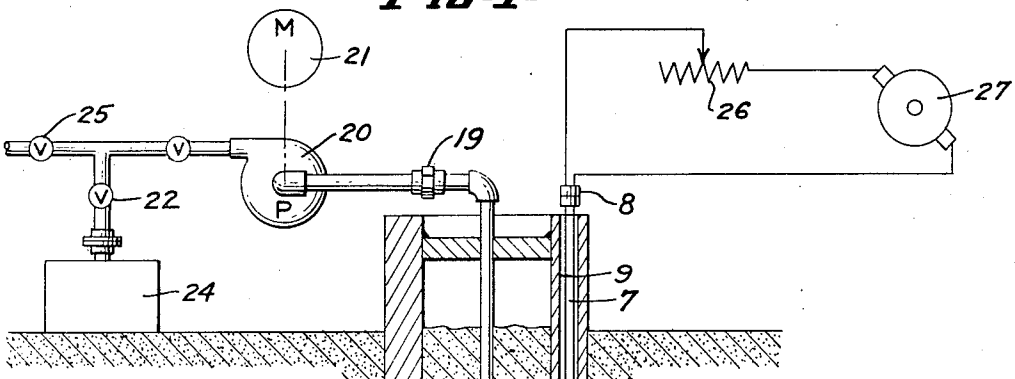
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METHOD OF OBTAINING SOIL GAS SAMPLES

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Fig-1-



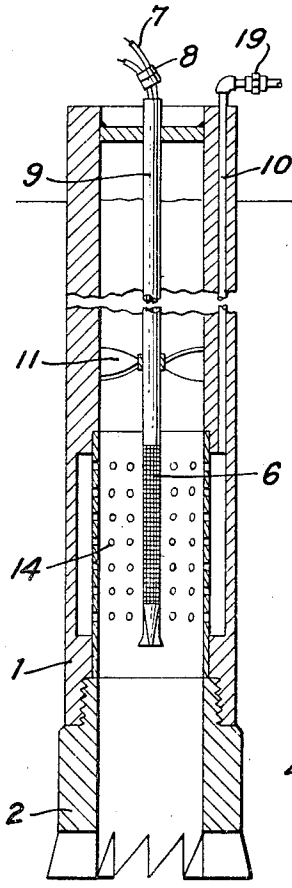


Fig-5-

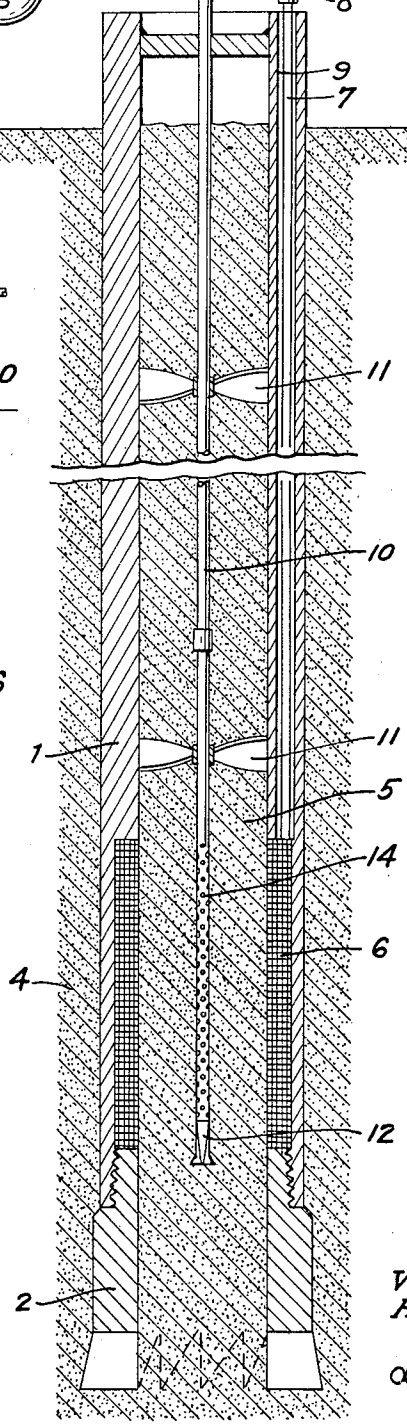
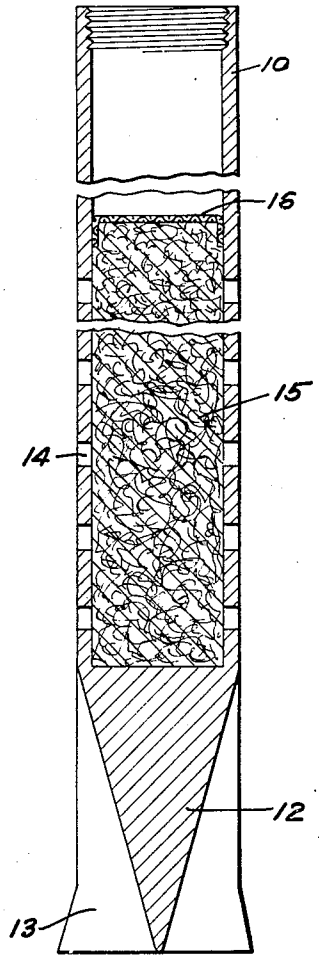


