F. SQUIRES.

METHOD OF LOCATING NATURAL GAS.

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Fig. 1.

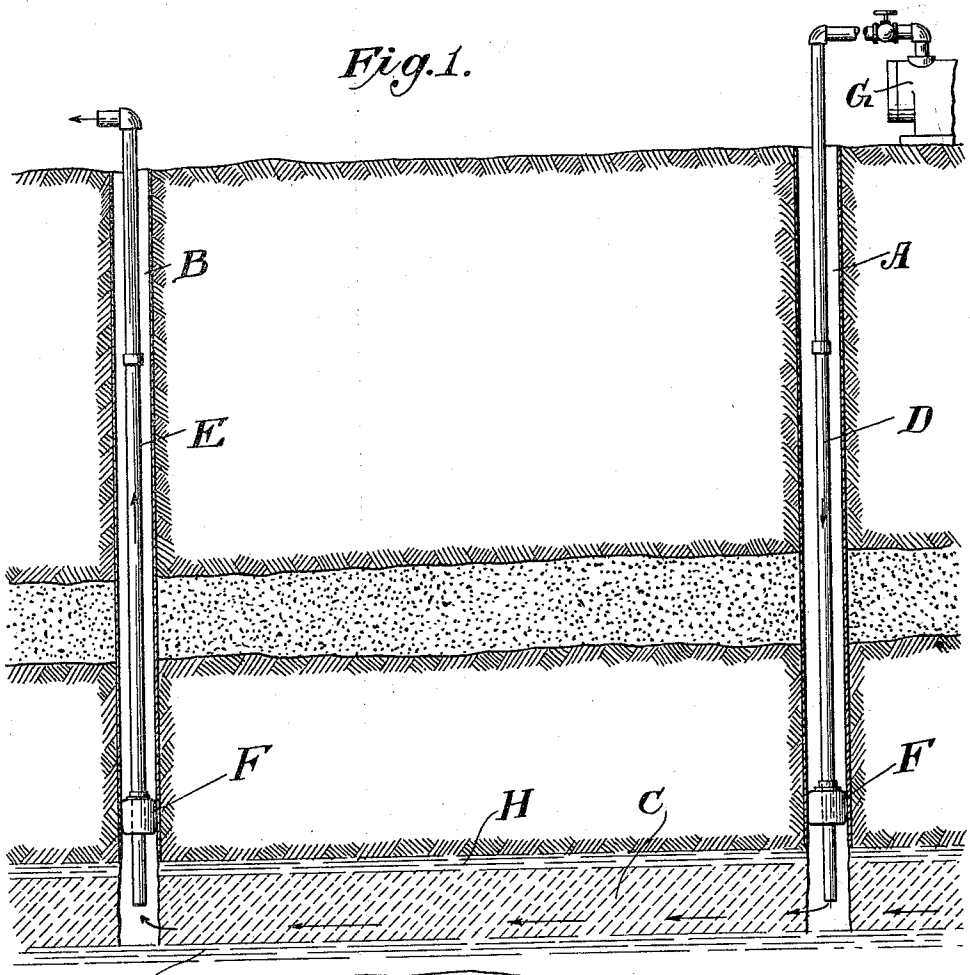
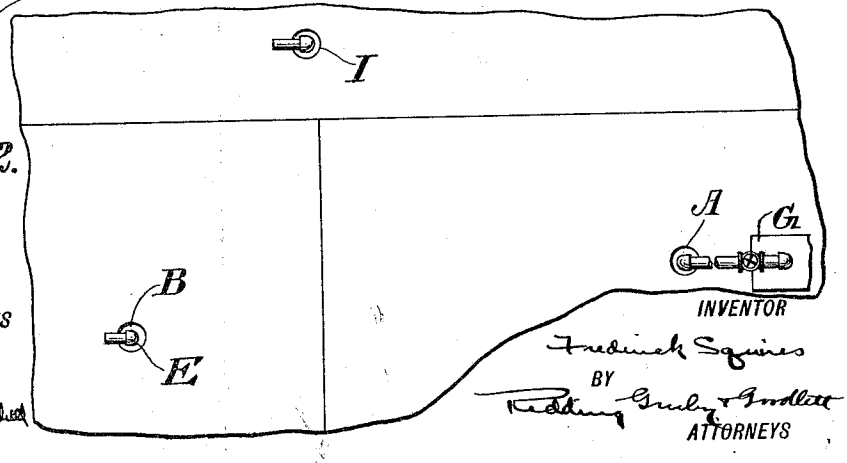


Fig. 2.



