Oct. 31, 1950 D. W. TURNER 2,527,690

ELECTRICAL APPARATUS FOR TREATING EMULSIONS

Filed Jan. 25, 1946 4 Sheets-Sheet 1

Fig. 1

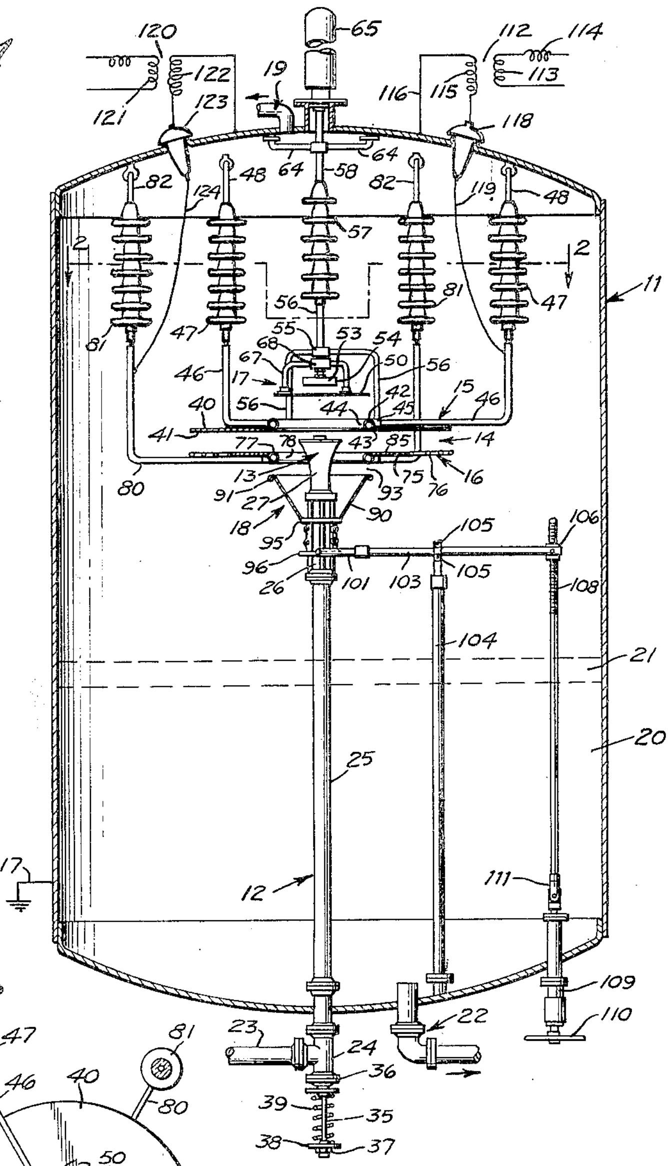
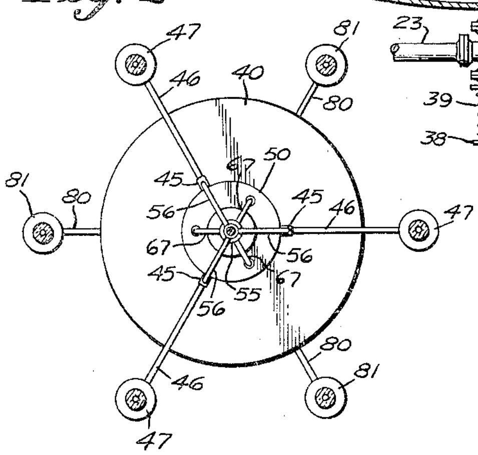


