Oct. 12, 1965 E. SARAPUU 3,211,220

SINGLE WELL SUBSURFACE ELECTRIFICATION PROCESS

Filed April 17, 1961 2 Sheets-Sheet 1

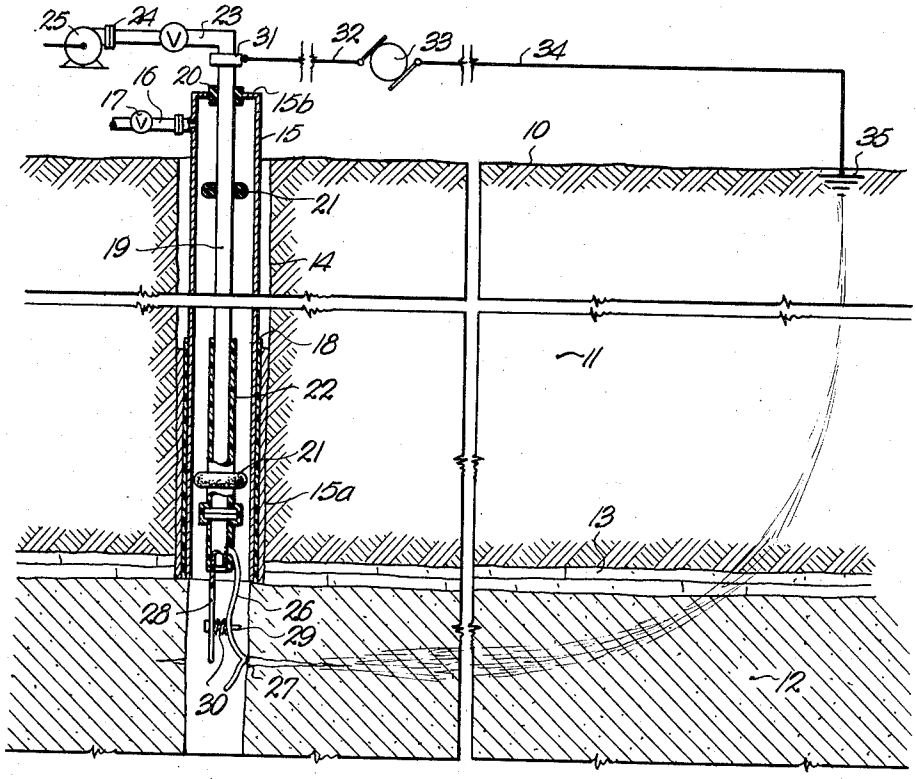



Fig. 1.

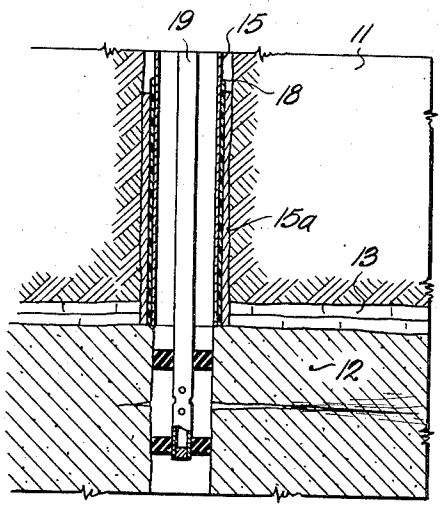



Fig. 2.



Fig. 3.

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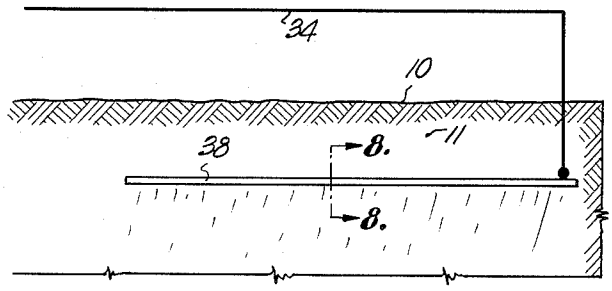



Fig. 4.