Fig-2-



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Fig-3-

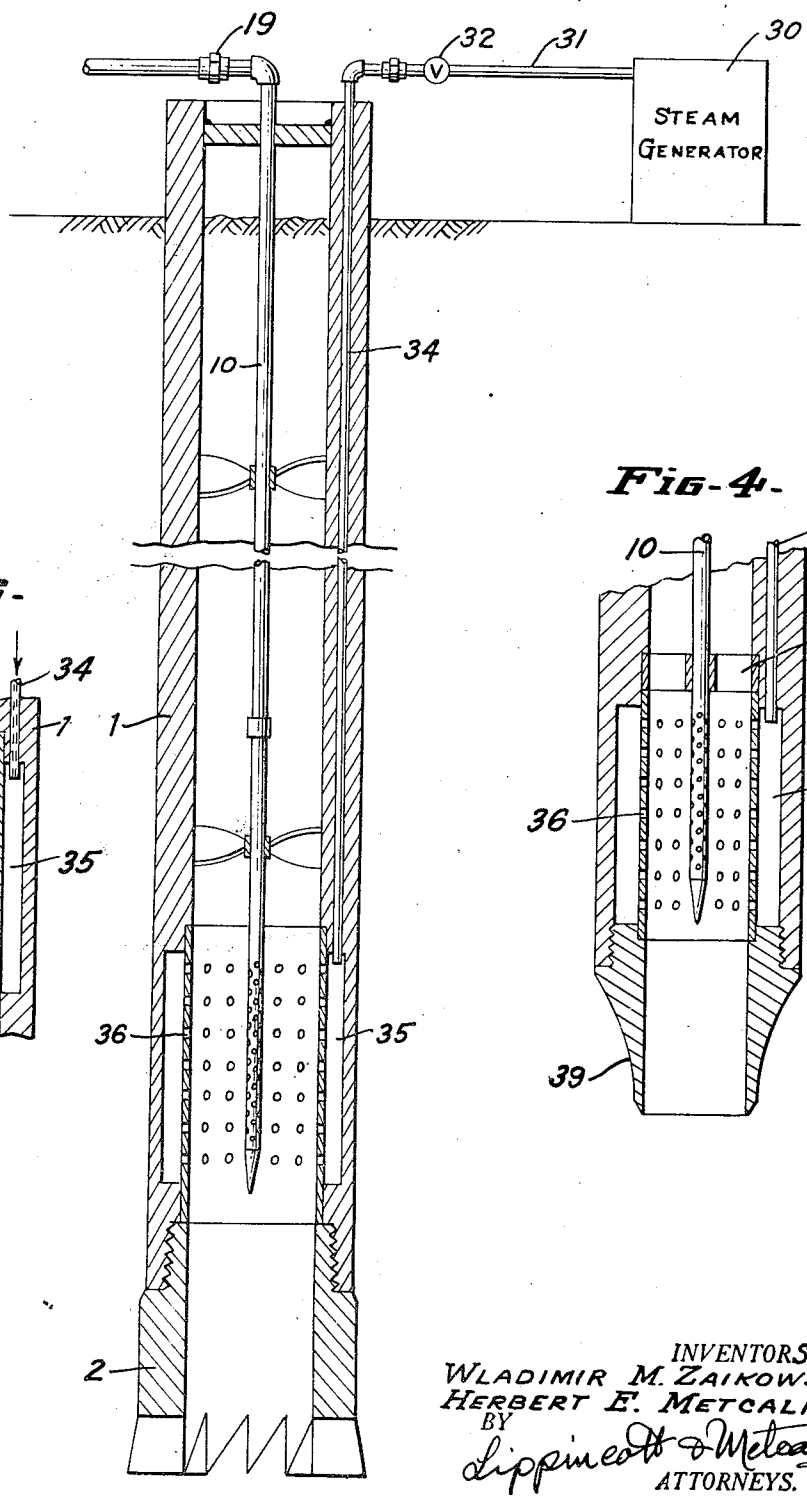


Fig-6-

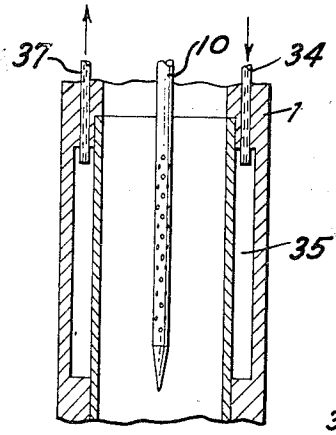


Fig-4-