WITNESSES

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UNITED STATES PATENT OFFICE.

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METHOD OF LOCATING NATURAL GAS.

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To all whom it may concern:

Be it known that I, FREDERICK SQUIRES, a citizen of the United States, residing at McConnelsville, in the State of Ohio, have invented certain new and useful Improvements in Methods of Locating Natural Gas, of which the following is a specification, reference being had to the accompanying drawings, forming a part hereof.

This invention seeks to cover broadly a method whereby natural gas may be recovered at much less expense than heretofore, and may be divided roughly into two interrelated steps, the first of which is concerned with the locating of gas bearing strata and the second of which is concerned with the recovery of the gas from such strata. In this specification, for the sake of clearness, it has been elected to describe these two steps separately so that a full understanding of the practice of the improved method in connection with each may be had, although it will appear that these two steps are so interrelated and the means for and manner of carrying each into effect are so similar, that they constitute, for the operator in the gas fields, a single method.

In the development of gas properties the operator is, of course, first concerned with the securing of land which he can satisfy himself with reasonable certainty, will give forth natural gas on a paying basis. Accordingly the first step in the improved method seeks to teach the engineer how he can determine with reasonable certainty, the area of a gas bearing stratum, the approximate outline of such area, and the general direction of flow of the gas therein whereby predictions as to the character of adjoining property can be made. Heretofore, it has been the practice for an operator to lease a tract of land and try it out for gas bearing strata by sinking a great number of wells, each well being drilled without regard to the location of every other well except in the matter of distance. The expense and inefficiency of this makeshift method is fully appreciated by those skilled in the art and yet no practicable way of determining the required information through the sinking of only a few wells, has been available. Again, an owner or lessee of oil or gas property usually carries on "spotted" drillings in which the locations are remote from the boundary of the tract, so that the owners of the adjoining tracts will receive no indication of pay areas on their properties as the result of operations of their neighbor. Obviously, if oil or gas was gotten from a well sunk near a boundary, the adjacent property holder would know immediately that his land also probably contained a pay area. By the present method, all such undeserved advantages are eliminated and it is made possible for an operator to locate pay areas through wide tracts. For instance, an operator can secure leases of many contiguous tracts of land and sink perhaps a single well near the center of each tract and determine between which wells oil or gas bearing strata lie, the approximate areas of such strata and the general directions in which they extend so that profitable locations for other drillings can be predicted.

The step of the improved method which is now under consideration can be employed to equal advantage in connection with either oil properties or gas properties although, inasmuch as the method generally is concerned with the recovery of natural gas, the description will be given in connection with gas properties. In accordance with this step of the method, two or more wells are sunk at relatively remote points with respect to each other, the distance between the wells being far greater than that commonly employed in what are termed "locations" where the wells are about two hundred feet apart. It has been found, in actual practice, that the locations of the wells which must be sunk for use in practising the present invention can range from 900 to 2,000 feet distant one from another, thereby effecting a saving which may be represented by the ratio of 2,000 to 200, in the number of wells, that is, about ten wells in the preliminary stages of development.

