

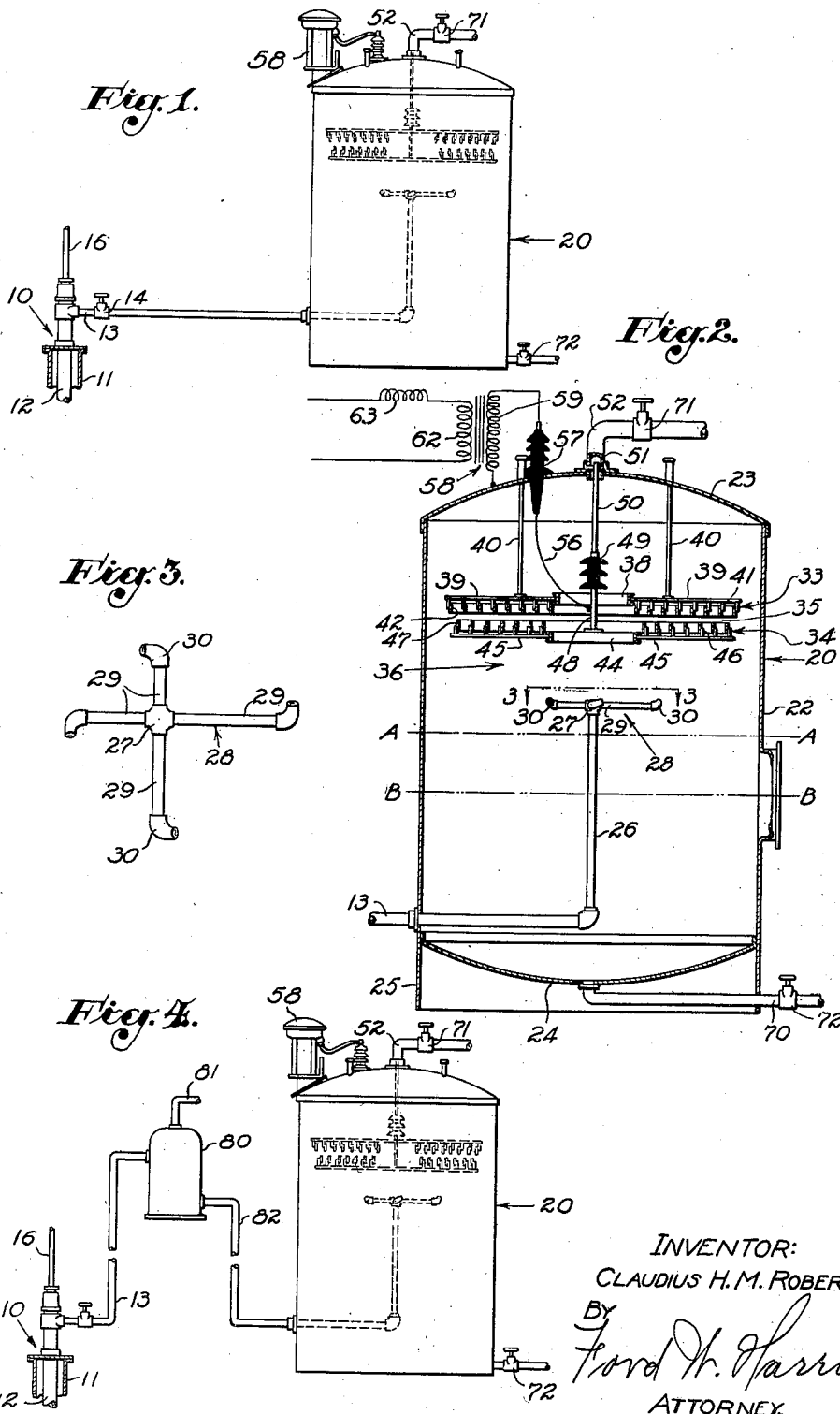
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METHOD AND APPARATUS FOR ELECTRICALLY TREATING EMULSIONS

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METHOD AND APPARATUS FOR ELECTRICALLY TREATING EMULSIONS

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My invention relates to a method of and apparatus for electrically treating emulsions, and more particularly emulsions containing a dispersed phase of aqueous material.

5 The conventional process of electrically resolving crude oil emulsions involves pumping these emulsions into storage tanks, the emulsion being subsequently withdrawn from these tanks and subjected to the action of an electric field to coalesce the dispersed particles. While such a process has proved quite successful in resolving many emulsions, certain defects are inherent therein as will be hereinafter discussed, and it is an object of the present invention to provide an improved method and apparatus for electrically treating emulsions to overcome one or more of the deficiencies of existing electrical processes.

10 In the first place, while numerous emulsions can be dehydrated by this conventional method, other emulsions appear relatively indifferent or entirely unresponsive to treatment under this prevailing system. In general, crude oil emulsions may be classified as treatable or untreatable by this prevailing process. Among the treatable emulsions it has been found that some emulsions treat with great ease while others can be treated only by utilizing in addition to electrical treatment such aids as chemicals, relatively large quantities of heat, recirculation through the electric field, etc. Among the emulsions heretofore considered as substantially untreatable by the electrical process may be mentioned certain of the Mid-Continent oils.

15 Careful investigation of the properties of both the treatable and untreatable types of emulsion has shown that the dispersed particles of any natural emulsion are electrically charged. With some emulsions this charge may be positive and with others it may be negative. Both the magnitude and sign of charge of these particles may be determined by the measurement of cataphoretic mobility in a unidirectional electric field.