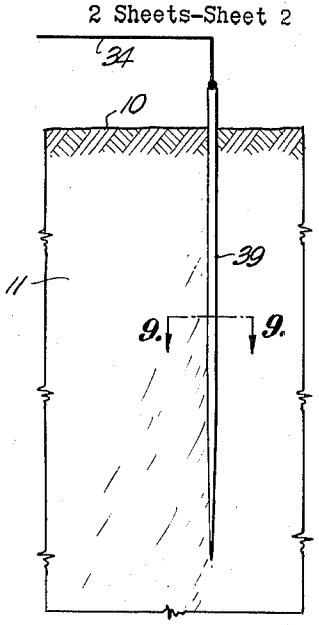



Fig. 5.

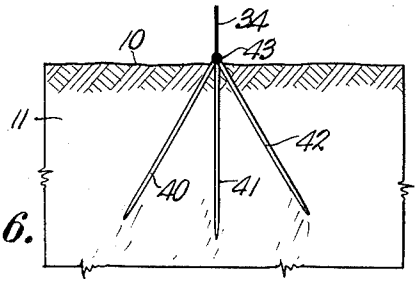



Fig. 6.

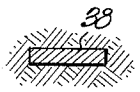



Fig. 8.




Fig. 9.

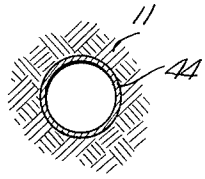



Fig. 10.

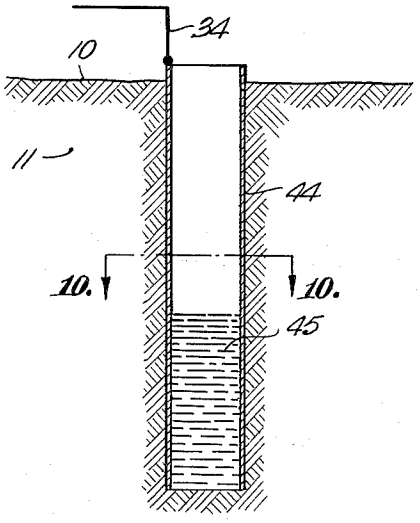



Fig. 7.

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United States Patent Office 3,211,220
Patented Oct. 12, 1965



# 3,211,220
# SINGLE WELL SUBSURFACE ELECTRIFICATION PROCESS

Erich Sarapuu, Kansas City, Mo., assignor to Electrofrac Corporation, a corporation of Delaware

Filed Apr. 17, 1961, Ser. No. 103,429
3 Claims. (Cl. 166—39)

This application is an improvement over my Patent 2,795,279, below, and is a continuation-in-part of my application Serial No. 3,897, filed January 21, 1960 "Electro-Repressurization," now U.S. Patent No. 3,141,504, and my application Serial No. 41,418, filed July 7, 1960, entitled "Electrolinking by Impulse Voltages."

This invention relates to subsurface electrical treatment and electrification processes such as wellbore and sand heating, ignition, electrolinking, electrocarbonization and electrofracturing and refers more particularly to the practice of such processes in a single wellbore utilizing only one electrode or electrode array in said single wellbore communicating therein with the formation to be electrically treated as a "surface" ground (a ground not communicating with the formation in which said subsurface electrode is established).

My Patent 2,795,279 issued July 11, 1957, discloses a "Method of Underground Electrolinking and Electrocarbonization of Mineral Fuels" wherein high energy electric current flows between separate electrodes in separate wellbores in a single earth formation, thereby linking the electrodes electrically and also physically by channels electrically formed in said formation.

My application Serial No. 3,897, filed January 21, 1960, and now Patent No. 3,141,504, for "Electro-Repressurization" discloses methods of and apparatus for electrically detonating and igniting explosive gas bodies positioned in earth horizons, particularly oil sands.

My application Serial No. 41,418, filed July 7, 1960 for "Electrolinking by Impulse Voltages" discloses means of and methods for applying high voltage impulses to subsurface gas formations whereby to so electrically link one underground electrode to another as to make actual physical cracks or fractures next to the wellbores containing the electrodes.

