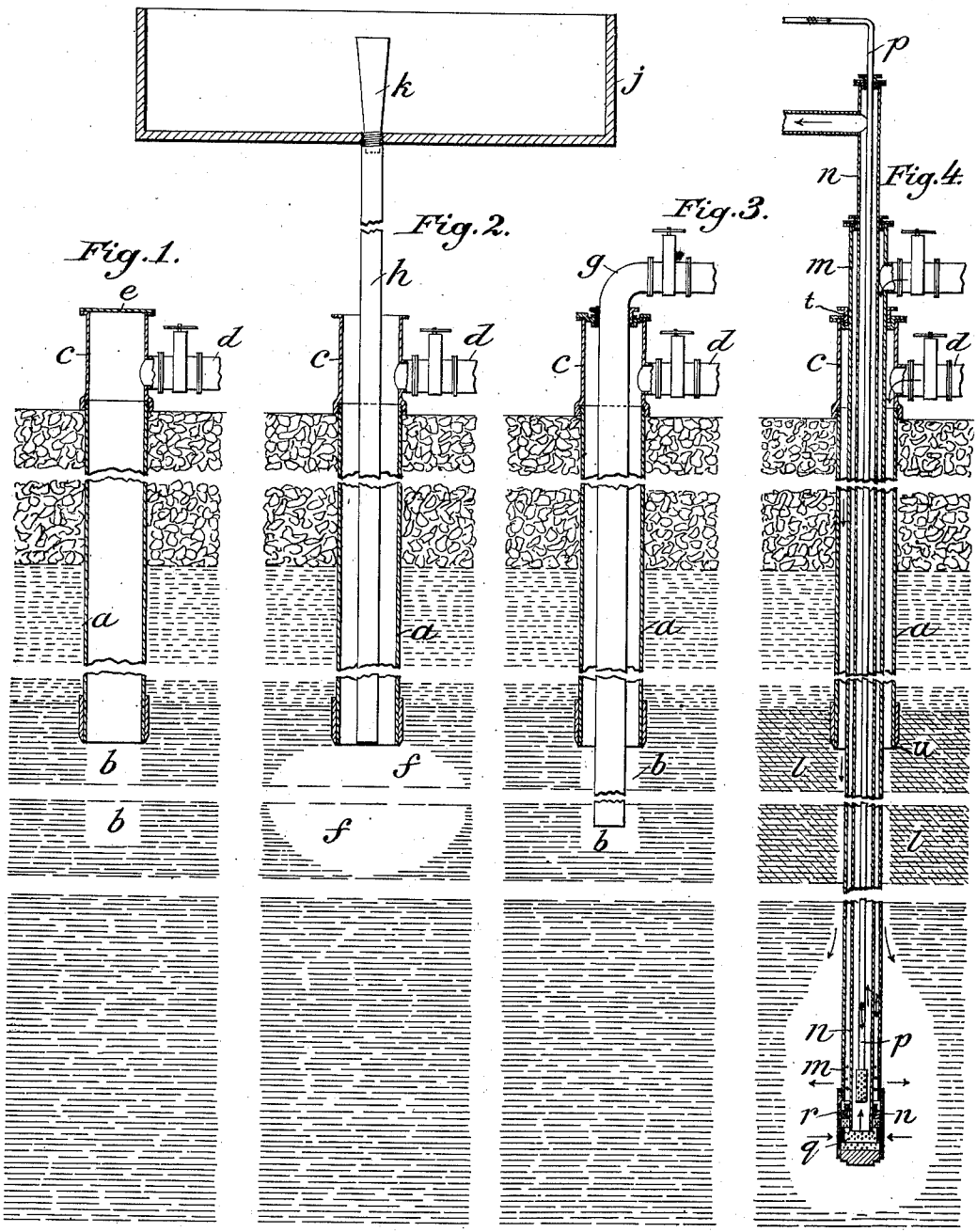
H. FRASCH.

INSTALLING WELLS.

APPLICATION FILED FEB. 6, 1905.

928,036.

Patented July 13, 1909.

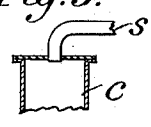


WITNESSES:

F. H. Schott

John T. Burch

Fig. 5.



INVENTOR

Herman Frasch

BY Chas. J. Hedrick

his Attorney

UNITED STATES PATENT OFFICE.

