

[54] **METHOD OF PROSPECTING FOR HYDROCARBONS**
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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 804,219, March 4, 1969, Pat. No. 3,609,363.
[52] U.S. Cl. 73/23, 23/230 EP
[51] Int. Cl. G01v 9/00
[58] Field of Search.....73/17, 23, 170, 188; 250/83 SA, 83.6 S, 43.5 R; 23/230 EP

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UNITED STATES PATENTS

1,843,878 2/1932 Laubmeyer.....23/230 EP

2,165,214 7/1939 Blau et al. 73/23
3,444,721 5/1969 Hearn et al. 73/23

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685,929 5/1964 Canada.....23/230 EP

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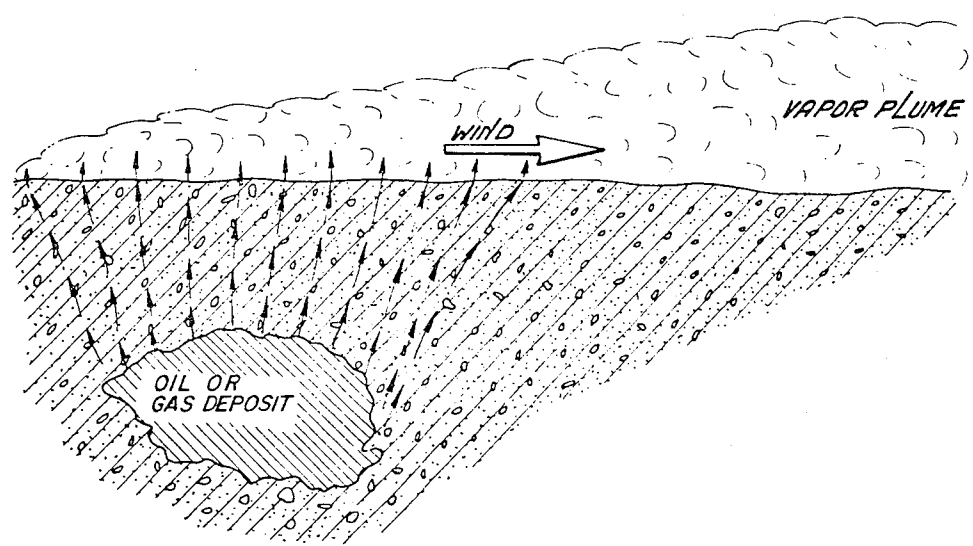
Davidson, "Geochemistry Can Help Find Oil if Properly Used" World Oil, July, 1963, pp. 94, 96, 100, 104 to 106.

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Attorney—David H. Semmes

ABSTRACT

Prospecting, particularly prospecting for hydrocarbons such as oil and gas on the basis of the mobile gaseous phase of hydrocarbons which diffuses through the earth's structure and becomes windborne.