It is well known to apply electrical current to oil horizons and other subsurface formations to aid oil or mineral production and achieve various related purposes therein. Thus, subsurface and formation heating by electrical means, electrolytic migration of subsurface fluids, linking of electrodes in subsurface formations, physically linking such electrodes by carbonized channels, circumferential wellbore carbonization, wellbore fracturing by electrical means, etc. are all described in these references. The typical complete well installations utilized in practicing such processes contemplates spaced wellbores with electrodes or electrode analogs embedded in a single formation or in the fluids of such single formation or yet in gravel packs communicating with a single formation whereby to transfer electrical energy to the formation or fluids thereof.

In most of the described applications, since it is desirable to retain as much as possible of the electrical energy within the horizon or sand or formation, this described paired wellbore and electrode completion into the sand is the most economic and feasible. Indeed, this is all the art contemplates.

However, in certain geographic, geological and physical situations, both subsurface and surface and also in the interest of economy, the necessity of utilization of drilling a plurality of closely spaced wells completing them and installing complex expensive apparatus thereat is most undesirable and impractical. Particularly this is the case



(1) where wellbores must be drilled into a formation (no old holes available), (2) when only one wellbore is readily available reaching to the formation to be treated, (3) where underground permeability conditions are unusual or peculiar, (4) where terrain makes it impossible or overwhelmingly expensive to provide wellbores spaced as would ordinarily be desirable or required and (5) where the formation to be electrically treated is extremely deep.

In any case, it can be truthfully said to be eminently desirable to be able to produce any, all or a substantial number of the benefits and operations of multiple wellbore electrification processes at, in or with a single wellbore penetrating the horizon to be treated. Particularly this is the case when the electrification process involved is one which creates effects at or adjacent to the wellbore itself, such as electrofracturing in my application 41,418, supra, or where it is desired to form a coke deposit in the vicinity of the borehole.

Therefore, an object of the instant invention is to provide methods of subsurface electrification where the benefits of subsurface electrical treatments of all types may be obtained in single well installations.

Another object of the invention is to provide methods of providing subsurface electrical and electrification treatment in single wellbore installations including permeability increase, wellbore fracturing, wellbore coking, channel carbonization, and the like.

Another object of the invention is to provide methods of subsurface electrification which make available the benefits of same at a much lesser cost in well completions, drilling, apparatus and equipment.

Another object of the invention is to provide new methods of increasing horizon permeability, penetrating an earth formation by electrolinking and electrochannel carbonization, preparation for the use of fluid production aids such as underground combustion, water and gas drive and accomplishing electrical fracturing.

Another object of the invention is to provide methods of subsurface electrical treatment which obviate the need of carefully spaced adjacent wellbores penetrating to the single horizon or formation to be treated.

Another object of the invention is to provide subsurface electrical treatment processes which may be employed in a variety of ways and utilizing a variety of apparatus.

Yet another object of the invention is to provide methods of subsurface electrical treatment and electrification which will make available such processes for a much broader spectrum of purposes, and a broader classification of horizons, earth formations, oil fields and the like, particularly with relation to inaccessible terrains and the like.

Yet another object of the invention is to provide methods of improving production conditions at a single wellbore by a variety of electrical processes which do not require the existence of an adjacent second wellbore linked into the electrical circuit.

Yet another object of the invention is to provide such single well subsurface electrification processes which do not require as much maintenance, require much less equipment, and wherein all elements of the apparatus are generally closer to hand for maintenance, repair and monitoring than in a multiple well application or completion system.

Other and further objects of the invention will appear in the coure of the following description thereof.

In the drawings, which form a part of the instant specification and are to be used in conjunction therewith, embodiments of the invention are shown and, in the various views, like numerals are employed to indicate like parts.

FIG. 1 is a cross-sectional view through an earth formation or horizon containing an oil sand or horizon, a

single wellbore drilled into the oil sand and apparatus adapted to practice the instant process schematically shown therein.

FIG. 2 is a fragmentary view of the earth formation of FIG. 1 showing apparatus installed in the same wellbore, adapted to fluid fracture the sand or horizon after such fracture.

FIG. 3 is a schematic plan view of the oil sand in FIG. 1 after practice of a first stage of one modification of the inventive process.

FIG. 4 is a cross-sectional view of the earth formation of FIG. 1 illustrating a first type of "surface" ground adaptable for use in the instant process.

FIG. 5 is a view similar to that of FIG. 4 illustrating a second type of "surface" ground usable in the instant process.