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METHOD OF OBTAINING SOIL GAS SAMPLES

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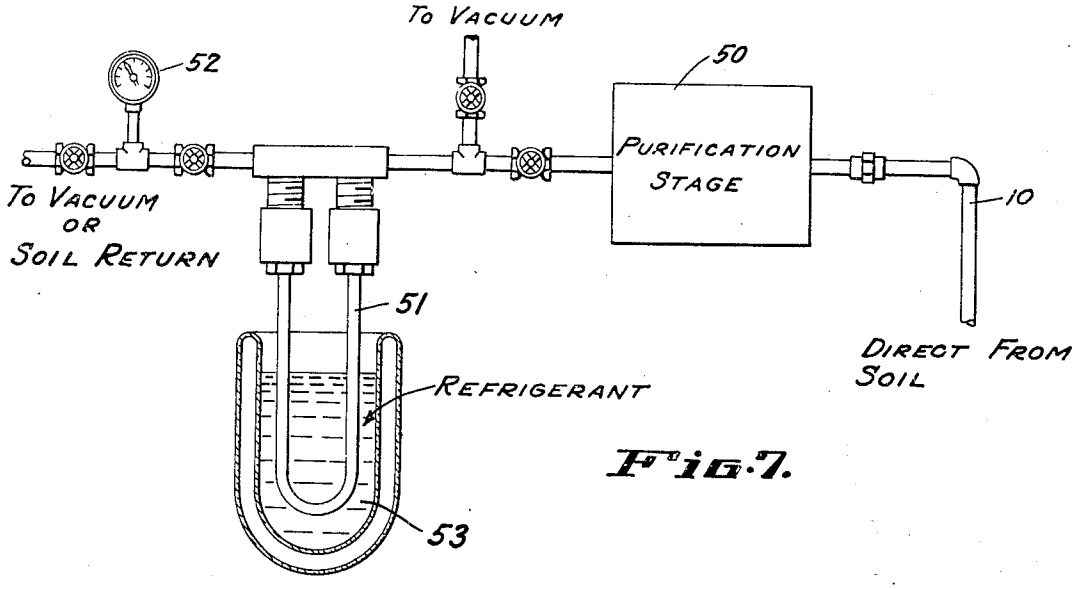


Fig. 7.