20 My investigations further indicate that in certain emulsions these charges remain of substantially fixed magnitude, while in other emulsions they change with age, this change being either a change in magnitude or a change carried to a complete reversal of sign. Investigation of the properties of such emulsions definitely indicates that the electrical process of dehydration is highly effective upon emulsions the sign of charge of which does not materially change in magnitude as the emulsion ages. On the other hand, the electrical process decreases in efficiency when applied to aged emulsions containing particles which

carry charges which materially change in magnitude with increase in age, and those emulsions containing particles which reverse in sign upon aging are quite indifferent to electric treatment after aging. From these observations it appears that the efficacy of the electrical process of dehydration is dependent upon the magnitude and sign of charge borne by the particles of emulsion. Thus, it has been found that certain of the Mid-Continent emulsions, ordinarily considered untreatable by electrical means, are of the type which materially change the charge of the particles upon aging either by a change in magnitude or by complete reversal.

5 However, my investigations have shown that many of the emulsions bearing charges which materially change or reverse with age may be treated electrically if subjected to an electric field before the emulsion has aged to such an extent that the interfacial conditions have become stabilized. Shortly after production of such emulsions, these emulsions appear to have characteristics quite similar to those emulsions which are readily treatable by electrical processes.

10 This aging or stabilization is primarily an adsorption process. I have found that the rate of aging depends upon various factors, and no fixed time limits applicable to all emulsions can be set forth. The adsorption age of an emulsion, as the term is here used, is not dependent solely upon chronological considerations, i. e., it is not dependent exclusively upon the length of time that has elapsed since the emulsion was formed. In any given emulsion system this adsorption age is also dependent upon numerous other factors such as the size of the particles of the dispersed phase, the characteristics of the oil and water components of the system, etc. As to the factor of particle size, it appears that the adsorption process which takes place proceeds at a faster rate upon small particles than upon larger particles. This has been clearly demonstrated by observing the greater time rate of diminution of charge and the earlier reversal of charge which occurs when small particles are present.

15 This aging process may proceed at a relatively fast rate. In such cases it is necessary to treat the emulsion soon after it is formed to secure successful results by the electrical process. In other instances several hours may elapse before the emulsion becomes substantially indifferent to electrical treatment. It thus becomes impossible to set definite time limits within which all such emulsions must be subjected to electric treatment to secure coalescence of the dispersed phase.

However, in general, it can be set forth that the earliest possible treatment is advantageous. After such emulsions have aged for a period of from six to forty-eight hours after production and after exposure to air, a condition which usually occurs when emulsified oil is stored in open tanks, many such emulsions are quite unsu-

ceptible to electric treatment. The factors involved in this aging process may be more easily understood by reference to the following detailed remarks relating to modern concepts of emulsions, though it will be clear that these remarks are set forth as explanatory and not as definitely limiting the invention. In this connection, my experiments indicate that all crude oils can be considered as relatively dilute solutions of ions and polar molecules in a relatively non-polar solvent. Similarly, all waters or brines can be considered as relatively concentrated solutions of ions and polar molecules in a relatively highly-polar solvent. Considering the continuous phase of an emulsion as being oil, and the dispersed phase as being water or brine, there is, of course, a definite interface between the water particles and the oil. It is at this interface that important changes take place both in the aging process and in the process of resolution of the emulsions.

My experiments lead me to the conclusion that petroleum emulsions contain both ions and polar molecules at this interface. An ion, of course, is characterized by possessing a net electric charge. Such an ion, like any charged body, when placed in an electric field, will bodily move toward the electrode of opposite polarity. On the other hand, polar molecules are characterized by possessing no net electric charge. However, their component equivalent charges are so separated that a polar molecule can be considered as being positively charged at one end and negatively charged at the other. Such a polar molecule if placed under the influence of an electric field will not tend to migrate, since it contains no net charge. It will, however, tend to rotate in the field so that its charged ends will come as near as possible to the oppositely charged electrodes, this being due to weak residual fields operative in the immediate vicinity of the polar molecule.

In such a petroleum emulsion, adsorption or preferential segregation of certain components of the system occurs on both sides of the interface between the oil and water. On the water side, such adsorption is predominantly ionic, due to the ionic nature of the aqueous solution, and reaches approximate equilibrium in an extremely short time.

On the oil side, due to the much lower ionic concentration, strengths and mobilities, adsorption proceeds at a much slower rate. Both ions and polar molecules tend to adsorb at the interface. However, in doing so, such materials will orient in a definite manner. It is apparent, then, that the net electrical charge exhibited by the outer side of the adsorbed film will depend specifically upon the number of and ratio of ions to polar molecules present in the film. If, then, adsorption proceeds so that negative ions adsorb on the oil side of the interface, polar molecules will also adsorb there, with their negative ends directed toward the interface and their positive ends directed outwardly. The net free charge of the interface will, therefore, depend upon the excess of charges in the interfacial film.