13 Claims, 13 Drawing Figures



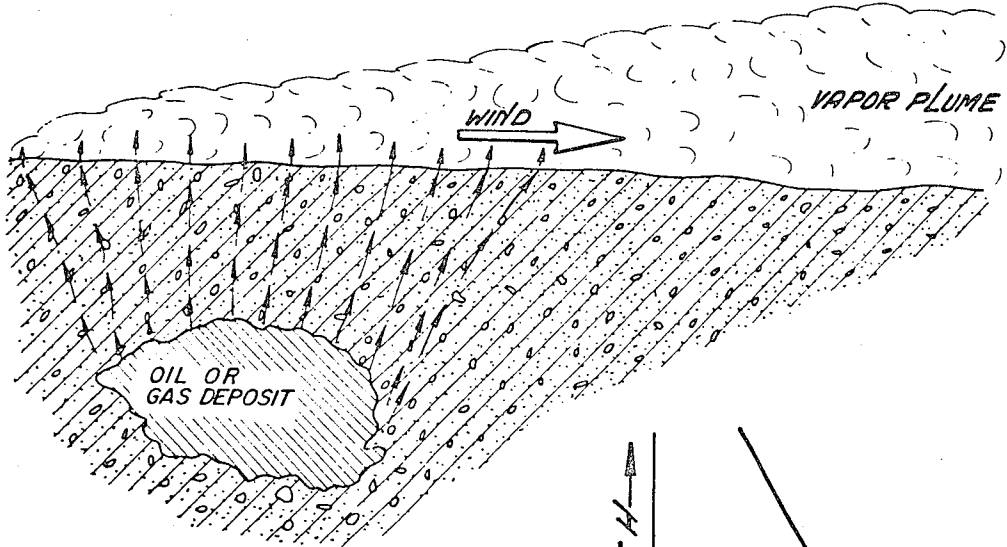


FIG. 1

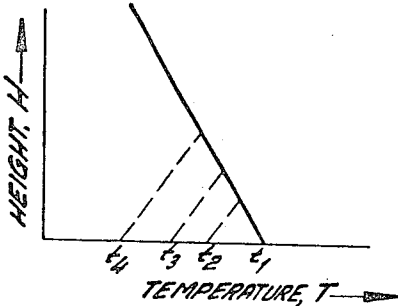
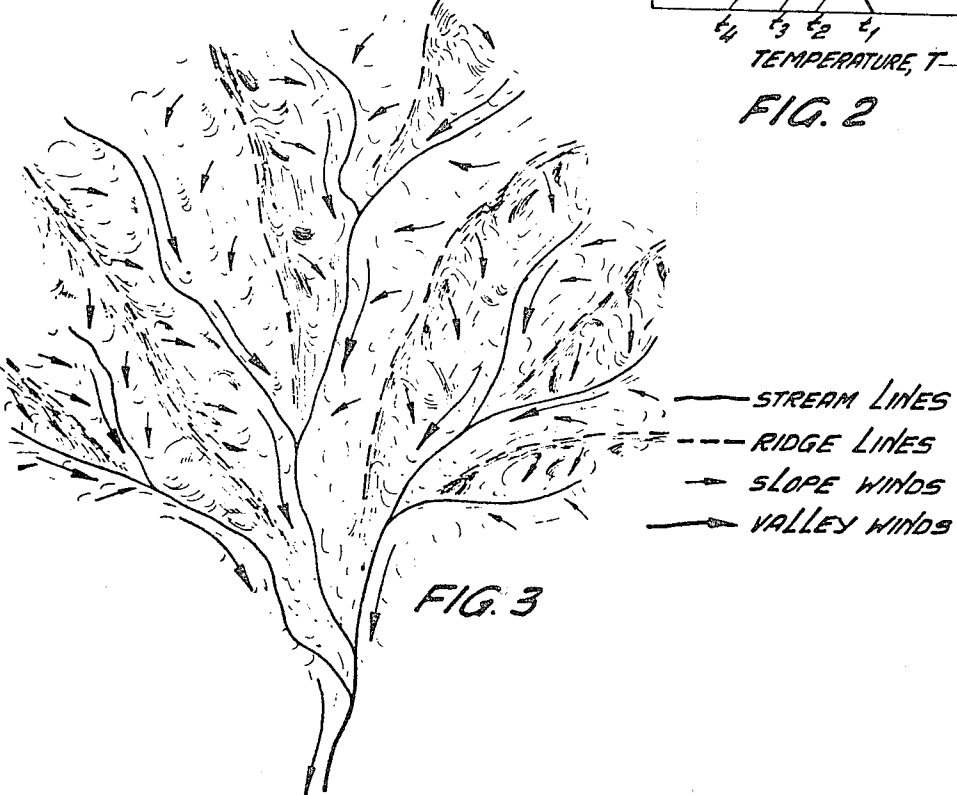