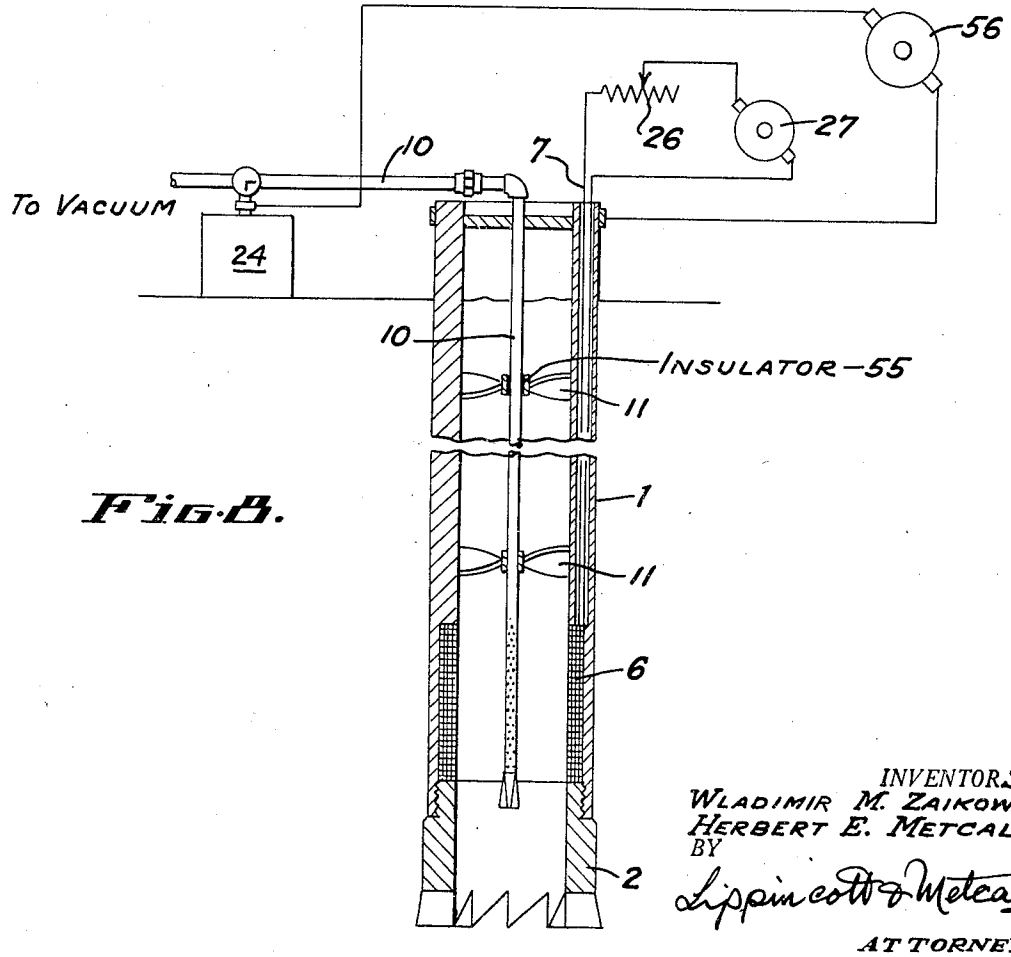


Fig. 8.

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METHOD OF OBTAINING SOIL GAS SAMPLES

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Application August 20, 1940, Serial No. 353,370

5 Claims. (Cl. 23—232)

Our invention relates to a method of obtaining soil gas samples, and more particularly to a method of removing gas from soil in situ beneath the surface of the earth. One of the preferred uses of the soil gas samples obtained is for geochemical prospecting such as, for example, prospecting for petroleum deposits.