FIG. 6 is a view similar to those of FIGS. 4 and 5 illustrating a third type of "surface" ground usable in the instant process.

FIG. 7 is a view similar to those of FIGS. 4–6, inclusive, showing a fourth type of "surface" ground usable in the instant process.

FIG. 8 is a view taken along the line 8—8 of FIG. 4 in the direction of the arrows.

FIG. 9 is a view taken along the line 9—9 of FIG. 5 in the direction of the arrows.

FIG. 10 is a view taken along the line 10—10 of FIG. 6 in the direction of the arrows.

*FIG. 1 completion*

Referring first to FIG. 1, therein is shown a typical application of apparatus to practice the inventive method in an oil horizon. The showing is to some extent schematic, but involves actual apparatus employed to practice the invention, with the exception of the schematic designation of the "surface" ground which will be amplified by later reference to FIGS. 4–7, inclusive. At **10** is designated the ground level of the earth formation **11** which overlies oil formation or horizon **12** and overburden **13** of nonpermeable rock, shale, etc. thereby furnishing a reservoir for the hydrocarbon containing oil horizon **12**. At **14** is shown a wellbore which is drilled through earth formation **11** and overburden **13** into and optionally through or to the bottom of oil sand **12**. The criterion of extension of the wellbore **14** into sand or horizon **12** is to provide sufficient wellbore face within the horizon to permit the flowing of an adequate or desired quantity of gas or liquid into the horizon at a desired level if fluid fracturing is desired to be employed and also sufficient depth to permit the spacing of and positioning of the subsurface wellbore electrode or electrodes used in the instant process at a desired level therein. The upper portion of wellbore **14** down to horizon **12** may be of greater diameter than the wellbore in the horizon or the same diameter, as desired. If the casing of the well is to be inserted in wellbore **14** before drilling is continued into the sand, the hole into the sand may be "rat-holed" within the larger diameter wellbore and casing.

Suitable pipe or casing **15** is run from the surface at least to the top of oil horizon **12** and preferably slightly thereinto. If there are any earth formation zones above the oil horizon which need to be sealed to avoid leakage of formation fluids into wellbore, these may be sealed or cemented in conventional manner and, if there is any problem of leakage of horizon fluids into permeable zones above the formation, the casing **15** may be sealed as required as at **15***a* to avoid such leakage and fluid loss. Casing **15** preferably extends continuously from horizon **12** to the surface and has input flowline or pipe **16** with valve **17** thereon connected thereto adjacent well end **15***b*. Suitable air compressors or fluid pumps of conventional sort (not shown) may be provided on line **16**. Casing **15** may be, particularly in the vicinity of horizon **12**, of electrically insulating material or have an electrically insulating sheath **18** of tape or other material wrapped



or formed therearound such as a layer of electrically insulating plastic on the outside thereof.

A hollow, electricity-conducting metal (steel) tubing **19** extends downwardly through wellhead **15***b* into horizon **12** to a desired depth. Insulator **20** electrically insulates tubing **19** from casing wellhead **15***b*, while electrically insulating centralizers **21** of any suitable material such as plastic, rubber or ceramic are periodically spaced and positioned along the length of tubing **19** so as to prevent any electricity conducting contact between tubing **19** and casing **15** and also to evenly space the former from the latter. Centralizers **21** must be particularly spaced near the tubing joints, as well. Tubing **19** preferably has an electrically insulating sheath **22** of plastic or insulating tape surrounding its entire length within casing **15**, and in any case, very preferably has such insulation sheath from its lower end in the horizon to a level above any contemplated liquid level in the wellbore **14**. Flowline **23** with valve **24** controlling flow therethrough and having pump **25** of conventional type connected therewith is taken from the top of tubing **19** above wellhead **15***b*.

A suitable form of electrode for applying current in the wellbore or formation in the instant processes is shown connected to the lower end of tubing **19** and contacting the wellbore wall within the oil sand at a desired level. Curved steel spring **26** having horizon contacting "point" **27** is connected at its upper end to tubing **19**. A brace **28** of steel, which may be insulated or of a dielectric substance, particularly on the opposite side thereof from electrode **26**, preferably extends downwardly at least a substantial portion of the vertical distance of extension of electrode **26** and carries pin **29** extending through an opening (not shown) in electrode **26** whereby coil spring **30**, backed by brace **28** may force electrode **26** outwardly toward the wellbore wall. Coil spring **30** may be so constructed as to be compressed during electrode insertion in the wellbore and released thereafter in the horizon.

