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METHOD OF MAKING BORE HOLES

Filed Dec. 19, 1931

FIG:1

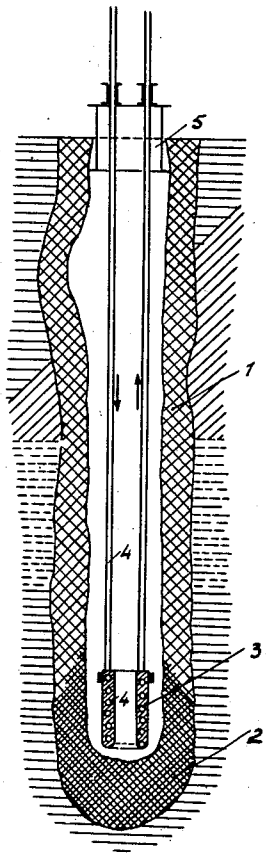


FIG:4

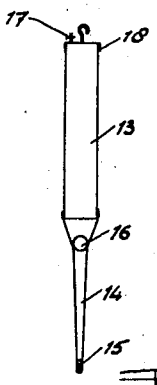


FIG:3

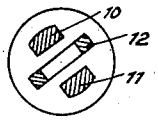
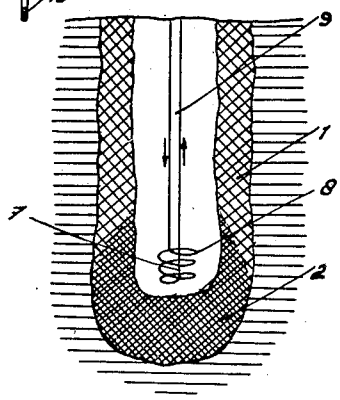


FIG:2



Inventors:

Christianus Josephus Godefridus Aarts

and Johannes Anthonius Alphonsus Mekel

By Lucien Bonnefoy

Attorney.

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UNITED STATES PATENT OFFICE

CHRISTIANUS JOSEPHUS GODEFRIDUS AARTS, OF VOORBURG, AND JOHANNES ANTONIUS ALPHONSUS MEKEL, OF DELFT, NETHERLANDS; SAID AARTS ASSIGNOR TO WALTER FRANCISCUS CORNELIS BAARS, OF ROTTERDAM, NETHERLANDS

METHOD OF MAKING BORE HOLES

Application filed December 19, 1931, Serial No. 582,144, and in the Netherlands February 2, 1931.

The invention relates to a method of making bore holes.

An object of the present invention is to provide methods of thermally boring into the earth and apparatus suitable for use in carrying the method into effect.

The present invention is based on an entirely new principle, i. e., the action of causing the ground, in which the bore hole is to be made, to melt or at least to become plastic. This molten or plastic material is then removed in this condition from the bore hole.

The molten material resulting from the boring operation most frequently possesses a density far greater than that of the rock constituting the ground, this latter being, in the majority of cases, very porous, a fact which applies particularly to most sedimentary strata. When the rock near the bottom of the bore hole is caused to melt and is simultaneously subjected to pressure (which must be superior to the pressure in the strata surrounding the bore hole) there will be formed, at the moment of the contraction caused by fusion, a certain space which constitutes the bore hole, whilst the molten material is compressed at the bottom and ejected laterally being eventually forced into the cracks and holes present in the surrounding rock.

In this way a ring of molten gangue is formed this ring being forced against the rock in its original state by the pressure prevailing in the hole. If there is no material removed upwards out of the bore hole, the difference in volume between the molten and the non-molten rock is the sole cause of the formation of the hole. If the rock, owing to the action of the internal source of heat at the bottom of the bore hole, acquires a certain viscosity, this is ordinarily sufficient for attaining the required result.

The internal source of heat at the bottom of the hole may be obtained in different ways. An electric arc may, for example, be struck between an electrode suspended in the base of the hole and the bottom of the latter. The rock at the bottom of the hole melts or becomes viscous, and owing to the high pressure prevailing in the hole as well as the contraction produced at the moment of fusion, the viscous mass is forced against the rock. The rate of formation of the hole depends, therefore, on the rate at which the heat penetrates into the rock. This latter rate is promoted by the ohmic resistance offered to the current by the incompletely molten or non-molten rock situated a short distance below the bore hole.