After the two or more wells have been sunk, fluids, having distinctive physical or chemical properties, are introduced into one or more wells, usually under pressure, and observations made at one or more of the other wells, to detect the presence of such fluids. Air will serve the purpose. In this method, it should be noted, advantage is taken of the geological fact that oil and gas bearing strata are porous in their nature, oil usually being found in sand and gas being found in coal or the like, and of the further fact that the porous stratum is completely

inclosed by a nonporous stratum of deposits, such as slate, etc. When the fluid referred to is introduced through one well into the porous oil or gas bearing stratum, its escape from such stratum can only be effected through one of the other wells, it being entrapped and directed in its travel by the nonporous walls of slate or the like. If the tests referred to, indicate the presence of the testing fluid at one or more of those wells which are remote from the well through which the fluid is introduced, it is a reasonable deduction that the fluid has traversed a porous oil or gas bearing stratum (depending upon whether the well sunk terminated in an oil or gas bearing stratum), and that the stratum thus traversed lies between the point of introduction of the gas and the point of its escape. If the testing fluid cannot be detected at any well, then it is equally certain that it has been interrupted in its flow between the point of introduction and such well by reason of the discontinuance of the porous stratum. The results obtained in the manner briefly pointed out will indicate at once just where other wells are to be located to yield gas or oil on a paying basis.

As will appear hereinafter the invention is not to be limited to the character of the testing fluid or to the character of the tests for determining the continuity of the porous stratum.

Another feature of the first step of the improved method which can be practised conveniently during the carrying on of the test referred to, is the determining of the general direction in which the located strata extend, with respect to the drilled wells. In making this determination the pressure of the testing fluid at two or more of the wells is taken and these pressures will show whether the fluid tends to seek any particular well by reason of a ready passage afforded by an extensive porous stratum lying beyond it (as will be the case where the pressure is relatively great), or whether the testing fluid reaches the well at a relatively low pressure, thus indicating that the stratum terminates at a point very near to such well. From these observations the operator will be able to predict with reasonable certainty the general outline of the areas of porous strata and the general directions in which they extend, thereby insuring that all drillings subsequently made will strike pay strata and not result, in the usual hit and miss method now employed, in the costly location of many "dry" wells.

Another method by which the direction of the extension of a field can be determined in accordance with the present invention resides in a pressure test depending upon the volume of compressed fluid retained near any particular well. For instance, pressure is applied to all of several wells in a field until meters at each well indicate uniform pressure throughout the field. The pressure creating apparatus is then removed and readings taken from volume meters at each well. The meter showing the greatest reading will indicate the direction in which the greatest amount of the pressure fluid is escaping and by this the direction in which the field extends.

The second and very closely interrelated step of the improved method will now be outlined briefly. As noted before, this part of the method is peculiarly useful in connection with increasing the productiveness of natural gas wells, particularly those wells which are drilled into strata having gas under relatively low pressure or in which the pressure of the gas has been lowered materially by the escape thereof. No successful method has yet been devised for recovering more than a certain percentage, by volume, of gas to be found in any given field, the pressure of the entrapped gas being depended upon for the venting thereof. Under this practice, each shaft is operated as a unit independently of all other drillings in the neighborhood and, as has been pointed out before, the drillings are determined by a hit and miss method and without regard to the probable location of the gas bearing stratum.

By the improved method, after the wells referred to in the description with respect to step one, have been drilled and the tests incident to the step have been made and such other wells located as may be desired, the gas is permitted to vent itself under its own pressure until such pressure becomes insufficient for continued flow. The apparatus which may have been used in connection with the first step for forcing the test fluid into the stratum under pressure may then be applied to one or two or more wells which have been shown to communicate with a porous stratum and a suitable fluid under high pressure is forced into the stratum. The effect of this introduction of fluid under pressure is to drive the natural gas from all parts of the porous stratum to one or more of the wells communicating therewith and cause it to escape until the particular stratum to which the pressure is applied is completely exhausted of gas. The fluid used may be either liquid or gaseous and may be such as is determined to be best adapted under the particular conditions although, in practice, air has been found to serve the purpose satisfactorily. This step of the method is not to be limited to the introduction into the porous stratum of a fluid under pressure but can be carried out by any chemical or physical means for creating pressure within the porous stratum, and in such relation to the gas contained therein

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as to cause the latter to escape through the communicating wells. For instance, a gas might be introduced into the stratum which would be of such properties as to combine with the natural gas contained therein and form therewith a different gas greater than the combined volumes of the two known gases, thereby creating a pressure. Again, a combustible gas might be introduced into the porous stratum or some gas which would combine with the entrapped gas to form a combustible mixture might be introduced and combustion then brought about by some convenient means, the resulting products of combustion serving to set up the desired pressure. Other modifications of this step and other ways of practising it successfully will be pointed out more particularly hereinafter in connection with the detailed description and the general scope of the entire method will be defined in the appended claims.