In addition, due to the difference in strength and configuration of the electric fields surround-

ing ions and polar molecules, and to the previously discussed factors, it is apparent that, when an interface is freshly formed, adsorption of ions from the oil will proceed at a rate much faster than adsorption of polar molecules. In the early stages of adsorption, therefore, the oil side of the interface will be stabilized almost exclusively by ions, which will confer on the dispersed aqueous particles a relatively high net charge, giving a high degree of cataphoretic mobility. It should also be noted, in accordance with accepted theories of physical chemistry, that ionic adsorption is essentially a dynamic and reversible phenomenon. As the interface becomes older, more and more polar molecules adsorb at this interface, displacing some of the ions formerly there. Here they persist tenaciously and more or less irreversibly, due to the fact that they, unlike the ions, are electrically neutral. It is apparent that the slowly increasing concentration of polar molecules at the interface will result in a correspondingly slowly decreasing net external electric charge, which will be reflected in a slowly decreasing cataphoretic mobility. With continued aging, an approximation to equilibrium between ionic and molecular adsorption will eventually be attained or at least a condition in which further appreciable changes in adsorption conditions will occur only over long periods of time. At such approximate equilibrium the emulsion may be said to be aged. If this approximate equilibrium is attained on the ionic side, it is apparent that the dispersed particles will retain the sign of charge which they possessed when freshly dispersed, but will exhibit decreased cataphoretic mobility in proportion to the degree to which the replacement of ions by molecules has proceeded. If the approximate equilibrium is attained on the molecular side, it is equally apparent that the sign of charge of the particles will have reversed and that their cataphoretic mobility will be relatively low.

When such emulsions are subjected to the action of an electric field, the action of this field depends in an important manner upon whether the oil side of the interfaces of the dispersed aqueous particles is stabilized chiefly by ions or chiefly by polar molecules, for adsorbed ions will respond directly and immediately to the applied field and will be set in motion at velocities and in directions dependent upon the relative strengths and distribution of the ionic and applied electric fields. Polar molecules, on the other hand, will not respond to the action of the applied electric field other than to orient slightly in the direction of the lines of force of the external field. My experiments have shown that many of the emulsions heretofore considered untreatable or difficult of treatment by electric methods can be resolved if treated in the early stages of this change in interfacial adsorption conditions.

It should be understood, however, that the invention is not limited to the treatment of such emulsions which have heretofore been impossible to treat electrically or which have been treated electrically only with difficulty. The invention is also applicable to the more easily treated emulsions. In fact, greatly improved results accrue from the use of the present invention in treating substantially all of the emulsions which are now being electrically dehydrated.

The invention thus comprehends the early treatment of emulsions produced by a source. If this source is an oil well, it is usually sufficient to electrically treat the emulsion immediately after

flow from this well. With certain emulsions, however, the adsorption process may progress at such a rate that it becomes desirable to treat the emulsion even before it issues from the top of the well, this species of the invention being shown and claimed in my co-pending application entitled Method of and apparatus for electrically treating emulsions, filed September 25, 1933, Serial No. 690,806, of which the present application is a continuation in part. Both systems are within the scope and the objects of the present invention, this being true whether or not the well is a flowing one or is being pumped.

Numerous factors are present which control the formation of an emulsion in an oil well. In some instances the emulsion may be present in the oil strata itself or may be formed as the oil is flowing through the oil sands and toward the well, assuming that both oil and water are present in these sands. In other instances, oil may enter a well at one level and water may enter at another level. Emulsification can take place either through frictional engagement between the fluids and the walls of the pipes through which the fluids are passed, or it may take place when the liquid flows through a restricted orifice such as may be formed by a flow bean positioned at the bottom or at the top of the well. Further, if the well is being pumped, there is a strong tendency for the emulsion to be formed when the oil and water move through the valves of the pump or when a portion of these fluids escapes past the piston as it reciprocates. The adsorption age of an emulsion may thus depend upon the place where the emulsion is formed, especially as far as the chronological aspect of aging is concerned. Thus, if an emulsion which ages at a fast rate is produced near the lower end of the well, it may be necessary to use an electric field which is positioned in the well.

It is an object of the present invention to electrically treat emulsions before complete stabilization of the interface and preferably while in the early stages of stabilization of the interface. This is true whether the emulsion is one which can be electrically treated with facility or one which can be electrically treated only with difficulty, or one which has heretofore been considered impossible of electrical treatment. Stated on the basis of the emulsion system hereinbefore explained in detail, this treatment will take place in the present invention while the stabilizing action is primarily ionic in character and is in its early stages.

It is another important object of the present invention to electrically treat an emulsion as fast as it is produced from a source by moving this emulsion from the source into an electric dehydrator. This insures that the dehydrator will receive an average cross-section of the emulsion production. This is not the case with conventional dehydrating systems which temporarily store the oil in large tanks prior to dehydration. In such systems it is inevitable that stratification will take place. The usual practice is to withdraw any free water which separates in these storage tanks, the remaining emulsion being drawn from the bottom of the tank and being moved into a dehydrator. It will be clear that the portion of this emulsion first reaching the dehydrator will be much wetter than the portion which will be at last delivered thereto. The emulsion reaching the dehydrator is thus not uniform, and there is a very strong tendency for the dehydrator to bog down when the first portion

of the emulsion is withdrawn from the bottom of the storage tank. This difficulty is entirely eliminated in the present system which proposes to deliver to the dehydrator emulsion constituents such as water and oil at a rate and of a composition as determined by production conditions of the source.

Another feature of the present invention is to provide a method and apparatus which utilizes the properties of the freshly-produced emulsion in assisting the dehydrating action, this being true regardless of whether or not the emulsion is of such character that upon aging it becomes untreatable by electrical means. Thus, by treating the emulsion before or immediately after it issues from the source, all or a portion of the gases in solution in the emulsion can be retained during electric treatment. Material amounts of such gases are in solution in the oil prior to the time that the pressure thereon is entirely released. The presence of such dissolved gases materially reduces the viscosity of the emulsion and appears to further contribute to the efficacy of electric treatment.