FIG. 2



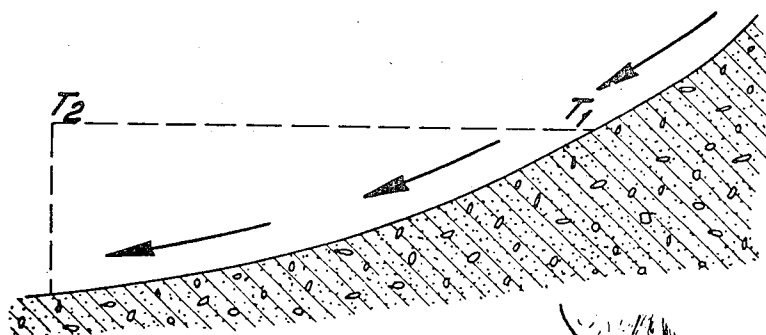


FIG. 4

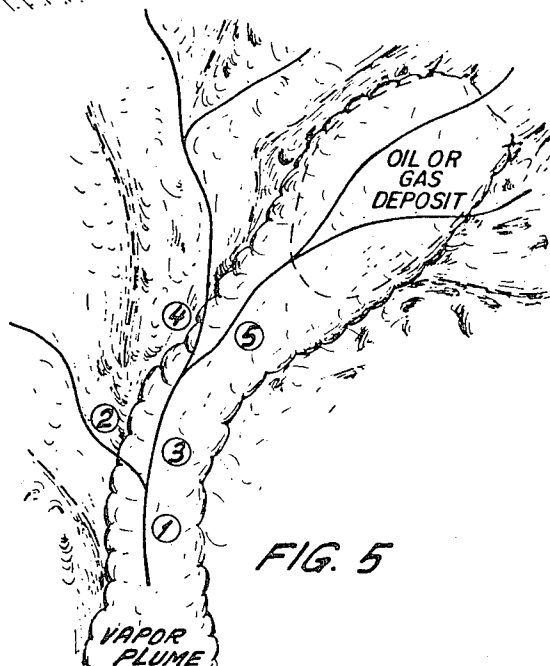


FIG. 5

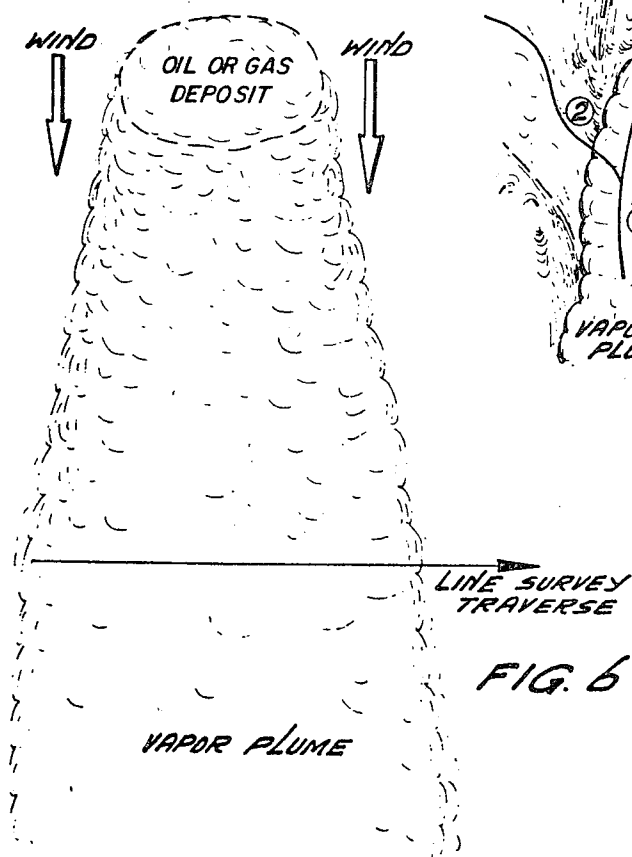