Electrical connection **31** to the upper end of tubing **19** connects cable or wire conductor **32** of conventional sort to a source of electrical power schematically shown at **33**. The latter is preferably but not necessarily an alternate current source of sufficient current capacity and voltage level for the process to be practiced. A D.C. source is also acceptable. Suitable generators and transformers of conventional type or connection to an electrical power line or other source of power of the desired magnitude and intensity may be employed. Connected to the other side of the electrical power source by cable or wire conductor **34** is a "surface" ground schematically designated at **35** in FIG. 1, which may be of the type shown in any one of FIGS. 4–7, inclusive, or other suitable ground for the purposes to be described.

The purpose of the described apparatus and well completion in wellbore **14** and associated therewith is to provide a path for current flow from the source of power **33** through conductors **32** and **34** to tubing **19** and from thence to electrode **26** from whence the current is to be passed, without arcing between the tubing and casing or electrode and casing, through the earth formation and horizon **12** to the ground electrode connection **35** outside strata **12**. The presence of any liquids or vapors in casing **15** which might tend to cause a short or an arc may be nullified, as previously mentioned, by suitable sheathing and insulation of the various conductors and casings along their lengths to avoid any short circuits or arcs. Additionally, apparatus as shown in my application Serial No. 94,375, filed March 8, 1961, now abandoned for "Potential Equalization Between Ground Electrode and Casing" to minimize a current arcing between tubing and casing may be installed. Metal-to-metal contact between the tubing **19** and casing **15** cannot be permitted.

In place of a conventional source of electrical power such as an A.C. or D.C. generating system, the source of

electrical power may constitute or comprise any one of the impulse discharge systems disclosed in my application Serial No. 41,418, supra.

*Types of "surface" ground electrodes*

The varying forms of surface ground electrodes shown in FIGS. 4–7, inclusive, will be now described. In each case, the ground surface will be designated as **10** and the subsurface earth layer thereto designated **11**.

FIG. 4 shows the insulated conductor **34** coming from the power source, and passing to and electrically connecting with an underground conductive metal piece **38**, typically a steel or copper beam or bar, having a length completely buried in the earth. More than one linked in parallel may be employed. If desired, and in place of the beam or bar **38**, a hollow cylindrical steel pipe could be buried in the earth extending vertically or horizontally as desired. It is desirable to have at least a portion of the surface ground electrode or array thereof exposed at the surface whereby they can be observed to see whether steam or water vapor is being produced thereat in practice of the process, in which case it may be inferred that the resistance is rising at same and a greater electrode surface is required.

FIG. 5 shows a single rod-type electrode **39** connected to insulated conductor **34**. Steel rod **39** extends vertically into the earth a sufficient distance to handle current densities of the process involved without sufficiently heating the earth formation therearound and substantially raising the resistance thereat. In all cases, the surface ground electrode contact with the earth will be considerably greater in area than the electrode contact in the earth formation or horizon to be treated. If the given surface ground electrode can handle the current densities over the period of time of operation of the process without itself heating to any appreciable degree, it will not heat the ground therearound and raise the resistance therein.

FIG. 6 shows a plurality of steel bar electrodes **40**, **41** and **42** connected at a common juncture **43** to conductor **34**. This installation has the virtue of requiring lesser depth of insertion to achieve a given result than the installations of FIGS. 4 and 5.