HERMAN FRASCH, OF NEW YORK, N. Y., ASSIGNOR TO THE FRASCH SULPHUR PROCESS COMPANY, A CORPORATION OF MAINE.

INSTALLING WELLS.

No. 928,036. Specification of Letters Patent. Patented July 13, 1909.

Application filed February 6, 1905. Serial No. 244,508.

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 Installing Wells, of which the following is a specification.

This invention relates more particularly to the installation of wells for use in mining sulfur or other proper solid substance by liquefying the same it its natural underground deposit (as by fusion, for example, or by solution) and removing such substance in the liquid state from said deposit; but each of the improvements composing the invention is intended to be secured for all the uses to which it can be applied, with or without modification.

The invention includes new or improved wells and new or improved processes of installing wells.

In making a well for any of the purposes for which bored wells have for the most part at least been employed, including the mining of sulfur and other substances by underground liquefaction, it has heretofore been customary to bore and case the well to a certain depth and to continue the well hole below the casing. In some cases, however, at the depth at which it is most desirable to terminate the casing or beyond which it is not feasible to extend it, the ground by which a casing there terminating must be supported may not be strong enough naturally to resist the weight of the casing, or of the casing and any interior piping or other parts carried by said casing; or if the said ground should be strong enough naturally it may become weakened during the use of the well and thus be so no longer. There is special danger of such subsequent weakening where the casing extends to the vicinity of liquefiable material, with or without actually penetrating the same to a greater or less distance; and this danger is particularly great if the well should be used for mining by liquefaction or if the casing should be used as a fluid-conducting pipe.

In accordance with the present invention, the casing is provided with an artificial foundation, which is formed in place by forcing a more or less fluid or pasty cement (Portland cement is recommended) into space below the said casing for a sufficient distance and in sufficient amount to give the requisite strength, with or without first preliminarily removing from part at least of said space material naturally present therein. Thus if sulfur or other liquefiable material should be present naturally in the space which the foundation ought to occupy, it is advantageous and a special improvement to remove it before forcing in the more or less fluid or pasty cement. And, irrespective of the capacity to be liquefied of material in the vicinity of the bottom of the casing, it may be advantageous to remove it preliminary to the introduction of the cement. Liquefiable material would best be removed by liquefaction or, in other words, by liquefying it in place and withdrawing it (or allowing it to flow away) in the liquid state.

When cement has hardened, it forms, by itself or in connection with material originally present, a mass of underground artificial rock which constitutes a foundation for the casing. The well hole is continued through and to the desired depth beyond this artificial foundation. The artificial rock not only upholds the casing; but it also resists the action of any fluids tending to undermine the same.

The introduction of cement into space at the side of a well to form in place a mass of artificial rock through which the well hole is continued may also be useful otherwise than in the formation of an artificial foundation for a casing; and, indeed, it may be useful without reference to the presence of a casing in the well. When used as a foundation for a casing, the artificial rock, formed in place, has, in fact, two functions, namely (1) that of forming itself a part of the casing, it may be, through ground which is porous or consists in whole or in part of liquefiable material, in addition (2) to that of upholding the said casing; and these functions can be separated; since artificial rock through which a well hole is continued would protect the portion of the well hole in which it should be located against caving in and also against passage laterally of fluid from the well hole into the surrounding ground or from the latter into the well hole, with or without the presence of a casing in the well in such relation thereto as to be upheld thereby or in any other relation.

The invention includes generally the formation in place of artificial rock, with or

without reference to a casing, after preliminary removal by liquefaction or otherwise of naturally present material from part at least of the space to be occupied by said artificial rock; through which latter the well hole is continued.

The well hole of a well for mining sulfur or other liquefiable substance by fusion or other liquefaction would be extended into a natural deposit of the substance to be mined, and also ordinarily at least through the same; and the casing could be adapted to conduct fluid (as liquefying fluid downward or the liquefied substance upward) between the said deposit and the surface of the ground. The casing for such a well (with or without itself serving as a fluid-conducting pipe) would receive whatever interior piping (if any) it might be considered advisable to employ therein. It is also sometimes advantageous, especially if the deposit of liquefiable substance to be mined is porous, to form a body of artificial rock in the upper part of said deposit (through which artificial rock the well hole is continued) in order to prevent the passage of fluid laterally from or into the well hole at such part of the deposit. It is not feasible, at least in the porous sulfur deposit which I have encountered, to extend the casing more than a limited distance into the deposit, owing to the caving in of overlying quicksand when the boring tool penetrates porous ground; and to use casings in series would necessitate narrowing the well hole; but the artificial rock can be bored of the same, or nearly the same, diameter as the portion of the well hole above it.