FIG. 6

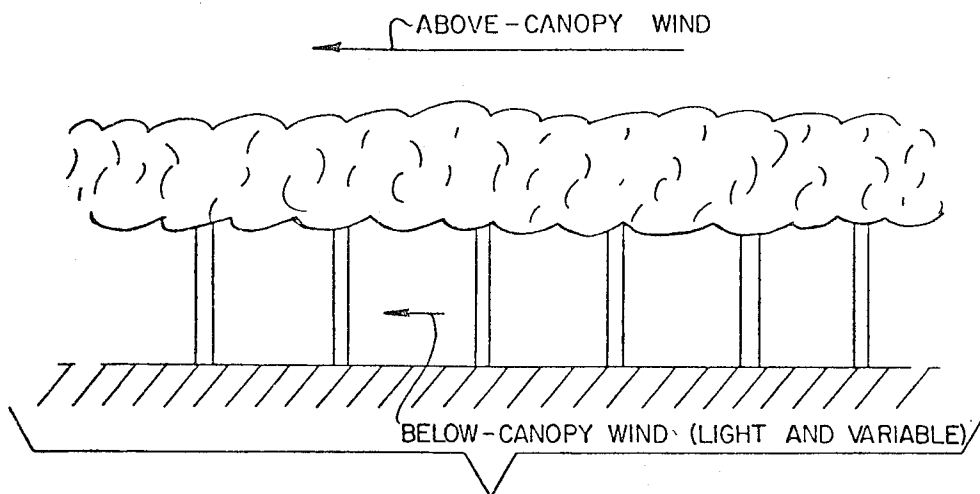


FIG. 7

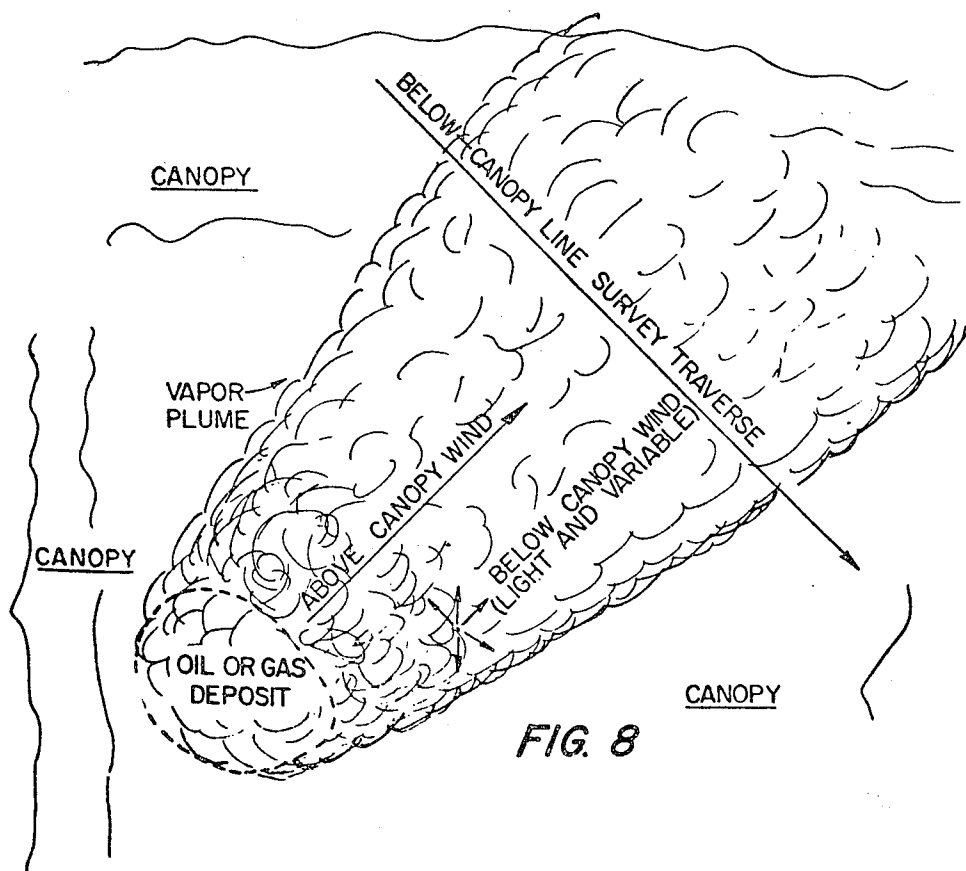
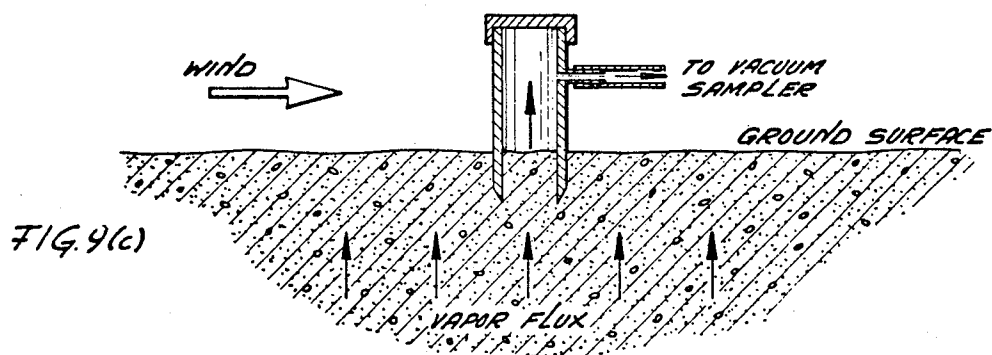