FIG. 7 shows yet another "surface" ground electrode installation which has proved satisfactory in the instant process. In many earth formations, old wells, often completely cased, remain in the field to greater or lesser depths than the wellbore carrying the electrode to the horizon or sand to be treated. In the case of casings running through the sand to be treated, this sort of "surface" ground connection has been found undesirable for the reason that the vertical extent of the opposite "electrode" to the producing electrode in the sand is so great that the current diffusion is not channeled as desired. Installation of a conventional dual electrode circuit is easier and more successful. However, in lesser depth (than the horizon to be treated) pipes or casings set in the ground in the manner shown in FIG. 7 the "surface" ground effect is most often eminently satisfactory. In an open-ended casing **44** of the type shown, particularly when the interior of the casing is somewhat filled with water or other liquid **45**, often considerable electrically generated heat loads may be applied to the casing without seriously disturbing the desired current activities in the horizon or sand itself. The current load and current density applied over a long period of time may well boil the electrolytic liquid in the casing itself, but, if this liquid is not boiled off, the electrical conductivity will remain satisfactory and the process may be carried out for long periods of time under extremely high current densities. For the heaviest current density loads and time periods of operation, the modification of FIG. 7 is generally more satisfactory than the other electrodes shown. However, when conductive surface casing is not available it is often much cheaper to employ the other forms shown.



The shape and location of "ground" is not significant. However, it has to carry enough power without reaching 212° F. At this temperature, the ground is lost.

*Process general description*

The remarks on the art and applications listed in the preamble indicate that it is known to be feasible to (1) electrically current flow-link two wellbores embedded in the same oil sand whereby to increase permeability of the oil sand or coal seam therebetween, (2) actually physically link two wellbores in the same earth strata by electrocarbonizing a channel therebetween, (3) electrocarbonize the vicinity of the wellbores of two linked electrodes in a single earth strata, (4) electrically physically fracture the wellbore walls in two electrodes in the same strata and the like, and (5) utilize preliminary physical (fluid) fracturing to aid subsurface electrification in paired boreholes.

I have discovered that I can accomplish permeability increase in, physical channeling through, wellbore carbonization in and physical fracturing (electrical) at the wellbore of a single well into the strata to be treated in the instant process without requiring another electrode in a laterally spaced well in the same strata. I can also combine in single wellbore practice various processes such as electrolinking followed by electrocarbonization, physical fracturing by electrical means followed by electrolinking and electrocarbonization, etc.

The unique apparatus arrangement and provision of my instant process is to provide a surface ground, that is, ground means suitably varied in the earth strata above the horizon to be treated (and most conveniently at, communicating with, or closely adjacent to the surface) which will handle the current transfers to be employed in the process without heating sufficiently in the ground installation to dry out the ground water and electrolyte-carrying fluids therearound in such manner as to substantially raise the resistance (electrical) in the surrounding terrain. I accomplish this by providing "surface" ground electrodes of sufficient number and/or length and area to handle the electrical current and current densities in the operating system without such heating. As the resistance characteristics of any given formation, indeed, any given level of a formation may vary greatly according to the electrolyte or mineral content therein, it is essentially impossible, as it has been in the double well art systems to precisely predict beforehand what the precise electrical characteristics of the system will be.

A further variable in selecting "surface" ground electrodes depends upon the type of process to be carried out. Thus, if it is merely desired to coke a wellbore, a conductor may be extended a short distance from the wellbore with a suitable pattern of electrodes distributed in the earth concentrically around the wellbore or concentrated on one side thereof if it is desired to coke particularly in one direction. In this completion, arcing from the top of the tubing is the particular concern so that the electrode must be spaced away from the wellbore sufficiently to avoid this contingency.

In any case, observation of the ground electrodes as to whether they are steaming off water vapor from their vicinity or heating up will soon demonstrate whether or not the current carrying capacity of a given ground electrode is adequate for the current densities and patterns being employed in the process.

When it is desired that the electrification extend a greater distance in one direction than the other, then the ground electrode or electrodes of my system are moved further outwardly from the wellbore whereby the current will tend to take a more lateral direction rather than an immediate vertical upturn as would be the case in wellbore coking. Generally, any oil sand will offer a relatively greater permeability to electrical current passage (due to connate water therein acting as electrolyte) than the nonoil-containing earth strata thereabove or below.

This permeability also contributes to the desired lateral electrification effects. I have discovered that it is almost an axiom of practice that, to achieve a "surface"-horizon linkage in the manner described in this application, as opposed to the creation of a horizon-horizon linkage as in my previous applications and patent, a greater electrical current is required to achieve a comparable effect at the electrode in the wellbore penetrating the horizon. However, the other advantages of the instant process in most cases far out weigh this particular drawback.