In geochemical prospecting it has been the custom to obtain soil samples from beneath the surface of the earth, preferably below the water table and systematically over the area to be prospected. These samples are then analyzed for significant components, such as, for example, hydrocarbons which may have migrated from subterranean deposits of petroleum. The results of such analyses are correlated, preferably by use of maps or other similar records, with the locations at which they were obtained in an attempt to determine the location of the deeper subterranean deposits. Such a means and method of geochemical prospecting by using soil samples is exemplified, for example, in the Zaikowsky copending patent application, Serial No. 342,064. Such a method, however, may have distinct disadvantages, for it is very difficult to remove from the soil and place in containers, samples of dirt or earth without so disturbing these samples before they are hermetically sealed to an extent that certain of the significant gases may escape, thus introducing another uncertain factor into the results obtained. Laubmeyer, in his United States Letters Patent No. 1,843,878, obtains straight gas samples by digging a hole in the ground, covering the hole, and waiting for the gas from the surrounding soil to diffuse into the hole, and then takes a sample of the gas so migrating into the hole. Such a method using gas samples obtained in that manner is extremely uncertain and depends solely upon the normal migration of the significant gases which may or may not be separable from the soil particles when the Laubmeyer method is used. Furthermore, heat treatment of soil samples is highly desirable in order to release some of the more tightly bound gases which are entrained or entrapped in the soil, and thus it is quite probable that there is a large amount of significant gas in the soil exposed by Laubmeyer which is not recoverable in his method.

It is the main object of our present invention to provide a method of extracting from the soil only gas samples. To extract these samples from the soil in situ, we prefer to heat treat the soil in situ to release gas therefrom. We collect the released gas in sealed containers and thus obtain truly representative samples of gas from the soil in situ under controlled conditions which favor the release of the gas. It is another object of our invention to at least partially segregate the soil in situ which is to be treated, so that the increased pressure due to heat treatment does not cause the gas to be dispersed through the surrounding soil. Another object of our invention is to heat soil in situ to procure gas released therefrom. Another object of our invention is to extract gas from soil which is substantially undisturbed and in its normal position beneath the surface of the earth. Another object of our invention is to release and entrap gas released from soil in situ, so that this released gas may be collected and stored for future analysis. The treatment in situ may comprise heating, flushing with gas or liquid, and complete scavenging of the desired gas from the soil.

Our invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing our novel method. It is therefore to be understood that our method is applicable to other apparatus, and that we do not limit ourselves, in any way, to the apparatus of the present application, as we may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

In the drawings:

Figure 1 is a view, partly in vertical section and partly diagrammatic, of one embodiment of our invention for heat treating and extracting gas from soil in situ beneath the surface of the earth.

Figure 2 is an enlarged sectional view of a gas exhaust pipe, having a cutting edge.

Figure 3 is a sectional view, partly diagrammatic, of a device useful for treating soil in situ with steam.

Figure 4 is a sectional view of the end of a driving rod embodying the treating mechanism of Figure 3.

Figure 5 is a sectional view of a modification utilizing a central source of heat.

Fig. 6 is a fragmentary view of the apparatus of Fig. 3 illustrating a modified embodiment of the invention.

Fig. 7 is a view illustrating preferred apparatus for making determinations of hydrocarbon contents directly as the gas sample is obtained from the soil.

Fig. 8 is a view, partly in vertical section and partly diagrammatic, illustrating a different pro-

cedure in the utilization of the underground portions of the apparatus of Fig. 1.

Our invention may be more fully understood by direct reference to the drawings. Here a hollow drill rod 1 is provided at its lower end with a coring bit 2. The exact construction of this coring bit is unimportant, it being used only to segregate a core from the mass material of the earth, when used in relatively soft and unconsolidated soil material, this term being used as opposed to solid rock. The device is adapted to be progressed into the ground 4 by rotation, as is well known in the art, so that a core 5 is produced which extends upwardly inside of the drill rod 1. The material of the core will be relatively undisturbed adjacent the end of the drill rod 1. At the lower end we position, facing the interior of the drill rod, an electric heating coil 6, this coil being energized from the upper end of the drill rod by electric wires 7 passing through passageway 9 in the side wall of the drill rod. We provide a plug 8 for quick connection and disconnection of wires 7 from any external circuit to which it may be desired to connect such wires.