Reference is now to be had to the accompanying drawings which indicate in a very simple manner an arrangement of suitable apparatus and wells for practising the improved method.

In these drawings—Figure 1 is a view in section of two wells sunk through the earth to a gas bearing stratum, one of the wells being provided with means for introducing a fluid under pressure into the porous stratum and the other well being equipped with an escape pipe for the entrapped gas. Fig. 2 is a purely diagrammatic representation of three wells so located with respect to each other as to enable the advantages of the improved method to be realized when employed in connection with them.

In order to maintain the arrangement proposed in the preamble, the two steps of the improved method will be described independently, in so far as it is possible, and accordingly reference will first be made to Fig. 2 of the drawings for a description of the manner of locating oil or gas bearing strata, determining approximately the areas of such strata and securing indications of the general direction in which such strata extend for the purpose of predicting proper locations for additional wells.

It may be supposed, first, that the tract of land, indicated conventionally in Fig. 2, is owned by an operator and that he desires to determine at just what points on this land, if any, wells should be sunk. In following the present method, a well A will be sunk at any convenient point and a second well B will be sunk at a relatively great distance therefrom, perhaps anywhere from 900 to 2000 feet, although it is to be understood clearly that this invention is not concerned with the distances between wells. The operator after sinking the wells to the porous gas bearing stratum C, shown in Fig. 1, will introduce piping D and E into the wells and effect a gas-tight joint between such piping and the well linings by suitable packers F through which the pipes extend and which are preferably disposed near the bottoms of the wells and engage the linings therefor with a gas-tight union. To the pipe D will be connected a compressor G, while the pipe E, which will serve as the escape pipe, may either terminate adjacent the earth's surface or may communicate with any desired point, as will be understood. The porous stratum C in which the gas is found is walled in solidly by strata H of impervious minerals, such as slate, etc. By the arrangement of apparatus described and the geological formation of the strata H with respect to the porous stratum C, a continuous communication is formed between the compressor G and the outlet of the pipe E. Accordingly, if a fluid is forced from the compressor G into the porous stratum C, it will traverse the intervening space between the lower ends of the wells A and B and escape through the outlet pipe E. If this fluid be one having distinctive physical or chemical properties, such as of taste, color, odor, inflammability, etc., its presence at the outlet E can be readily detected in due time. Air will serve the purpose. If this presence is detected, then the operator can feel reasonably certain that there is a gas bearing stratum C extending from the well A to the well B and that he can sink wells between these two and recover gas on a paying basis. Such tests and resulting information will obtain with any well, such as I, sunk at some distance from both the wells A and B. The outlet from the well I can be tested by fluids introduced at A and other fluids introduced at B, so that it can be determined readily whether there is a continuous gas bearing stratus between the wells A and I and another gas bearing stratum between the wells B and I. Three wells have been illustrated in the accompanying drawings as it will be appreciated that by reason of their triangular disposition with respect to each other a relatively great tract of land can be tested at a relatively slight expense and locations for many intermediate wells determined. Given the wells A, B and I the following test will determine the direction of the stratum beyond them. It is to be noted that many gas and oil bearing sands exist in connected pools or long narrow streaks. Apply the same pressure at all the wells A, B and I and after a sufficient time has elapsed to place the stratum under pressure take readings from volume meters at each well A, B and I. The meter showing the greatest reading will determine the direction in which the greatest amount of the pressure fluid is escaping and by this the direction in which the stratum extends from