Where, as in FIG. 1, the "surface" electrode or electrode array is moved a considerable lateral distance from the wellbore in a directional manner, the passage of current is generally as seen in FIG. 3 with the greatest current density present at and permeability increase and carbonization effects first achieved closely adjacent the wellbore on the side of the electrode and ground connection. The current flow distributes itself approximately in the fan shape shown before moving upwardly out of the horizon toward the ground electrode.

When it is desired to increase permeability strongly on one side of a wellbore, or carbonize and channel in a single direction from the wellbore, or prepare for a sweep injection in a single direction, the apparatus and process of FIG. 1 is that employed and is as illustrated. Another use of the FIG. 1 completion and process is to link two wellbores in a single seam as in the manner of my previous patent and applications, but where permeability conditions are such and the distance apart of the wellbores is such that a stable directional linkage is very difficult or impossible to accomplish. In such case, the desired single strata interlinkage between the two distant wellbores may be obtained by first surface linking as immediately above described and shown in FIG. 1 from each wellbore in the direction of the other to establish a definite trend of permeability in that direction, then removing the surface electrodes and linking paired electrodes in the same seam or horizon, one to the other, in the manner of my patent.

*Process variations*

I disclose, without limitation, the use of the single wellbore electrode with "surface" ground electrode technique and apparatus in the following processes:

(1) Circumferential wellbore carbonization or coking employing a concentric pattern of "surface" ground electrodes around the wellbore of the type shown in the figures, particularly FIGS. 5 and 6.

(2) A process of wellbore carbonization with similar results to (1), supra, but biased to one side of the well by the lateral placement of the "surface" ground electrode or electrode array, rather than having a concentric ground electrode as in the manner of (1), supra. This is an arrangement identical to that of FIG. 1, but with the surface ground electrode or array not as far laterally displaced as in FIG. 1, indeed, preferably not any further laterally displaced than required to obviate arcing between the casing and the surface ground electrodes under the current densities employed.

(3) Step linking or subsurface electrification involving one or two wellbores. In the case of one wellbore, an initial subsurface electrification may be undertaken with a laterally displaced "surface" ground electrode whereby to cause electrical effects to extend laterally to a certain distance in the horizon. Following this, the electrode may be yet further displaced in the same general radial direction from the wellbore whereby the horizon electrification effect may be extended along the line or trend of permeability increase carbonization, etc. already started. In this manner, it is possible to electrically treat and create increased permeability effects, carbonization, wellbore charring effects, etc. in greater extent and to a greater distance in a single direction than are able to be created when the "surface" ground electrode is initially moved out to the further distance originally.

As a variation on this process, two rather widely separated wells may be more efficiently and effectively electrolinked and electrocarbonized therebetween if intermediate electrification steps are taken from each wellbore toward the other by at least one step link utilizing a "surface" ground electrode as seen in FIG. 1.

(4) This process also contemplates the beneficial use of electrolytic or electricity-conducting particles, such as copper, steel filings, etc., in a single wellbore installation in the following manner. As a first step, a hydrofracture may be made in the wellbore prior to any horizon electrical treatment or after processes (1) or (2). The hydrofracture utilizing fluid carrying electrolytic particles is then followed by lateral electrification as in FIG. 1. The current flow is aided by the use of the conducting particles injected in the fracturing process. Such particles enable a greater concentric of current flow in the horizon (as desired) for a greater time and a greater lateral extension than without same.

As a further improvement involving the step of wellbore coking I disclose first hydrofracing in the manner of FIG. 2 with the injection of conductive particles, then utilizing a single well electrification circuit as seen in FIG. 8 with the horizon contacting electrodes positioned at or closely adjacent the fractures whereby the current is carried laterally by the conductive particles a more considerable distance before being displaced upwardly toward the casing. Either of the processes of FIG. 1 or FIG. 8 may be used after the fracturing step. This procedure may be also employed with a plurality of concentrically spaced "surface" ground electrodes as described elsewhere in the application to obtain a wellbore coking effect extending yet further laterally. In all instances, the primary fracture with conductive particles in the fluid, is preferably made at the greatest vertical displacement from the casing as possible.