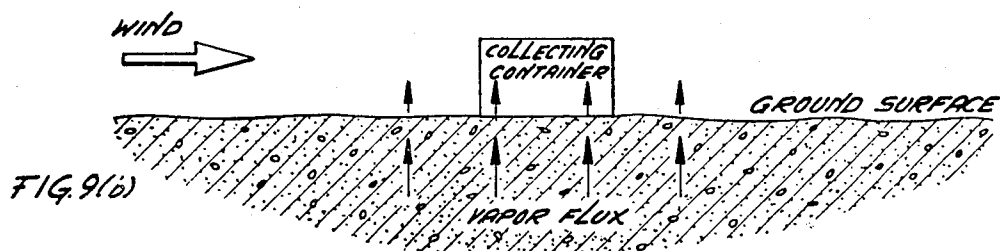
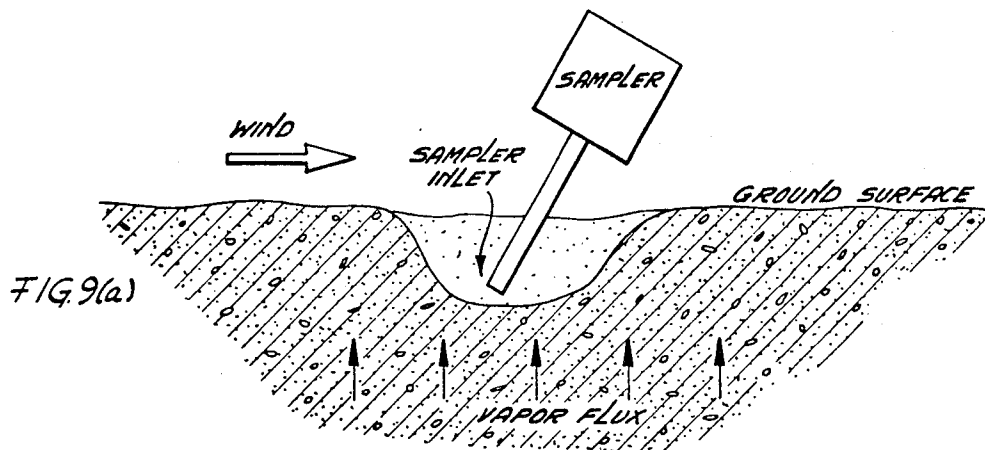
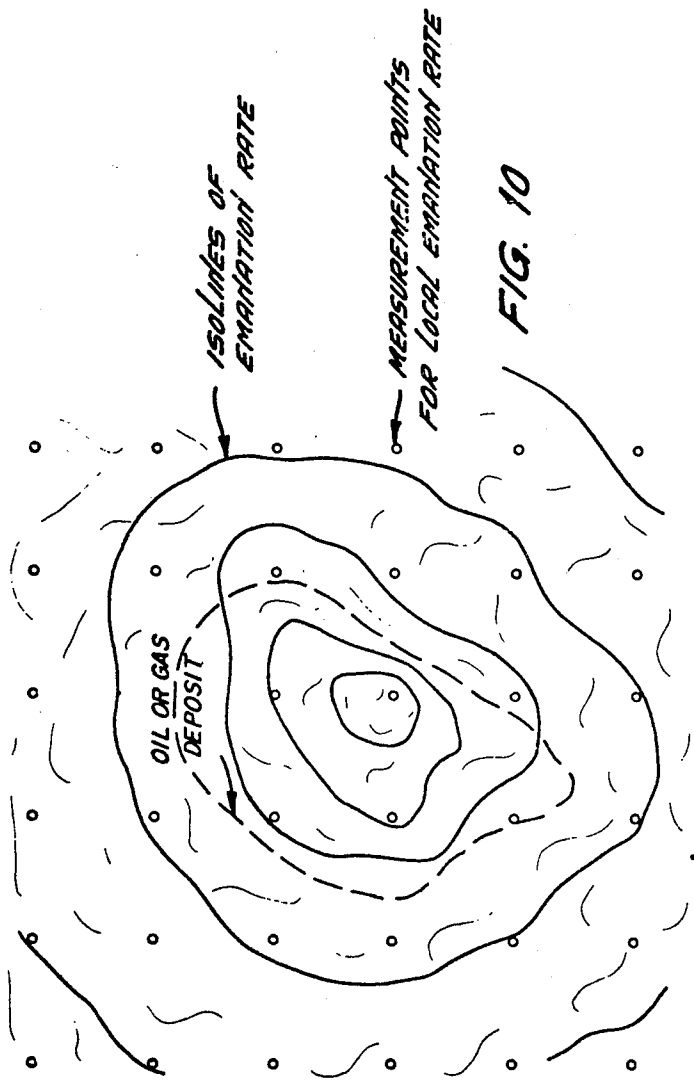