the triangle A, B, I. Again, the use of three wells in the manner described enables the approximate area of the gas bearing stratum to be determined within the limits of the territory bounded by the three wells. Of course, the preliminary development may be extended by sinking additional wells in other directions, and the improved method carried on with respect to such additional wells. Whenever it is found that the distinctive fluid introduced at one well cannot be detected at another well, it can be concluded that the porous stratum is interrupted at some point between the wells and that drillings cannot be carried on between them to advantage. Another point to be emphasized is that the invention is not to be limited to the use of liquids or gases of any particular character where a fluid is used in the manner hereinbefore referred to and that other ways can be employed for determining the continuity of the porous stratum between any two wells. Again, a gas might be introduced which would combine with the natural gas to form a combustible mixture and the combustible nature thereof determined by bringing the mixture into contact with igniting means at the point of escape. Inflammability would indicate that the gas has traversed the space between the wells, while, if the union expected were not formed, then it would be known that the gas had not been able to traverse such space and the continuity of the stratum was broken. Electrical emanations may be made to enter and traverse a proper fluid introduced into the porous stratum and detected at test wells or where a conductive fluid, such as salt water, is present, a current may be passed through it and the continuity of the stratum thereby established.

A useful application of this first step of the present method will be found where it is supposed that the wells A, B and I are on separate tracts of land. In such a case, the operator might obtain short term leases of these three tracts at relatively little expense and sink the three wells A, B and I and carry out the tests above described. From these tests he would be able to ascertain whether the land between the wells were worth drilling or whether it was not worth while to take over any one of the separate tracts.

Another feature of this first step of the method resides in the means for determining the probable direction in which a gas bearing stratum extends with respect to any well. Where a fluid under pressure is introduced at the well A and escapes from the wells B and I, the pressure and direction of motion at these two last named wells could be determined in any convenient manner and that well which showed the higher pressure would be the one nearer to the larger portion of the stratum. If under these circumstances it were found that the well I showed a higher pressure, then it would be reasonable to conclude that other drillings in the neighborhood of the well I would be more productive than drillings near the well B, the pressure at which indicates that the gas bearing stratum terminates at a point somewhere near this well. An active motion through and beyond the well B would indicate that the area beyond the well B would be productive.

The second step of the improved method is concerned with the recovery of the gas after the stratum C has been located and is practised whenever the gas within the stratum is at such a low pressure as to be insufficient to vent the gas or where this pressure has been so materially reduced by venting of the gas that it is necessary to impress an artificial pressure on it to force it from one of the escape wells B or I. In accordance with the method, a fluid is introduced into the stratum C through the well A by the compressor G and permeates the entire stratum, thereby impressing a pressure upon the entrapped natural gas. The gas, under the influence of the artificial pressure, seeks to escape and finds its only outlet at the wells B, I, where it may be recovered. In this step of the method, as in the one first described, the invention is not to be limited to the character of the fluid used, whether liquid or gaseous, nor is it to be limited to the use of a fluid under pressure introduced as described. In practice it has been found convenient to use compressed air at high pressure and satisfactory results have been obtained. If preferable, however, a gas such as air may be introduced into the natural gas which will combine therewith to form an explosive mixture. When this mixture is ignited the products of combustion will force the natural gas throughout the stratum C to escape from the wells B and I. Other means for attaining the same end by employing the present invention will suggest themselves to those skilled in the art.

From the description given, it will be apparent that the improved method consists essentially in the locating of two or more wells so situated with respect to each other as to make it possible to carry on operations or tests from one to another, which will give the results more particularly stated in the preamble. The many variations in the method hereinbefore indicated may be practised without departing from the spirit of the invention, as may many others not particularly referred to, provided that all such variations fall within the scope of the appended claims.

I claim as my invention:

1. The method of determining the location and probable direction of extent of gas or

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oil bearing strata which consists in sinking three or more wells to such strata at relatively remote points, creating an artificial pressure at one well which shall be observable at the other wells when the wells communicate with a common stratum, and recording the pressures at all of the wells, whereby the general direction of flow of the fluid in the stratum is indicated.

2. The method of determining the proper direction of extension of gas or oil bearing strata, which consists in sinking two or more wells to an oil or gas bearing stratum, introducing a pressure creating fluid into all of them at the same degree of pressure, removing the source of pressure, and measuring the volumes taken by each well as an indication of the direction of the continuation of the stratum beyond it.

This specification signed and witnessed this 20th day of March, A. D. 1915.

FREDERICK SQUIRES.

Signed in the presence of—
H. T. CARTER,
T. E. MCELHENNY.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."