It is another object of the present invention to provide a novel dehydrating system utilizing partially or exclusively the naturally elevated production pressures existing in the emulsion source, either naturally or set up therein with the end in view of pumping the emulsion from this source, for moving the emulsion constituents to the dehydrator and, if desired, maintaining a pressure therein. It will thus be apparent that an increase or decrease of the pressure in the source, such as an oil well, will be reflected in increasing or decreasing pressures in the stream flowing to the dehydrator. For instance, if the emulsion source is a well which is being pumped, the production pressure of the pumped emulsion is usually sufficient to force the emulsion constituents through the electric treater. With a flowing well, pressures many times higher are sometimes available and, if desired, may be utilized in developing higher pressures in the electric treater, this being advantageous with certain emulsions. High pressure, of course, tends to retain in the emulsion the dissolved gases which may be present, thus further facilitating electric treatment. Usually, however, the pressure in the dehydrator need not be high to obtain satisfactory results. Pressures from substantially atmospheric to 25 lbs./sq. in. are usually satisfactory, though higher pressures may be used, if desired.

It is another object of the present invention to provide a novel method and apparatus for electrically treating emulsions which operates at much lower temperatures than have previously been considered necessary in commercial practice. Thus, with the conventional dehydrating system in which the emulsion is moved from the source into storage tanks and subsequently dehydrated, temperatures of from 160 to 190° F. have been found desirable. These same emulsions can be treated, by use of my invention, with temperatures ranging from substantially atmospheric temperature to approximately 140° F. In this connection I take advantage of the fact that most crude oil emulsions are produced from the well at super-atmospheric temperatures, by which term I have reference to average yearly temperatures, and further savings result from this factor in view of the fact that in most instances the emulsion can be moved directly from the well to the electric treater without the addi-

tion of external heat thus using in the electric dehydration step the natural temperature characteristic of this well and permitting any raising or lowering of the well temperature to be reflected in a raising or lowering of the temperature of the emulsion constituents reaching the electric treater. External heat may be added, however, if desired.

It is a further object of the present invention to provide a method and apparatus for dehydrating emulsions, to produce pipe-line oil, by a single flow through an electric field. In many instances application of my system of dehydration has resulted in elimination of the necessity of re-running the emulsion one or more times through the electric field to meet pipe-line requirements.

It is another object of the present invention to provide a novel method and apparatus which eliminates the use of chemical agents added to the emulsion to facilitate electric treatment. I have found it possible to most instances to entirely eliminate the use of chemicals if the emulsion is moved from the source directly and immediately into the electric treater. Thus, as to those emulsions which have previously required the use of chemicals prior to electric dehydration, my invention results in a considerable saving in cost of dehydration.

It is another object of the present invention to provide a novel method and apparatus for electrically treating emulsions in which the dehydrated oil is of materially higher gravity, thus permitting the operator to obtain higher prices for the dehydrated oil, this saving often amounting to from two to four cents a barrel. By moving the emulsion directly from the source into an electric dehydrator, the lighter fractions or ends are retained to produce easier electric treatment and also an oil of higher gravity.

It is a further object of the present invention to provide a novel method and apparatus for dehydrating emulsions which is practically automatic in operation and requires a minimum of attention on the part of the operator.

Still another object of the invention is to provide a system of dehydration effecting considerable saving in plant investment. Smaller dehydrators may be utilized and there is no necessity for installation of wet oil storage tanks. So also, it is usually unnecessary to install any dehydrator feed pump.

Another object of the invention lies in the provision of a novel dehydration system capable of handling very wet emulsions, if desired. In one installation my invention has been capable of handling emulsions in which the emulsion constituents contain a total wet cut of water and emulsion of 95%. Freshly-produced emulsions which may contain as a part of the emulsion constituents free water in large quantities can be readily treated due to the facility with which this free water separates from a freshly-produced emulsion, the remainder of the emulsion constituents being readily treated in an electric field.

Further objects and advantages of the present invention will be evident to those skilled in the art from the following description.

Referring to the drawing:

Fig. 1 is a utility view illustrating one possibility of performing the method.

Fig. 2 is a sectional view of the dehydrator shown in Fig. 1.

Fig. 3 is a sectional view taken on the line 3-3 of Fig. 2, and illustrates the distributor.

Fig. 4 is a utility view illustrating an alternative mode of connecting the apparatus.

Referring particularly to Fig. 1, I have indicated a source of emulsion by the numeral 10. This emulsion source is shown as an oil well including the usual casing 11 and oil string 12. A suitable pump, not shown, pumps the oil upward through the oil string 12 and discharges same into a conduit such as a pipe 13 including a valve 14. This pump is usually of the reciprocating type and is driven by reciprocation of a polish rod 16 operatively connected to the pump in the usual manner through a series of sucker rods not shown. Any suitable pumping means may be utilized, preferably delivering a pressure sufficient to force the emulsion through the pipe 13 and into and through the electric dehydrator indicated by the numeral 20. High pressures are not necessary in most instances, it being usually necessary to develop only sufficient excess pressure to cause flow through the dehydrator. However, if desired, a booster pump may be installed in the pipe 13.