(5) A fifth form of the instant process comprises the application of the instant process as an improvement over my Serial No. 41,418, supra, wherein electric shock physical fracturing of the wellbore is achieved with the use of but the single wellbore to be fractured, a "surface" ground electrode of the types described and the electricity sources of Serial No. 41,418. Utilizing the apparatus of FIG. 8, the casing alone may be used as the surface ground, but the arcing problem is more severe. However, this gives a more concentric fracture, if such is desired. Concentrically placed "surface" ground electrodes applied far enough away to avoid surface arcing give much better control. In this process, larger area "surface" ground electrodes are required. In the event that the fracturing is desired to be directional as in FIG. 1, the ground electrode or array of same may be laterally displaced a considerable distance whereby to draw the fracturing force in the same direction.

Thus it is seen that I have provided processes of and apparatus for carrying out all of the noted subsurface electrification processes contemplated by the art wherein the art used a plurality of wellbores and a plurality of electrodes in the same horizon yet have limited the necessary apparatus to a single well bore penetrating the horizon with an additional ground electrode. I have improved and modified these processes and added new processes with new results. The tremendous saving and economy of equipment, drilling expenses, etc. will make possible for more general application of electrical subsurface treatment as its undesirable benefits can be achieved at a relatively minimum cost. Additionally it is well-known that unforeseen and unpredicted phenomena can take place in wellbore fluids, the geology and geographic earth formation, the type of mineral fuel or hydrocarbon horizon being treated, etc. By focusing the electrical efforts in a single wellbore and in a single, easily observable "surface" ground electrode or electrode array, adjustments and changes may be undertaken far more quickly and with far less expense and trouble and any difficulties isolated and

compensated for far more easily and quickly than in a multiple wellbore setup as known to the art.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the process.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A process of aiding production of oil from a subsurface oil horizon comprising the steps of drilling a wellbore into an oil horizon in an earth formation, establishing an electrode in said oil horizon in electrical current conducting contact with said wellbore wall, establishing at least one other second electrode in said earth formation in high electrical current conducting surface ground contact therewith outside of, above and laterally displaced from said first wellbore, connecting a high energy source of electrical current to said electrodes, flowing a sufficient quantity of electrical current between said electrodes in said earth formation as to create and establish a zone of increased fluid flow permeability in said oil horizon extending outwardly and laterally from said first electrode toward said lateral position of said second electrode, said second electrode of such physical size and characteristics and so inserted in said surface ground relationship in said earth formation as not to substantially heat the earth formation receiving same at the current densities applied, then ceasing said current flow, then further laterally displacing said second electrode away from said electrode along the line of said fluid flow permeability increase, then again establishing said second electrode as a surface ground and, following the latter, flowing a second sufficient quantity of high energy electrical current between the said electrodes in said earth formation whereby to establish a further laterally extending second zone of increased fluid flow permeability in said horizon extending toward the lateral position of said second electrode, the second electrode in its second position in such physical and electrical conducting character and so positioned in said earth formation as a surface ground as to not substantially heat the earth formation receiving same as to raise the resistance thereat at the current densities applied.

2. A process of aiding production of oil from a subsurface oil horizon comprising the steps of drilling a wellbore into an oil horizon in an earth formation, establishing a first electrode in said oil horizon in high electrical current conducting contact with the said wellbore wall within said horizon, fracturing the oil horizon in said wellbore subsequent to drilling the wellbore into the oil horizon and prior to electrical treatment whereby to establish an outwardly extending radial fracture zone in said horizon, establishing at least one other second electrode in high electrical current conducting surface ground contact with said earth formation outside of, above said oil horizontal and laterally displaced from said first wellbore, connecting a high energy source of electrical current between said electrodes, flowing a sufficient quantity of electrical current between said electrodes in said earth formation as to create and establish a zone of increased fluid flow permeability within said oil horizon, said zone extending laterally from said first electrode within said horizon toward the lateral position of said second electrode with respect thereto, said second electrode of such electrical conducting size and character and so inserted in said earth formation as to not substantially heat the earth formation receiving same at the current densities applied, whereby to substantially raise the resistance thereat.

3. A process as in claim 2 including the step of forcing electrically conductive particles into said fracture prior to any electrification.

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