit a stout perforated lining of approximately at least the diameter of the well bore and an interior fluid delivering pipe with outlet below a large part at least of the perforations of said lining, introducing liquefying fluid into the deposit in part after delivery into said lining above the outlet of said interior pipe and passage through perforations in said lining and in part after conveyance through said interior pipe to a lower level, and removing the liquefied substance, substantially as described.

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Witnesses:
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