No definite dimensions as to the length of the pipe 13 can be given. It is usually necessary to place the dehydrator a slight distance from the derrick of the well. As a general proposition, however, it may be stated that the pipe 13 should be as short as possible so that when treating an emulsion having an aging characteristic impeding electric treatment the emulsion will reach the dehydrator 20 before substantially complete stabilization of the interface and preferably while the emulsion is in the early stages of stabilization of the interface. It is also desirable that this pipe be short to maintain the temperature of the emulsion substantially the same or only slightly lower than when produced by the source. While it is usually desirable to install the dehydrator 20 as close to the derrick as is permissible, this is not required on many emulsions which do not age at a rapid rate.

While various types of dehydrators may be utilized, I have found the form illustrated in Fig. 2 to be very effective and to require a minimum of attention on the part of the operator. Current consumption is low and this type of dehydrator is well adapted to handle the emulsion constituents as they are produced directly from a source such as a well.

Referring particularly to Fig. 2, the dehydrator 20 is shown as including a tank 22 closed at its upper end by an upper wall 23 and at its lower end by a lower wall 24. The tank may be continued downward to form a support 25 resting upon a suitable foundation not shown. The emulsion flows from the pipe 13 directly into the tank through a riser 26 which communicates with a discharge head 27. This discharge head forms a part of a distributor 28, best shown in Fig. 3, as including four pipes 29 of unequal length extending from the distributor head 27. The end of each pipe is preferably provided with an elbow 30 discharging the emulsion tangentially. It is usually preferable to slightly incline these elbows so that they discharge in a direction inclined upward, though this is not essential to the invention. While other distribution systems may be utilized, the embodiment shown is particularly advantageous in that the tangential discharge at different radial distances from the riser 26 uniformly distributes the emulsion and causes the emulsion constituents in the tank 22 to slowly rotate.

Means are provided in the tank 22 for establishing an electric field. Fig. 2 discloses this

means as including an upper grounded electrode 33 and a lower live electrode 34 defining a treating space 35 therebetween. In addition, an auxiliary treating space 36 will be formed beneath the live electrode 34 to preliminarily treat the emulsion.

The upper grounded electrode 33 is shown as including a framework including a ring 38 with a plurality of arms 39 extending outward therefrom. This framework is supported by rods 40 from the upper wall 23 of the tank, being electrically connected to the tank through these rods. A plurality of pins 41 depend from each of the arms 39 in such position as to support a plurality of rings or hoops 42. These hoops are concentrically arranged and may be formed of long and narrow strips of metal bent into circular form and secured to corresponding pins 41 by any suitable means.

Similarly, the lower live electrode 34 includes a framework shown as including a ring 44 with arms 45 extending outward therefrom and carrying pins 46 which in this instance extend upward. Concentric hoops or rings 47 are suitably secured to the pins 46. The framework of the live electrode 34 is supported from a rod 48 depending from an insulator 49, this insulator being suspended on a rod 50 secured in a spider 51 inside the dry oil pipe 52 which withdraws dry oil from the top of the tank 22.

The live electrode 34 is energized through conductor means 56 extending through a bushing 57 suitably mounted in the upper wall of the tank 22. This conductor means is connected to a high-potential source indicated as the transformer 58, this conductor means being connected to one terminal of a high tension winding 59 thereof. The other terminal of this high tension winding is grounded and electrically connected to the tank 22. The transformer 58 includes the usual primary winding 62, it being usually preferable to install a choke-coil 63 in the line supplying an alternating potential to this primary winding. It will be clear, however, that other types of high-potential sources may be utilized without departing from the spirit of this invention.

Energization of the live electrode 34 will establish a plurality of edge-to-edge fields in the treating space 35. It is usually preferable to position the hoops 47 of the electrode 34 directly beneath the spaces between the hoops 42 of the electrode 33. This insures that the most intense portions of each field will be inclined, and insures that all of the emulsion moving upward into the treating space 35 will be subjected to an edge-to-edge field. It will be apparent that as the hoops 47 of the electrode 34 are at the same potential, the annular spaces therebetween will be of an equipotential nature. Similar remarks apply to the annular spaces between the hoops 42 of the electrode 33.

It will further be apparent that energization of the live electrode 34 will establish an electric field in the auxiliary treating space 36 therebeneath. This field may exist to the distributor 28, or to the surface of any body of water carried in the lower portion of the tank 22, or to the bottom of the tank 22 in the event that the body of water is not permitted to separate therein and an emulsion-distributor is utilized which is not positioned in this auxiliary treating space 36.

In operating this form of the invention, the emulsion flows from the well through the pipe 13 and directly into the dehydrator 20. It is usually preferable to preliminarily fill the dehydrator with dry oil prior to the starting of con-

tinued operation. The emulsion will be discharged tangentially through the elbows 30 and will move upward in helical paths through the electric field established in the auxiliary treating space 36. A preliminary treatment will be imparted by this field, after which the remaining emulsion constituents will move through the equipotential spaces between the hoops 47 and thence into the intense field in the treating space 35.

The action of an electric field on such an emulsion is to coalesce the dispersed phase into masses of sufficient size to gravitate from the continuous phase. If a water-in-oil emulsion is being treated, the aqueous phase will be coalesced and the coalesced masses will move downward from the treating space 35 due to gravity. The form of the electrode 34 is such as to permit ready settling of these coalesced masses with a minimum of impedance to this gravitational flow. The dehydrated oil will rise from the treating space 35 through the grounded electrode 33 and will accumulate in the upper end of the tank 22 from whence it can be continuously withdrawn through the pipe 52.