In those cases in which this ohmic resistance is too great for a specific rock and would consequently necessitate the application of excessively high voltages, the electric arc can be struck at the bottom of the hole between two electrodes and, if necessary, be blown towards the bottom of the hole by the action of a magnetic field, or may strike from both electrodes to a molten slag at the bottom of the hole.

The heating can also be effected by an electric resistance such as a tungsten filament.

In all these cases the lateral ejection of the molten or plastic mass can be further facilitated by directing a vigorous current of gas on to the middle of the bottom of the bore hole, the molten material being thereby laterally ejected.

It is also possible to produce the source of heat at the base of the bore hole by directing, for example, a gas flame on to the bottom of the hole. The admission of the gas and the air or oxygen must in this case be effected under a pressure greater than the normal working pressure prevailing in the hole. According to the two last indicated methods, the rate at which the hole is formed is determined by the rate at which the heat penetrates by conduction, into the rock. When employing the first method, this conduction of heat is further promoted by the ohmic resistance offered to the current by the rock.

In cases where the rock surrounding the hole does not possess sufficient conductivity this can nevertheless be overcome by exciting a high frequency alternating electromagnetic field in the bottom of the hole, for example with the aid of a high frequency alternating current. The molten rock at the bottom of the hole is first strongly heated and thereby becomes the seat of closed Fou-

cault currents, so that the same effect is obtained in a still better fashion. If in this latter case it is necessary to commence working in a cold hole (and therefore with insufficient electrical conductivity in the rock) a metallic conducting cushion is first formed in the bottom of the hole by causing pieces of metal to fuse together, for example pieces of iron, which can be introduced into the hole from above.

It is necessary to cool the coil which conducts the high frequency alternating current, which cooling may be effected by employing tubular conductors for the current and circulating cooling water therethrough.

It is obvious that all substances capable of favourably influencing the fusion and formation of the bore hole can in general be introduced into the bore hole from above, in which case these substances can be selected in accordance with the composition of the rock to be bored, so that chemical influences can contribute at the same time as the thermal influences to the formation of the bore hole.

In general any means of heating capable of co-operating in the formation of the bore hole, according to the invention, may be employed.

The molten rock itself constitutes the material for the formation of the walls of the bore hole.

The pressure prevailing in the inside of the bore hole is always maintained higher than the hydrostatic pressure exerted in the rock on the exterior of the bore hole. This pressure can be regulated from above by the introduction or by the escape of the gas under pressure. In those cases where these gases or vapours are produced in the hole itself, they may be allowed to escape through a valve. The formation of the hole can always be effected under a pressure higher than the highest pressure to which the hole would be exposed during its subsequent use.

Most rocks which have to be drilled are, in practice, sufficiently porous in themselves in order to render possible the formation of the hole, according to the process hereinbefore described. If it is necessary to drill a rock which is non-porous or insufficiently porous, or if it is desired to drill more quickly, the whole or a part of the molten material will have to be removed from above. When drilling a non-porous rock it is not necessary to exert a pressure in the hole, because in such a case it is impossible to eject the molten matter laterally into the surrounding rock and on the other hand the hole in such a rock possesses sufficient resistance.

The method to be adopted in this case for removing the molten rock from the hole depends on the nature of the rock. A portion will evaporate and escape from the top of the hole in the form of vapour or will become deposited during its passage upwards in the form of an easily removable powder on the walls of the hole. This evaporation may be promoted by introducing a current of gas or air from above in the hole, as a result of which a large quantity will be vaporized and swept away. This current of gas directed towards the bottom of the hole can also be reinforced in such a way that mechanical pulverization is effected as well as evaporation, it being possible sometimes to facilitate the former, particularly by sudden cooling of the molten rock which causes the latter to chip, by the introduction, from time to time, of a little water together with the gas.