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 may 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 the drawings: Figures 1 and 2 are diagrams in vertical section, illustrating operations to be performed in the installation of a well; Fig. 3 is a similar diagram, illustrating another mode of performing the operation of Fig. 1; Fig. 4 is a similar diagram of the installed well; and Fig. 5 is a detail view, illustrating an additional means which can be used in effecting the installation.

The well is bored in any suitable way to the depth to which it is to be cased, say into the upper part of a deposit of sulfur to be mined, which deposit is porous and naturally flooded with water. The casing *a* is inserted by driving or in any suitable way. The ground is bored as shown at *b* below the casing for twenty feet, more or less, according to the depth of artificial rock to be formed in place. A head *c* is applied to the casing; which head has a hot water inlet *d* and is otherwise closed. As shown, the inlet *d* is on the side of the casing; and this is closed on top by the plate *e*.

Water heated sufficiently above the melting point of sulfur is sent under appropriate pressure to prevent vaporization and to overbalance the pressure of the water naturally present in the deposit into the casing *a* through the inlet *d* for, say, two or three hours, more or less, at the rate of one hundred to one hundred and fifty gallons a minute more or less, or until it is considered that sulfur will have been melted from sufficient space at the side of the well hole. The melting may also extend more or less below the boring *b;* but in a porous deposit naturally flooded with water, the hot water (being the lighter) tends to flow away laterally or upwardly rather than downwardly. As it thus flows away underground it melts the sulfur with which it comes in contact, until the temperature falls below the melting point. The so melted sulfur descends into the lower parts of the porous deposit and solidifies there. The water sent into the casing *a* may advantageously have the temperature of ordinary steam under about ninety pounds per square inch of superatmospheric pressure, or, in other words, about 335° F. In Fig. 2 the vacant space *f* is intended to suggest the enlargement of the hole *b* by the melting operation. It may be that the sulfur will simply be melted out from the containing rock, leaving the latter in place as a honey-combed mass. If the rock should not be so porous as to allow the fusing water to flow away underground, a pipe *g* (as shown in Fig. 3) may be provided for the return of the water or for its introduction, the pipe or casing *a* and branch *d* serving for the return. The melted sulfur, if it should not sink to lower levels, could be raised to the ground through the pipe *g* after one of the modes for raising sulfur set forth in my patents of October 20, 1891, Nos. 461,429 and 461,430, or it could be otherwise raised. Having thus artificially provided below the casing at the side of the well hole a part at least of the space for the artificial foundation to be formed in place below the casing *a*, a grout, or, in other words, the more or less fluid or pasty mixture of cement and water is introduced into said space. Portland cement is recommended for the mixture with water enough to make it flow.

As shown (Fig. 2), a grout-introducing pipe *h* is inserted through the casing *a*. The grout is placed in the elevated tank *j* from which the pipe *h* extends, while the upper end of the latter is closed by the stopper *k*. The stopper is then removed and the grout

forces itself into the space below the pipe or casing *a* under pressure of the column in the introducing pipe *h*. The quantity of cement to be introduced can be varied, according to the case. Thirty barrels of cement to a well (350 pounds of dry cement to a barrel) have been used satisfactorily. After the grout has disappeared from the tank *j*, water may be introduced to displace any cement in the pipes *h* and *a*. The pipe *h* is then removed; and, after the cement has sufficiently hardened, a hole in continuation of the interior of the casing *a* and somewhat smaller in internal diameter to allow the boring tool to pass freely through the casing *a* is bored through the artificial rock *l* (Fig. 4) and so continued through the sulfur-bearing deposit. The hardened cement (or the hardened cement in connection with naturally present rock) forms an artificial foundation *l* for the casing *a*. It also forms itself a sort of casing below the casing in the upper part of the sulfur deposit.

At the lower end of the casing *a* there is a ledge (due to the internal diameter of the hole below the casing being smaller than the internal diameter of the hole which receives the casing); and on this ledge *u* the casing *a* rests; since its external diameter is greater than the internal diameter of the well hole below the same. The grout, moreover, will pass up around the lower edge of the casing, should there be spaces there to receive it, as there may well be; so that the artificial rock *l* (in such cases at least) will closely surround the casing *a* for some distance above its lower edge as indicated by the oblique lines, as well as furnish a supporting ledge below the same.