Centrally mounted within the drill rod 1 is a hollow exhaust pipe 10, this exhaust pipe being supported within the drill rod by cross-members 11, these members preferably being angularly positioned and provided with cutting edges to move the core material upwardly relatively speaking, as the drill pipe 1 is being rotated to cut downwardly. The lower support 11 is preferably positioned above the heating coil 6 so that the core material is relatively undisturbed until this core material has passed the upper level of heating coil 6. The end of terminal 12 of exhaust pipe 10 may be sharpened, if desired, when used in relatively soft material or may be provided with a small cutting end 13 similar to the core bit itself for use in other materials, as shown in Fig. 2. In any event, the terminal of exhaust pipe 10 is made relatively small in diameter and may be provided with gas entrance holes 14 opposite the extent of heating coil 6. Dirt may be prevented from entering the exhaust pipe 10 by a packing of filter material 15 held in place by screen 16, as shown in Fig. 2.

After the drill pipe 1 with its bit 2 and exhaust pipe 10 has been progressed into the ground to a predetermined depth so that the heating coil 6 is preferably below the water table and the core 5 extends up past the heating coil, the exhaust pipe 10 is connected by a union 19 to a vacuum pump 20 operated by a motor 21, this vacuum pump discharging through control valve 22 into a sample container 24. It may also be desirable to provide vacuum pump 20 with free outlet controlled by outlet valve 25. Plug 8 is connected and heating coil 6 is energized through a resistor 26 from a generator 27 or other convenient source of power preferably located at the surface of the ground.

In operation, after the drill has been inserted into the ground to the desired depth, the exhaust pipe 10 may be cleared of residual air by operation of the vacuum pump 20 direct to the atmosphere and valve 25 may then be closed, and valve 22 opened. Heating coil 6 is then energized to bring the core soil surrounded by the electric heater up to a desired temperature to release gas from the soil. It is obvious that thermo-couples may be utilized in conjunction with heating coil 6 to determine the soil temperature. As the soil is heated, the vacuum pump 20 may be operated and the gas which is released from the soil surrounded by heating coil 6 will then be exhausted from the soil and pumped into container 24. This heat treatment may be continued for a predetermined length of time. Valve 22 may then be closed and this valve and the container 24 removed from the line. Sample container 24 may then be labeled and recorded as to the position, depth, et cetera, at which the sample was taken, brought into the laboratory or field truck and analyzed for significant gases, which in the case of petroleum prospecting may be, for example, ethane and propane, as is customary in petroleum prospecting. The device may then be pulled, cleaned out, and reinserted at another location and another sample taken. However, the drill rod may be stopped at different and predetermined depths and the soil treated to remove and recover the gases therefrom. Such recovered gases may be analyzed for hydrocarbon content and the results used to compute a vertical hydrocarbon gradient.

It will be noticed that we prefer to surround the soil from which we take our sample with the heating coil and take the gas from the interior of the soil body. However, the central member, which in this case is the exhaust pipe, may be heated and the gas exhausted through the side wall of the drill pipe, as shown in Fig. 5. In either case, the soil which is being heat treated is segregated from the surrounding soil so that the expelled gas cannot dissipate itself in all directions during the heating period, as would occur if the treated soil were not surrounded. The gas released utilizing our invention could only escape upwardly or downwardly, but we have found that very little escapes in this manner in comparison to the amount which escapes if an attempt is made to heat the soil without at least partial confinement. We are thus able to get a very high percentage of the reelased gas.