It is preferable to maintain a body of water in the lower portion of the tank 22, the treated oil and the water being withdrawn from this tank at such a rate as to maintain the water level substantially constant. The position of this water level is not critical. Usually it is satisfactory to maintain the water level between the levels A—A and B—B or even beneath the level B—B so that any free water present in the emulsion constituents discharged from the distributor can be removed. However, in some instances it is desirable to maintain the surface of the body of water above the distributor 28 but beneath the live electrode 34 a sufficient distance to prevent any possible arcing. This is especially desirable if the emulsion produced by the source includes in the emulsion constituents large quantities of free water. This free water may be in the form of slugs of water in the emulsion stream, some wells producing such slugs of water at intervals and even to the extent of producing water alone for a very short period of time. It is desirable to remove such slugs of water if they are produced in too great a quantity. By submerging the distributor in the body of water the incoming emulsion constituents are introduced into this body of water in a manner to be washed thereby in this instance, the free water becoming associated with the body of water and the remaining emulsion constituents rising into the auxiliary field in the treating space 36 and then into the main treating space 35. In at least one instance, raising of the water level to a level above the distributor eliminated a sludging tendency present when operating at well temperature and gave a clear water bleed. Such a higher water level also increases the gradient in the auxiliary field and thus increases the coalescing action therein, thereby allowing the main field to operate on an emulsion of lower water content and thus permitting the use of higher potentials or gradients between the electrodes 33 and 34. A high water level also eliminates any tendency toward local jetting or stream flow from the nozzles and gives a more uniform distribution of the emulsion into the treating fields.

It will be apparent that any suitable means may be utilized for regulating the position of the water level. In the embodiment shown this water level is controlled in position by the rate at

which dry oil is withdrawn through the pipe 52 and water is withdrawn from the bottom of the tank through a pipe 70. Suitable valves 71 and 72 or other means respectively control the flow of oil and water through these pipes and can be adjusted to maintain the water level constant with reference to the particular emulsion being treated, only periodic inspection being necessary. These valves and the valve 14 also control the pressure in the tank 22, this pressure being slightly lower than the pressure of the source 10 due to the small frictional drop between this source and the dehydrator 20.

By use of my invention it has usually been found that the dry oil cuts are much lower than with conventional systems of dehydration which involve preliminary storage of the emulsion after production and prior to electric treatment. The dry oil moving through the pipe 52 may be conducted directly to a pipe line or to storage. The lower water content of the oil treated by my process is of special importance in refinery practice, for the lower water content means lower residual emulsion and salt content in the oil delivered to the stills.

It is usually desirable to conduct the emulsion constituents from a source directly to the treater and without permitting substantial separation of these emulsion constituents forming the continuous and dispersed phase liquids of the emulsion. Some wells are provided with conventional gun barrels providing gas-tight tanks, and if my invention is utilized on such wells, there are two possibilities of installing the equipment. If desired, the emulsion can be taken from the gun barrel and moved directly to the dehydrator 20. In this instance it is preferable not to separately withdraw emulsion and water from the gun barrel, but to use this gun barrel merely as a conduit even though a small portion of water may eventually separate therein. Even with this system it will be clear that after equilibrium conditions have been reached the emulsion constituents supplied to the dehydrator will be exactly the same as those produced by the well. Free gas may be withdrawn from the gun barrel in certain instances. On the other hand, it is sometimes desirable to completely eliminate the gun barrel from the system, taking the emulsion directly from the well and moving it directly and immediately to the dehydrator 20.

However, in one or two instances I have found it desirable to preliminarily remove excess undissolved gas from the production flow of the well, especially if the production flow of the well contains or has associated therewith large quantities of such free gas. In this instance a system such as shown in Fig. 4 may be utilized, the pipe 13 discharging into a gas trap 80 which separates the free gas and removes same through a pipe 81. The emulsion constituents move through a pipe 82 to the dehydrator 20. If desired, the gas trap 80 may be supported at an elevation above the dehydrator 20, allowing gravity flow from the gas trap to the dehydrator. In this instance the pumped emulsion moved from the source will be under sufficient pressure to enter the gas trap 80, though auxiliary pumping means may be utilized if desired. No exposure of the emulsion to the atmosphere is permitted in such a gas trap, if used. Thus even with this system the emulsion constituents can be moved into the dehydrator under the influence of the production pressure.

It will be clear that my invention is applicable to the treatment of emulsion produced by various emulsion sources. While in Figs. 1 and 4 I have shown the system in conjunction with an oil well which is being pumped the production pressure thereof forcing the emulsion constituents to the dehydrator, it will be clear that the invention is not limited thereto. For instance, another emulsion source may comprise a flowing well, in which event the naturally elevated production pressure will be sufficient to force the emulsion constituents into and through the dehydrator 20. In this instance the valve 14 may be the conventional flow bean used on such flowing wells. Emulsion from still other emulsion sources can be utilized in the invention without departing from the spirit thereof.

It will further be apparent that various types of dehydrators 20 may be utilized. While I have illustrated a particular type utilizing edge-to-edge fields, this embodiment has been shown only because it is one of the most effective types of dehydrator for use in my system. Various other types of dehydrators can be utilized. These dehydrators may be of the type which permits separation in the main tank, or they may be of the type which coalesces in one container and later delivers the treated emulsion constituents to another container for separation. It will be clear that my invention comprehends the desirability of early treatment of the emulsion before excessive aging thereof, but it is not necessarily limited to immediate separation of the treated emulsion constituents. The electric treatment appears to interrupt the aging process by removing the adsorbed ionic materials from the emulsion interfaces and by increasing the average particle size by coalescing the finely divided particles, and it is entirely feasible to separate the constituents after electric treatment in a tank separate from the container in which the electric field is formed.