The molten rock may also be removed by mechanical means, for example by lowering into the bore hole an evacuated iron tube. This tube is of a cone-like shape and has a special conical base in which an iron ball is disposed, which, after the filling of the tube, can function as a stop valve during its ascent. At the bottom of this conical iron receptacle a suction pipe is disposed, the base of which is closed, for example, by a plug of lead. (In place of lead any other sufficiently fusible material may also be used). On plunging the base of this suction pipe into the molten rock at the bottom of the hole, the lead plug will melt and in consequence of the tube being evacuated the molten rock will be drawn up. When the tube is raised the iron ball will function if necessary as a stop-valve.

This or an analogous procedure can be adopted when it is necessary to drill a non-porous rock.

The method of the invention is especially adapted to borings in the petroleum industry. The geological construction of the terrain to be bored is already known. During the boring the presence of oil or water strata can both be ascertained by slowly diminishing the pressure prevailing in the hole. The presence of oil or water will consequently cause the lower molten part of the hole to bend back inwards and the vapours and gases which escape in the hole can be controlled from above. After having examined the material brought to light, the pressure is again raised so that the liquid which may have entered the hole is ejected, after which the process of fusion can be continued.

In this way it will thus be possible to bore consecutively through different oil strata. After the bore hole has been completed, it will be possible to exploit at will all the strata at the same time or consecutively by perforating the side wall of the bore hole at the level of said strata by mechanical means according to one of the known processes, if necessary by utilizing explosives.

The method is applicable not only to borings in petroleum areas but also for all other borings, for example in areas containing salt, minerals, oils, water, etc.

The diameter of the bore hole depends on

the form of the electrode or coil used for the high frequency alternating current or other heating means and on the admission of heat, also on the porosity of the rock and whether there is more or less material removed upwards out of the hole. The descent of an electrode can be regulated and controlled from above. For example, the increase in the distance between the electrode and the bottom of the hole, if the heating is accomplished by an arc struck between an electrode and the bottom of the hole, is accompanied, with the same voltage, by a diminution of the intensity of the current.

In cases where the arc is broken at the bottom of the hole, or if the operation has to be restarted after an interruption, in a fairly cold hole, the arc can easily be restored, for example by letting a drop of mercury fall into the hole. Since the sides of the molten rock themselves function as the sides of the hole and since in consequence, iron piping will not be required, a direct current can be used equally as well as an alternating current.

It is evident that it is in general simpler to use an alternating current, and, having regard to the above consideration, this kind of current will ordinarily be used. In certain cases a direct current may be advantageous; and electrolytic phenomena may then be produced which can be utilized for the elimination of the material of the hole (for example in the form of vapour) in cases where it is necessary to drill, for example, a non-porous rock. In addition, it is evident that the atmosphere in the hole may, as desired, be rendered oxidizing or reducing.

It follows from the description hereinbefore given that the course of the boring can be exactly followed from above by manometer and ammeter readings.

Some advantages of the new method of boring are as follows:—

The bore hole is directed perpendicularly downwards.

The diameter of the bore hole is approximately the same the whole of its length; it is possible, for example, to construct a bore hole having a diameter of 20 to 30 centimetres and extending to an almost unlimited depth.

A very much greater depth can be obtained than by applying the hitherto known methods. Owing to this it is possible to exploit supposed oil strata at great depth and hitherto inaccessible. There is no danger, when applying the process in areas insufficiently known from a geological point of view, of inadvertently drilling through a stratum of oily sand without noticing it, such as has been the case hitherto, or of blocking an oil stratum on applying the usual rinsing with the aid of liquids and losing the latter from the operation. For a specific source the quantity of oil raised may be much increased owing to the circumstance that a considerable diameter can be realized even at a great depth.

If necessary, the hole can be enlarged at the bottom by maintaining the heating means for a long time at the lowest level. An enlarged chamber is then formed at the bottom of the hole, into which, after the walls have ruptured, the oil can easily flow.

Not only is a better hole bored more rapidly and, if desired, to a greater depth and of greater diameter, but it is also much more economic, owing to the fact that iron pipes are not required and that a considerably greater average speed of drilling is attained with the use of less personnel. In fact the construction of pipes, cementing and "fishing jobs" can be dispensed with.