In Fig. 3, we have shown a modification having the same general construction as shown in Fig. 1, with the exception that instead of electrically heating the soil enclosed by the drill pipe in the core, we apply steam directly thereto. This we accomplish by utilizing a steam generator 30 preferably located at the surface of the ground, the steam therefrom being conducted through pipe 31 under the control of valve 32 into a conduit 34 in the wall of the drill pipe 1 down to a cavity 35 surrounding a portion of the undisturbed core soil of substantially the same volume as surrounded by heating coil 6 in Fig. 1. Cavity 35 opens up into the interior of the drill rod through steam apertures 36, and, if it is found that too much soil will enter cavity 35, then the cavity may be loosely packed with filter material, such as used in the packing of the exhaust pipe adjacent apertures 14. In view of the above-described apparatus of Figs. 1 and 5, it will be obvious that in this case also surface connections may be reversed and steam admitted through central apertures 14 and exhausted through lateral apertures 36 after having passed through the soil. When steam is passed into the soil, care must be taken not to contaminate the soil gases by impurities coming from the boiler.

In some cases, however, it may be desirable not to pass the steam through the soil but to use it for heating purposes only. In this case (Fig. 6), steam apertures 36 may be omitted and cavity 35 may have steam circulated therein by providing an exhaust bore 37 to the surface. In this case, the effect on the soil is identical with the

action of the electrically treated modification shown in Fig. 1.

The operation of the device of Fig. 3 is slightly different than the operation of the device shown in Figs. 1, 5, and 6 because in this case steam is forced into and through the soil enclosed by the drill pipe, and this steam, after having passed through the soil, has heated the soil, released gas therefrom, and is then exhausted, with the released gas, through the exhaust pipe 10 and pumped into container 24 as in the first modification. Container 24 will therefore contain the water condensed from the steam as well as water vapor and other gases released from the soil.

In Fig. 4, we have shown a modification of the drill bit used for shallow holes, or at the bottom of large holes, the end 39 of the drill rod being sharpened so that it may be driven into the ground instead of rotated. In this case, support members 11 are made vertical and sharpened at the lower edge so that they may be passed readily through core material. However, this passage should be above the area to be heat treated so that the heat treated body may be disturbed as little as possible.

Instead of collecting the entire gas taken from the soil, we may wish to make at least partial determinations of hydrocarbon content directly at the sample location. Fig. 7 shows a preferred apparatus set up for this purpose. Gas exhausted from the soil is passed through a purification stage 50 to remove CO_2 and water vapor, and thence into a U-tube 51 which is immersed in a refrigerant 53, such as liquid nitrogen for example. Hydrocarbons are condensed and frozen in the U-tube and, if desired, the time required to stop up the U-tube as determined by the vacuum gage 52 may be used to represent the concentration of hydrocarbons in the soil volume being heated. As the volume of core soil being heated will be constant from point to point, accurate concentration measurements can be made, and compared as between points.

After the U-tube has concentrated the hydrocarbons therein, the legs thereof may be sealed off after evacuation, and the U-tube with its hydrocarbon sample, used for further analytical purposes, as desired. The U-tube technic herein referred to is more fully described and is claimed in the copending Zaikowsky application, Serial No. 350,998, filed August 3, 1940.

The use of this apparatus in situ is highly desirable as we are able by heating, flushing, and exhaustion of a defined volume of soil to substantially deplete the soil of its contained hydrocarbons. We may then leave rod 1 in place and wait for a predetermined time, such as for example twenty-four hours, and repeat extraction procedure on the same soil. Any hydrocarbons recovered in the second extraction will be a true indicator of the rate of diffusion of hydrocarbons to the soil volume under treatment. We may, if necessary, eliminate bacterial activity by heat sterilization of the soil volume under study, or, for example, by flushing the soil with selected disinfectants such as CO_2SO_4 or bichloride of mercury. Such sterilization removes errors due to organic disintegration by bacteria and similar organisms during the period between extractions.