When the well hole is ready, whatever interior piping may be used is inserted. The interior piping shown consists of an inner hot water pipe *m*, a sulfur-raising pipe *n*, and an air-injecting pipe *p*. The sulfur-raising pipe *n* terminates in a strainer *q* which is attached to the interior hot water pipe *m*, but which is shut off therefrom by the plug *r*. The casing *a* is intended to be used concurrently with the pipe *m* to convey hot water, as a fusing fluid, into the deposit; and it is shown, therefore, as retaining the casing head *c* of Fig. 1, with its hot water inlet *d*. In Fig. 4 the top plate of the casing head *c* has a hole in the middle to allow the interior piping to pass through it; and a stuffing box *t* is provided around the pipe *m*, which may be supported in any suitable way.

The hot water from interior pipe *m* and casing *a* (advantageously of the temperature mentioned above) flowing away underground melts the sulfur which collects about the lower end of the pipe *n* and is raised to the surface of the ground by the pressure in the deposit, aided by the effect of the air, which is introduced through pipe *p* into the lower part of the column of melted sulfur in said pipe *n*, in lessening the average density of said column.

The interior piping of Fig. 4 is the same which is set forth in my application of May 27, 1897, No. 636,357 as suitable for use in carrying out processes therein claimed and which is set forth and claimed in my application of November 23, 1903, No. 182,359, the latter being a division and continuation of the former and being made solely in consequence of official requirement. Patents Nos. 799,642 and 800,127 were granted September 19, 1905, on my said applications of May 27, 1897, and its said division of November 23, 1903, respectively. So far as the present invention is concerned, the interior piping, when used, may be of any suitable description. The temperature mentioned above for the hot water for fusing is the same which is set forth in my said applications; and its use embodies a part of what is claimed in my said application of May 27, 1897.

Apart from certain additional improvements which are herein first disclosed by me and which each include as an element the removal of naturally present material from a part at least of the space to be occupied by the artificial rock, the present specification covers only matter which was previously embraced in each of my said applications and which the Patent Office required to be divided from other matters also embraced therein. The present application is a continuation of my said application of May 27, 1897, so far as it covers subject-matter disclosed in the original specification of the latter. The same matter is disclosed in the specification of each of the herein above mentioned Patents 799,642 and 800,127.

If the ground below the casing *a* is adapted naturally to receive a proper body of cement and to constitute therewith a proper foundation, the preliminary removal of the sulfur by melting can be omitted. In such case, after the sinking of the pipe or casing *a* and the boring of the hole *b*, the mixture of cement and water would be at once introduced. After it should harden, the hole would be bored through the artificial rock (*l*, Fig. 4) and then continued through the sulfur-bearing deposit. In any case, pressure may be applied to the cement mixture by compressed air or other medium. It can, for example, be applied to the extent of, say, three hundred pounds, more or less, to the square inch, or as may be thought best. In Fig. 5 the casing head *c* is shown provided with a pipe *s* for introducing compressed air.

The well of the hereinafter written claims is more particularly a well for mining sulfur or other solid substance by underground

liquefaction by fusion or otherwise by means of a fluid sent into a natural deposit of the substance being mined; but it may be any well having the expressed features of the respective claims, except in claims 6, 7, 13 and 14, which are each limited to a well for mining sulfur or other solid substance by underground liquefaction by fusion or otherwise and in which the fluid-conducting mine piping may be either the casing or interior piping or both casing and interior piping.

I claim as my invention or discovery:

1. A well having a casing sunk into the ground and a foundation of artificial rock formed in place, through which foundation the well hole is continued and by means of which the casing is upheld, substantially as described.

2. A well having a casing sunk into the ground and a foundation of artificial rock formed in place, which foundation in part at least occupies space from which naturally present material has been removed and through which foundation the well hole is continued, the casing being upheld by means theerof, substantially as described.

3. A well having a casing sunk into the ground to the vicinity of naturally present liquefiable material and a foundation of artificial rock formed in place, which foundation in part at least occupies space from which such liquefiable material has been removed and through which foundation the well hole is continued, the casing being upheld by means thereof, substantially as described.