FIG. 8





METHOD OF PROSPECTING FOR HYDROCARBONS

CROSS-REFERENCES TO RELATED APPLICATIONS

A continuation in part of applicant's Method of Prospecting (relating to uranium, thorium and like radioactive ore deposits), Ser. No. 804,219, filed October, 1968 issued as U.S. Pat. No. 3,609,363.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Oil, gas, or oil and gas in association contain hydrocarbon compounds which have significant vapor pressure. This results in a mobile gaseous phase which diffuses through the earth's structure and emanates into the atmosphere, thereby serving as an indicator of the presence of oil and gas. Conventional prospecting techniques include traversing the earth's surface with a magnetometer which measures variations in the local magnetic field, or the use of seismic surveys, with the objective of making inferences concerning the presence of favorable sub-surface structures. Shortcomings of these techniques include short operational range, limitations in inferring the subsurface structure, and lack of unique relationships between structure and hydrocarbon occurrence. Another shortcoming of such techniques resides in the necessity for being physically present on the earth's surface, or airborne in the atmosphere, above that portion of the earth's surface at which the deposits are located. There has been no prior art attention given to the use of mobile vapor phase tracking or the combination of such tracking with combining meteorological considerations. For example, no earlier inventors have proposed horizontal tracking of density flow of vapor phase emanations downwind of a hydrocarbon deposit, then marking of the hydrocarbon deposit as density flow and diffusion vertically of the vapor phase through the earth's structure coincide.

2. Description of the Prior Art

There has been no prior patent or other teaching which remotely suggests tracking of a mobile gaseous vapor phase by azimuthally charting a sector of density flow of gaseous phase, then horizontally tracking the density flow toward the hydrocarbon deposit and marking the hydrocarbon deposit as density flow and diffusion vertically from hydrocarbon deposit coincide.

The measurement of hydrocarbons in the atmosphere and in soil gas, as an indicator during exploration for oil and gas deposits, is a well recognized technique. It has been accepted for some time and is unique in that it measures directly a component of the deposit being sought following its migration upward to the earth's surface, in contrast to the usual geophysical methods (gravity measurement, magnetometry, seismic soundings, etc.) which are related primarily to the structure of formations and hence only by inference to the presence of petroleum.

Various applications have been developed in order to exploit the mobile hydrocarbon vapor phase as an indicator of oil and gas deposits. For example, Hall, et al. (U.S. Pat. No. 3,180,983) explore for petroleum deposits by sampling soil gas near the earth's surface and analyzing for methane — one of the important and most volatile components of oil and gas. Weisz (U.S. Pat. No. 2,786,144) describes instrumentation for analyzing very small quantities of hydrocarbons in soil gas,

which is especially designed to be used in exploring for petroleum — being capable of measuring ethane and higher molecular weight hydrocarbons to the exclusion of methane which can often arise from non-petroliferous sources.

While the above applications have focussed on hydrocarbons in soil gas, others have dealt with the detection of hydrocarbons in the atmosphere in the vicinity of gas emanations. For example, Blau, et al. (U.S. Pat. No. 2,165,214) propose measuring hydrocarbons over long path lengths (several miles) in the atmosphere by making use of absorption of short radio waves or of light waves. Bradley, et al. (U.S. Pat. No. 3,143,648) explore for hydrocarbons by detecting gas seeps in the atmosphere during flight along multiple parallel paths over the area to be explored. Slobod, et al. (U.S. Pat. No. 2,918,579) explore for hydrocarbon deposits under water by making multiple parallel traverses perpendicular to the current and sampling for dissolved hydrocarbons arising from gas seeps. However, none of these studies involves or suggests tracking of the vapor phase as a means of vastly extending the range of the sensing principle.

DESCRIPTION OF THE INVENTION

Applicant prospects for oil and gas deposits having a gaseous hydrocarbon vapor phase which diffuses through the earth's structure into the atmosphere by initially sensing the gaseous phase in the atmosphere; discriminating between density flow of gaseous phase arising from oil or gas deposits and that from ambient background, horizontally tracking the density flow towards the oil or gas deposits and marking the oil or gas deposits as density flow and diffusion of gaseous phase through the earth's structure from said oil or gas deposit coincide. Refinements of invention include initially conducting a line survey downwind of the area being prospected; outlining katabatic flow as a function of topography; estimating bulk atmospheric drift in heavily wooded areas on the basis of above-canopy wind direction; vapor and dust sampling during tracking, and capping of the earth's structure adjacent the diffusion of gaseous phase through the earth's structure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view showing diffusion of gaseous phase products from the oil or gas deposit through the earth's structure and into the atmosphere where it becomes airborne;