Due to the fact that soils usually contain a large percentage of moisture, which, when the soil is heated, will evaporate and carry the soil gas along with it, and due to the fact that if steam is passed through the soil the water vapor recoverable is even greater, we are able to use the system as a diffusion pump by maintaining outlet pipe temperatures sufficiently high to prevent condensation of water vapor until the collecting chamber is reached, thus extracting without continuous operation of pump 20. This type of set-up is shown diagrammatically in Fig. 8. Here the lower cross-member 11 is conductively connected to exhaust pipe 10, all other cross-members being provided with an insulating bushing 55 around the exhaust pipe 10. A low voltage source of electrical current 56 is then connected to rod 1 and to exhaust pipe 10 near container 24 and the exhaust pipe resistively heated by passing a low voltage high amperage current therethrough, as is commonly done in thawing frozen pipes. The exhaust pipe 10 can be held at a temperature preventing condensation of water vapor, the water vapor condensing in container 24, which is not heated but held below condensation temperature. Thus, container 24 will contain, not only hydrocarbon gas released from the soil volume under treatment, but will also, when steam is not applied directly to the soil, contain the water content of the soil volume being heated. Under these circumstances, a new relation can be found, namely, the relation of hydrocarbons to soil water content, as well as the relation of the hydrocarbons to soil volume or soil weight under treatment. In this procedure the vacuum pump 20 need be used only for preliminary scavenging of container 24 and pipe 10.

It should be noted that in utilizing the sampling means and method outlined above, there is no release of pressure on the soil which is to have gas extracted therefrom, until the actual extraction is started. The full depth of soil is still above the body to be sampled and thus there is no release of gas due to the digging away and opening to the atmosphere of the soil from which the gas is to be obtained. Thus, the significant gases, if any, are held in the soil which is to be sampled up to the time of sampling, and this gas is extracted therefrom without chance of losses or dilutions due to handling or exposure to the atmosphere of the soil. Such elimination of extraneous factors greatly increases the accuracy of correlation of samples in adjacent relationship, and provides results which can be relied upon.

Furthermore, our invention provides for repeated recovery from the same soil volume after predetermined time intervals and thus can be used to measure diffusion rates of significant gases in the soil.

While we have described our invention as primarily utilizing heat for removal of significant components such as gases and water from a predetermined volume of soil in situ, and for scavenging of the soil by hot gas such as steam, it will be obvious to those skilled in the art that the segregated soil volumes can be scavenged by other fluid reagents, hot or cold, which have an affinity for hydrocarbons or other significant soil components, and the hydrocarbons thereafter recovered from such reagents.

Furthermore, there is one other mode of operation which can be accomplished with the devices shown in Fig. 3, in combination with refrigerated collector shown in Fig. 7. The steam generator of Fig. 3 may be eliminated and a pump may be attached to the vacuum line in such a manner that a closed system is formed. Gases are brought up from the soil volume under treatment through pipe 10 passed through U-tube 51, non-condensible gases returned to the ground through pipe 34, and a continuous circulation maintained

for a predetermined length of time. Under these circumstances, we prefer to use a scavenging gas which is hydrocarbon free, such as water-washed N_2 for example. If desired, the gas in the entire system may be kept under a slight positive pressure so that there will be no seepage from soil beyond the scavenged volume. In this manner the hydrocarbon gas in the segregated volume of soil can be accurately determined and collected, as a refrigerant may be selected which will not condense the scavenging gas.

We claim:

1. The method of obtaining a soil gas sample from a section of soil located beneath the surface of the earth which comprises isolating a core section in situ against an interchange of gas with adjacent laterally disposed soil, treating the core section thus isolated with heat and moisture to release soil gas from the section and collecting the gas released.

2. Process according to claim 1, in which the treatment of the core section with heat and moisture comprises passing steam through the section.

3. The method of obtaining a soil gas sample from a core section located entirely beneath the surface of the earth, which comprises isolating such core section in situ against an interchange of gas with adjacent laterally disposed soil, stimulating the flow of contained gas from such section and collecting the same.

4. The method of obtaining a soil gas sample from a core section located entirely beneath the surface of the earth, which comprises isolating such core section in situ against an interchange of gas with adjacent laterally disposed soil, heating such core section to stimulate the flow of contained gas therefrom and collecting the same.

5. The method of obtaining soil gas samples indicative of a vertical hydrocarbon gradient, which comprises progressively isolating substantially vertically aligned core sections against interchange of gas with adjacent laterally disposed soil and removing contained gas from each of said sections following its isolation.

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