4. A well having a well hole descending to a certain depth in the ground and at lower depth a body of artificial rock formed in place distinct from the overlying well hole walls, said artificial rock in part at least occupying space which has been enlarged by removal of naturally present material beyond the area of well boring and also beyond the area of incidental caving, and the well hole being continued through the said artificial rock, substantially as described.

5. A well having a well hole which extends to the vicinity of naturally present liquefiable material and a body of artificial rock formed in place and in part at least occupying space which lies beyond any area of caving incidental to the boring operation and from which such liquefiable material has been removed, the well hole being continued through such artificial rock, substantially as described.

6. A well for mining by liquefaction, extending into a natural deposit of the liquefiable substance to be mined, and having a casing sunk into the ground and a foundation of artificial rock formed in place, through which foundation the well hole is continued and by means of which the casing is upheld, substantially as described.

7. A well for mining by liquefaction, extending into a natural deposit of the liquefiable substance to be mined, and having a casing sunk into the ground, and below said casing a body of artificial rock formed in place and located in the upper part of said deposit, through which artificial rock the well hole is continued, substantially as described.

8. The process of installing a well, consisting in boring and casing the same to a suitable depth, introducing cement below said casing so as to form an artificial foundation therefor, and continuing the well hole through such artificial foundation, substantially as described.

9. The process of installing a well, consisting in boring and casing the same to a suitable depth, removing naturally present material from space at the side of the well hole below said casing, introducing cement below said casing, and in part at least into space from which naturally present material has been removed so as to form an artificial foundation for said casing, and continuing the well hole through such artificial foundation, substantially as described.

10. The process of installing a well, consisting in boring and casing the same to the vicinity of naturally present liquefiable material, removing such material by liquefaction from space at the side of the well hole below said casing, introducing cement below said casing, and in part at least into space from which such liquefiable material has been removed by said liquefaction so as to form an artificial foundation for said casing, and continuing the well hole through such artificial foundation, substantially as described.

11. The process of installing a well, consisting in boring the same to a suitable depth, removing naturally present material from space at the side of the well hole in addition to such material as may be displaced incidentally to the boring operation, introducing cement into said space and in part at least into that space from which such additional material has been removed, and continuing the well hole through the artificial rock formed in place by said cement, substantially as described.

12. The process of installing a well, consisting in boring the same to the vicinity of naturally present liquefiable material, removing such material by liquefaction from space at the side of the well hole in addition to such material as may be displaced incidentally to the boring operation, introducing cement into said space and in part at least into the space from which such additional material has been removed, and continuing

the well hole through the artificial rock formed in place by said cement, substantially as described.

13. The process of installing a well for mining by liquefaction, consisting in boring and casing the same to a suitable depth, introducing cement below said casing so as to form an artificial foundation therefor, and continuing the well hole through said foundation into a natural deposit of the liquefiable substance to be mined, substantially as described.

14. The process of installing a well for mining by liquefaction, consisting in boring and casing the same to a suitable depth, continuing the well hole below said casing into the upper part of a natural deposit of the liquefiable substance to be mined, introducing cement into the space at the side of the well hole in the upper part of said deposit, and continuing the well hole farther into said deposit through the artificial rock formed in place by said cement, substantially as described.

15. A well composed of a casing sunk into the ground, and an underlying artificial foundation with a ledge therein below the casing and also with a well hole through said foundation in continuation of the interior of the casing, which well hole is of less diameter than the exterior of the casing, substantially as described.

16. The process of installing a well, consisting in boring and casing the same to a suitable depth, introducing cement below said casing so as to form an artificial foundation therefor, and continuing the well hole through said foundation with an internal diameter less than the external diameter of the casing so as to leave a ledge below the latter for it to rest on, substantially as described.

17. The process of installing a well, consisting in boring and casing the same to the vicinity of naturally present fusible material, melting said material in place and so removing it from space at the side of the well hole below the casing, introducing cement into said space below said casing and in part at least into that space from which material has been so melted out, thereby forming an artificial foundation for said casing, and continuing the well hole through such artificial foundation, substantially as described.

18. The process of installing a well, consisting in boring the same to the vicinity of naturally present fusible material, melting said material in place and so removing it from space at the side of the well hole, introducing cement into said space and in part at least into that space from which material has been so melted out, and continuing the well hole through the artificial rock formed in place by said cement, substantially as described.

HERMAN FRASCH.

Witnesses:
J. C. UPDEGROVE,
W. W. WILKINSON.