FIG. 2 is a graph depicting formation of the low level temperature inversions under which the desired katabatic or density flow conditions occur;

FIG. 3 is a schematic view showing katabatic wind drainage within a given topographic sector;

FIG. 4 is a chart showing the development of slope winds within a valley of the topographic sector shown in FIG. 3;

FIG. 5 is a schematic illustration of tracking "upstream" according to the katabatic wind flow shown in FIGS. 3 and 4;

FIG. 6 is a schematic view of line survey tracking downwind of an area being prospected;

FIG. 7 is a schematic illustration of the relation between above-canopy wind and below-canopy wind in a heavily wooded area;

FIG. 8 is a schematic illustration of line survey tracking downwind of the bulk drift of below-canopy vapor plume from an oil or gas deposit, as controlled by the above-canopy wind;

FIG. 9 is a schematic view showing sampling of the earth's structure about a projected oil or gas deposit and measuring vapor phase emanation as a function of diffusion vertically through the earth's structure;

FIG. 9B is a schematic view showing capping of the earth's structure about a projected oil or gas deposit by means of a collecting container;

FIG. 9C is a schematic view showing capping of the earth's structure about a projected oil or gas deposit so as to direct captured gaseous phase products to a vacuum sampler;

FIG. 10 shows mapping of said gaseous diffusion, according to FIG. 8; and

FIG. 11 shows detection of anomalies during portable sampling in a wooded area.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

Applicant's method is based upon the detection and tracking of airborne clouds of gaseous hydrocarbons in the atmosphere, these clouds arising from the vapor pressure associated with oil or gas deposits in the ground to produce a mobile vapor phase which diffuses through the earth's structure into the atmosphere. The airborne gas can then be detected by means of observations over the ground surface and at points removed from the deposit; and these observations can then be related to the location of the deposit by meteorological considerations. Because of the diffusivity of the gaseous phase through the ground, detection of deposits at depth, without recourse to drilling, becomes possible and because of the travel of the gaseous cloud with the wind after diffusion into the atmosphere, detection of deposits can be accomplished at distances which are considered great by the standards of normal prospecting methods. Furthermore, by application of the principles of micrometeorology, advantage can be taken of the occurrence of conditions under which confluence of wind from vast regions prevails, rendering it possible thereby to scan comprehensively the entire region by measurements made at a single point.

An essential element in the successful employment of this technique is the application of meteorological knowledge, concerning cloud travel and dilution, to govern the observational regime and the interpretation of measurements. To achieve success, measurements must ordinarily be made under those conditions (which commonly occur) that give rise to concentration of the products in the lower atmospheric layers. This is readily done by taking advantage of low level temperature inversions arising particularly from ground surface radiation such as illustrated in FIG. 2. There, time frames t_1 - t_4 are designated to illustrate the formation of cool, dense air layers adjacent the earth's surface, beginning at sunset. Further, under these conditions katabatic, or density, airflow occurs and under synoptic anticyclonic conditions with weak geostrophic pressure gradients the airflow will be determined by the topographic relief. The result is that confluence of katabatic flow occurs in precisely the same manner as the hydrologic drainage of watersheds, and entire valley systems may be surveyed by measurements at the valley mouth. Successive measurements up-valley will serve to pro-

gressively eliminate subsidiary valley systems from consideration or identify them as major contributors. Continued up-valley study can then identify the region of the cloud source and hence, the responsible oil or gas deposit.

Strong relief is not required for successful application and other variations of survey technique are readily employed even for very flat country.

For example, continuous monitoring at a fixed point oversufficiently long time to characterize all wind directions will provide a survey of the surrounding countryside for distances of the order of miles. Similarly, continuous measurements along a line survey (as following a road) will scan the country to the upwind side of the line. In all cases, however, it is necessary that competent consideration be given to the meteorological factors which govern the efficiency with which the initial emanations are concentrated and with which subsequent travel and turbulent dilution processes occur.