There are no losses of oil or gas and there is also no longer any danger of fire when boring spouting sources since the bore hole is sealed to high pressure.

The invention will be explained with the aid of the accompanying diagrammatic drawing:

Figure 1 represents a method of operating where an electric arc is produced between a lowered electrode and the bottom of the bore hole.

Figure 2 represents the bottom of a bore hole with a coil lowered inside, this coil being activated by a high frequency alternating current.

Figure 3 shows a section of a bore hole where two electrodes are employed for the formation of the arc.

Figure 4 represents an apparatus for raising the liquid material from a bore hole.

In Figures 1 and 2, the solidified wall of the hole is represented by 1, and 2 represents the liquid or plastic material surrounding the front of the hole.

In Figure 1, 3 represents an electrode, which may be in the form of a hollow cylinder, and is cooled internally by the tubes 4. The electrode is suspended by tubes 4 through which a liquid circulates in the direction of the arrows. These tubes also convey the electric current. Between the electrode 3 and the rock 2 an electric arc is struck which causes the rock to melt or at least renders it plastic. The high pressure prevailing in the bore hole now forces the rock, which has become plastic, laterally outwards and downwards, this being rendered possible by the contraction of the rock during fusion. The hole is stopped by the plug 5, which hermetically seals the bore hole, even when very high pressures are used. The tubes 4 pass through this plug. The different strata are represented in the drawing by varied shading.

In Figure 2, 7 represents a coil with turns 8. A high frequency alternating current, conveyed by the cable 9, is passed through

these turns. The change of magnetic field generates Foucault currents in the rock 2, which produce great heat which melts the rock. In order to start the process small pieces of iron may be allowed to fall to the bottom of the hole. Once slag is formed, the feed of iron can be dispensed with.

In Figure 3, 10 and 11 represent the electrodes between which an electric arc is struck. 12 is a magnet giving rise to a magnetic field, which causes the electric arc to deviate downwards so that the bottom of the bore hole is strongly heated.

Figure 4 represents an iron tube 13 provided with a tip 14 closed by a plug 15 of readily fusible metal, and carrying at its upper end a ball 16. The apparatus also carries a stop cock 17, by means of which it can be evacuated, the apparatus being lowered into the bore hole after being evacuated. The tip 14 is then plunged into the molten rock, the plug 5 melts, the liquid mass mounts into the empty tube and fills the same. On raising the tube 13 filled in the manner described, the ball 16 prevents the material present above the ball from escaping.

In order to empty the molten mass from the tube 13, the lid 18 of the tube is unscrewed.

What we claim is:—

1. A method of making vertical bore holes of considerable depth in the ground, comprising converting the material, in which the boring takes place, into a non-solid condition by heating under a pressure superior to the pressure in the strata surrounding the bore hole.

2. A method of making vertical bore holes of considerable depth in the ground, comprising converting the material, in which the boring takes place, into a non-solid condition by heating and maintaining the material under a pressure sufficient to force it simultaneously downwards and sidewards into porous strata surrounding the bore hole.

3. A method of making vertical bore holes of considerable depth in the ground, comprising converting the material, in which the boring takes place, into a plastic or molten condition by heating under a pressure superior to the pressure in the strata surrounding the bore hole and at least partly removing the plastic or molten material upwards out of the bore hole.

4. A method according to claim 1, wherein the heating is effected with the aid of an electric arc between an electrode lowered into the hole and the bottom of the hole.

5. A method as claimed in claim 1, wherein the heating is effected with the aid of an electric arc between two electrodes lowered into the bore hole, a magnetic field being applied between these electrodes to force the electric arc downwards.

6. A method as claimed in claim 1, wherein the heating is effected by means of an electric resistance, such as a tungsten filament.

In testimony whereof, we affix our signatures.

CHRISTIANUS JOSEPHUS GODEFRIDUS AARTS.
JOHANNES ANTONIUS ALPHONSUS MEKEL.