As to those emulsions which become electrically untreatable or treatable only with difficulty upon aging, it is usually satisfactory to electrically treat the emulsions shortly after they are produced from the well. However, as to those emulsions which age very rapidly, it is sometimes desirable to electrically treat these emulsions while still in the source. For instance, with such fast-aging emulsions the electric field may be established in the well itself. Structural details of such a down-the-well treating system are not a part of the invention claimed in the present application, being claimed in my co-pending application supra. However, the general concept of early treatment of emulsion is a part of this invention claimed herein, this being true whether the emulsion is treated before leaving the well or after leaving the well, in the event the source of the emulsion is an oil well.

In utilizing the form of the invention in which the emulsion is moved from the source directly into the dehydrator, it is possible in most instances to dispense with any auxiliary heating of the emulsion. Flowing or pumped wells usually produce emulsion at superatmospheric temperature sufficient to permit effective dehydration by my method. However, in some instances a more efficient dehydration will be obtained by heating the emulsion flowing through the pipe 13, and the invention comprehends the use of such heating means if desirable. However, I have found that operating temperatures are much lower with my system than in conventional dehydration systems, so that if heat is supplied,

the temperature increase is relatively lower. This is especially true in view of the fact that my system utilizes the naturally elevated temperature of the emulsion as produced and does not require a treating temperature as high as heretofore used. Numerous installations have been made which require no auxiliary heating and which operate very successfully. While I have not found it essential to heat-insulate the pipe 13, this may be done if desired to prevent the slight loss in heat due to conduction through the walls of the pipe 13.

While I have described in detail the application of this invention to the treatment of emulsions of water (brine) in crude petroleum, it will be clear that I am not limited thereto. My invention is equally applicable to the resolution of any water-in-oil type of emulsion, irrespective of its source or mode of preparation, and limited only by the requirements that the continuous phase of the emulsion should be a relatively non-conducting liquid and the dispersed liquid should be a more-conducting aqueous medium. By the term "aqueous medium" I include water or aqueous solutions or any water-like liquid which has an electric conductivity higher than the liquid of the continuous phase and is relatively immiscible therewith.

Various changes and modifications may be made without departing from the spirit of this invention as defined in the appended claims.

I claim as my invention:

1. A method of electrically treating an emulsion produced by a well and containing a dispersed phase of an aqueous material, which method includes the steps of: subjecting said emulsion shortly after production thereof by said well and while it is in the early stages of stabilization of the interface and in any event before the lapse of from 6 to 48 hours to the action of an electric field of sufficient intensity to coalesce the dispersed phase of said emulsion, said treatment being performed at a temperature insufficient to vaporize the aqueous phase of said emulsion at the pressure existing in said electric field; and separating the phases of said emulsion.

2. A method of electrically treating well-produced emulsions which provide interfaces which become stabilized upon aging, which method includes the steps of: establishing an electric field of sufficient intensity to coalesce the dispersed phase of said emulsion; moving said emulsion into said electric field shortly after production and before complete stabilization of the interface and while the stabilization of said interface is in its early stages and in any event before the lapse of from 6 to 48 hours; and separating the phase liquids of said emulsion.

3. A method of electrically treating, by use of a dehydrator, an emulsion produced by a well at superatmospheric pressure and temperature, which method includes the steps of: moving said emulsion from said well as fast as it is produced thereby and directly into said dehydrator without preliminary separation of the emulsified phase liquids whereby the temperature in said dehydrator changes in response to changes in the super-atmospheric temperature of said emulsion as produced by said well; maintaining the temperature of the flowing material above atmospheric temperature during the flow from said well to said dehydrator; and establishing an electric field in said dehydrator of sufficient intensity to coalesce the dispersed particles of said

emulsion into masses of sufficient size to gravitate from the remainder of the emulsion.

4. A method of electrically treating an emulsion produced from a well at superatmospheric pressure and produced at a temperature characteristic of this well, which method includes the steps of: moving the emulsion constituents from said well as fast as produced and into a chamber without permitting any substantial separation of the emulsion constituents before reaching said chamber; establishing an electric field in said chamber and acting upon said emulsion constituents, whereby raising and lowering of temperature and pressure conditions in the production of said well are reflected in a raising and lowering of the temperature and pressure conditions of the emulsion constituents entering said chamber; and separating the phase liquids of said emulsion.

5. A method as defined in claim 4 in which the temperature is maintained in said chamber by the exclusive use of the natural production temperature of said well with no heat added to said emulsion constituents during flow from said well to said chamber, said temperature in said chamber being below the temperature necessary to vaporize the dispersed phase of said emulsion at the pressure existing in said chamber.

6. A method of electrically dehydrating an emulsion produced from a well at a given production pressure and produced at a natural well temperature characteristic of this well, which method includes the steps of: directly utilizing said production pressure for moving the emulsion constituents as fast as produced by said well and without permitting any substantial separation of the constituent phase liquids of said emulsion directly into a chamber whereby the natural temperature of the emulsion constituents as produced by said well influences the temperature in said chamber; establishing an electric field in said chamber of sufficient intensity to coalesce the dispersed phase of said emulsion; maintaining the temperature in said chamber below the temperature necessary to vaporize said dispersed phase at the pressure existing in said chamber; and separating the phase liquids of said emulsion.