In some circumstances, the development of katabatic or density flow is inhibited and other techniques must be employed in order to determine the direction of flow from which the sampled vapor has come. In particular, this problem arises in moderate to heavily wooded terrain. Under these conditions marked radiation inversions resulting in density flow are much less readily formed. Wind speeds under the canopy are very light and variable, averaging generally less than 1 mile per hour. Where topographic relief is slight the definition of the flow under the canopy by ordinary wind sensing instrumentation is virtually impossible. Nevertheless, despite the locally highly variable apparent wind directions under the canopy there is a bulk mean drift of air which parallels the above-canopy flow. This results from turbulent coupling which provides the mechanism whereby the driving force of the above-canopy wind is impressed on the below-canopy air, resulting in its drift and controlling its direction of bulk flow. Measurements of hydrocarbon vapor concentrations in heavily wooded area of low relief may therefore be tracked to the source by relating them to the above-canopy wind direction.

The concentration of hydrocarbon gases in the atmosphere may be measured by any one of a number of methods as most appropriate to the specific situation. Measurements of methane, ethane, ethylene and other natural volatile constituents of oil and gas deposits, can be utilized. Various types of instrumentation can be used, including long-path and short-path infra-red absorption, within the meaning of the technique of exploration described here.

After detection and general localization of an area of interest, further adaptation of the technique may be employed to outline more precisely the oil or gas deposit itself. By capping the emanating soil surface so as to trap the gaseous vapor phase at a succession of points over the area in question, and measuring the content so derived, contour analysis of the results will aid in definition of the oil or gas deposit.

Manifestly, various instrumentation may be employed in sensing, tracking and marking according to applicant's method without departing from the spirit of invention.

I claim:

1. Method of prospecting for oil and gas deposits from which a volatile hydrocarbon vapor phase diffuses

vertically through the earth's structure into the atmosphere, comprising:

- A. sensing said hydrocarbon phase in the atmosphere adjacent earth's surface and under katabatic conditions determined by topographic relief and temperature inversions;
 - B. charting an azimuthal sector of density flow of said hydrocarbon vapor above the earth's surface;
 - C. horizontally tracking said density flow along earth's surface towards the deposit from which it has diffused; and
 - D. marking said deposit within the earth, as said density flow and diffusion vertically from said deposit coincide.
2. Method of prospecting as in claim 1 including sensing in a line survey downwind of the area being prospected.
3. Method of prospecting as in claim 1, wherein said sensing is done from a fixed point with respect to proposed oil and gas deposits, said tracking is correlated with ambient wind conditions, and including marking of a projected deposit from said fixed point, gaseous phase density flow and diffusion vertically being projected as a function of ambient wind in the flow being tracked.
4. Method of prospecting as in claim 1, wherein said sensing is done within heavily wooded areas, from a fixed point with respect to proposed oil and gas deposits, said tracking being correlated with ambient above-canopy wind conditions as a means of estimating bulk drift of the below-canopy air mass, and including marking of a projected deposit from said fixed point, gaseous phase effective flow and diffusion vertically being projected as a function of the governing above-canopy wind related to the below-canopy flow being tracked.
5. Method of prospecting as in claim 4, wherein said sensing is done from at least two fixed points and including marking of a projected deposit by triangulating.

6. Method of prospecting as in claim 1 wherein said sensing is done within heavily wooded areas by a line survey downwind of the area being prospected; said tracking being correlated with ambient above-canopy wind conditions as a means of estimating bulk drift of the below-canopy air mass, and including marking of a projected deposit from said line survey, gaseous phase effective flow and diffusion vertically being projected as a function of the governing above-canopy wind related to the below-canopy flow being tracked.

7. Method of prospecting as in claim 1, including sampling of dust bearing adsorbed vapor, with said density flow during tracking and analysis of gas phase material adsorbed on said dust.

8. Method of prospecting as in claim 7, including capping of earth's structure surface about a projected oil or gas deposit and measuring vapor phase concentration as a function of diffusion vertically through the earth's structure.

9. Method of prospecting as in claim 7, including vacuum sampling of said atmosphere during tracking and analysis of gas phase concentrations.

10. Method of prospecting as in claim 7, including vertically tracking said density flow, while analyzing gas phase concentrations as a function of the magnitude of said density flow.

11. Method of prospecting for oil and gas deposits as in claim 1, wherein said sensing includes discriminating between density flow of said hydrocarbon vapor phase arising from oil and gas deposits and any ambient flow of gaseous hydrocarbons.

12. Method of prospecting as in claim 1, wherein said sensing is directed to volatile constituents of said hydrocarbon phase.

13. Method of prospecting as in claim 1, wherein said sensing includes infra-red absorption.

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