7. A method as defined in claim 6 including the step of removing free gas from said emulsion production of said well in the short interval of time necessary for flow from said well to said chamber.

8. A method of electrically treating an emulsion produced by a well at superatmospheric pressure, which method includes the steps of: utilizing the superatmospheric production pressure of said well to move the emulsion constituents as fast as produced from said well as a stream spaced from the atmosphere and directly into a chamber at a flow rate determined by the production conditions of said well, the conditions of flow in said stream being such as to preclude any substantial separation of the emulsion constituents before reaching said chamber whereby said chamber receives the emulsion constituents shortly after production from said well and receives a stream of said emulsion constituents which may vary in composition from time to time as production conditions of said well change; separating free water from said stream in said chamber; establishing an electric field in said chamber to which the remaining emulsion constituents are subjected; and separating the constituent phase liquids of said emulsion.

9. A method of electrically treating an emulsion produced by a well at superatmospheric

pressure, which method includes the steps of: utilizing the superatmospheric production pressure of said well to move the entire production flow of the well as a stream therefrom; separating free gas from said stream to leave a stream of emulsion constituents including some free water, said stream flowing at a rate determined by production conditions of said well and moving under such flow conditions as to preclude any substantial separation of the emulsion constituents; introducing said stream of emulsion constituents into a chamber while still in flow produced by the superatmospheric production pressure whereby said chamber receives the entire emulsion constituents as produced by said well and of a composition controlled by and varying with the well production; establishing an electric field in said chamber; separating free water from said emulsion constituents in said chamber; subjecting the remainder of said emulsion constituents to the action of said electric field; and separating the phase liquids of the thus treated emulsion.

10. In combination with an emulsion producing well: a pump means in said well for delivering emulsion constituents at the top of said well at superatmospheric pressure; an electric dehydrator tank; means for delivering the entire quantity of emulsion constituents produced by said well to said dehydrator tank under the influence of the pressure developed by said pump means, said means including a conduit communicating at one end with the superatmospheric pressure emulsion delivered at the top of said well and at the other end with the interior of said dehydrator tank, said conduit maintaining flow conditions of said emulsion constituents such that substantially no ultimate separation of the phase liquids takes place during flow therethrough; and means for establishing an electric field in said dehydrator tank of sufficient intensity to coalesce the dispersed phase liquid of said emulsion constituents.

11. In combination with an emulsion-producing oil well: means in said well for producing from the upper end thereof at superatmospheric pressure a production flow stream including emulsion constituents and free gas; an electric dehydrator; a gas trap; means for directly utilizing said superatmospheric pressure to deliver said production flow to said gas trap for removal of said free gas and to deliver the remaining emulsion constituents to said electric dehydrator, said last named means including conduit means connecting said well and said gas trap and connecting said gas trap and said electric dehydrator whereby changes in production conditions in said well are transmitted to said gas trap and to said dehydrator; and means for establishing an electric field in said dehydrator of sufficient intensity to coalesce the dispersed phase liquid of said emulsion constituents.

12. A combination as defined in claim 11 including means for mounting said gas trap at an elevation above the top of said dehydrator whereby the flow of said emulsion constituents from said gas trap to said dehydrator is assisted by

gravity, and in which said electric dehydrator is of the closed type whereby the elevation head of said emulsion constituents in said conduit means between said gas trap and said dehydrator assists in maintaining a superatmospheric pressure in said dehydrator.

13. In combination with an oil well producing an emulsion of the water-in-oil type in which the relative proportions of the total water and oil and the amount of free water may vary as determined by production conditions of said well: means in said well delivering said emulsion to the upper end of said well at superatmospheric pressure; a dehydrator tank containing a body of water in its lower end; means utilizing said superatmospheric pressure for delivering the emulsion constituents to said tank as fast as produced from said well, said means including a conduit means connecting said well and said tank; means for establishing an electric field in the upper portion of said tank of sufficient intensity to coalesce the water phase into masses which will gravitate to said body of water; and distributor means communicating with said conduit means for introducing the emulsion constituents into said tank at a level near the upper surface of said body of water whereby free water is immediately removed and the remaining emulsion constituents rise to said electric field thus compensating for said varying quantities of free water in the emulsion production of said well and preventing excessive current flow in said electric field.

14. A method of electrically treating an emulsion produced from a well at superatmospheric pressure and produced at a temperature characteristic of this well, which method includes the steps of: utilizing said superatmospheric pressure at which said emulsion is produced to move the emulsion constituents from the top of said well as fast as produced by the well to a chamber in a stream confined from the atmosphere and without permitting any substantial separation of the emulsion constituents prior to reaching said chamber, whereby said chamber receives the emulsion constituents shortly after production from said well and receives a stream of emulsion constituents which may vary in composition and flow from time to time as controlled by a change of production conditions in said well; maintaining the temperature in said chamber below the temperature necessary to vaporize the dispersed phase of said emulsion at the pressure existing in said chamber; establishing an electric field in said chamber of sufficient intensity to coalesce dispersed particles; and separating the coalesced particles from the other phase liquid.

15. A method as defined in claim 14, including the step of applying heat to said stream of emulsion constituents flowing as fast as produced by the well and out of contact with the atmosphere to heat same to a temperature above the well temperature but below the temperature at which the dispersed phase will vaporize when at the pressure existing in said chamber.

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