Fig. 2



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ELECTRICAL APPARATUS FOR TREATING EMULSIONS

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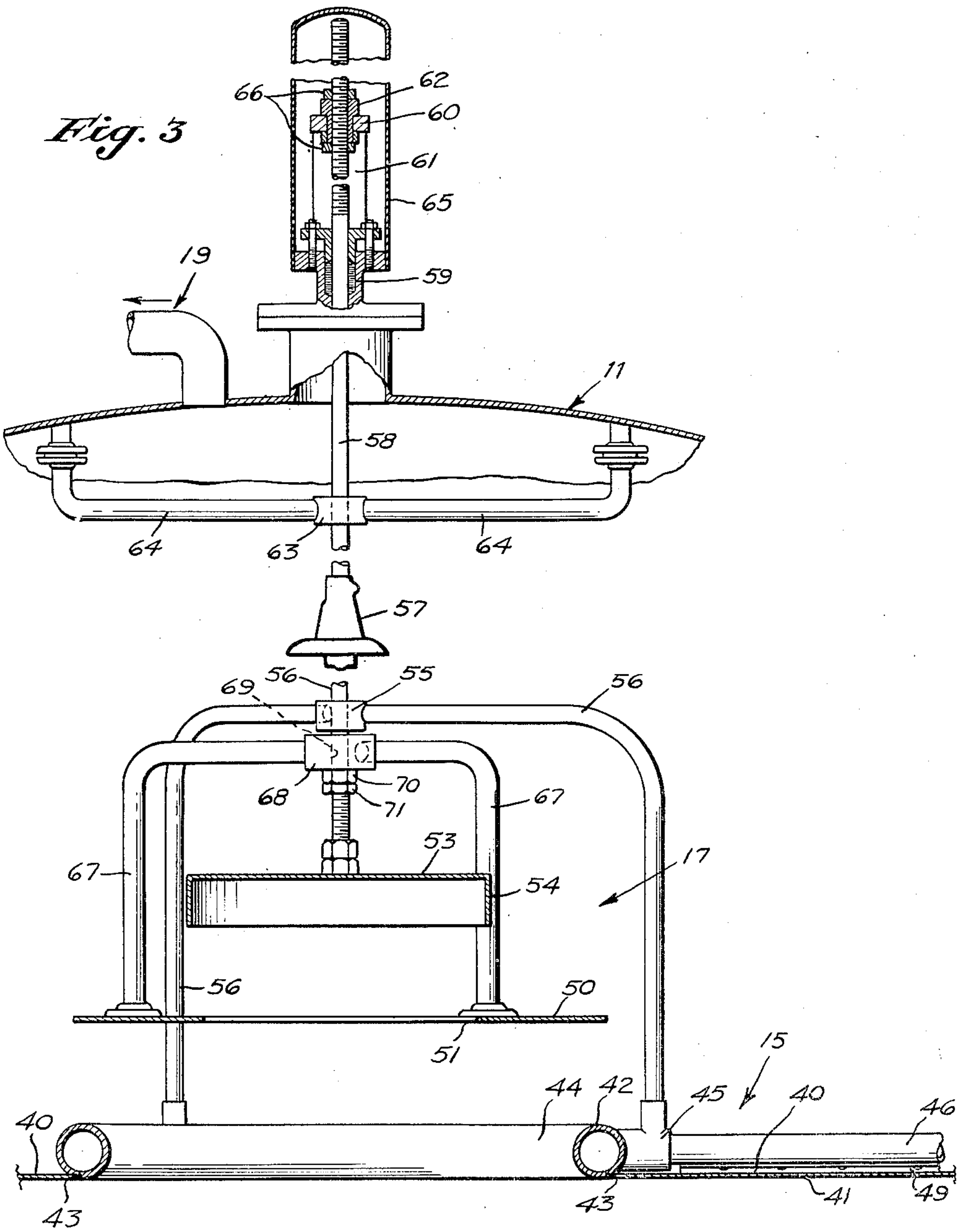
Fig. 3



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ELECTRICAL APPARATUS FOR TREATING EMULSIONS

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Fig. 5

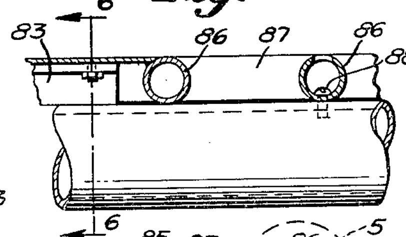


Fig. 4

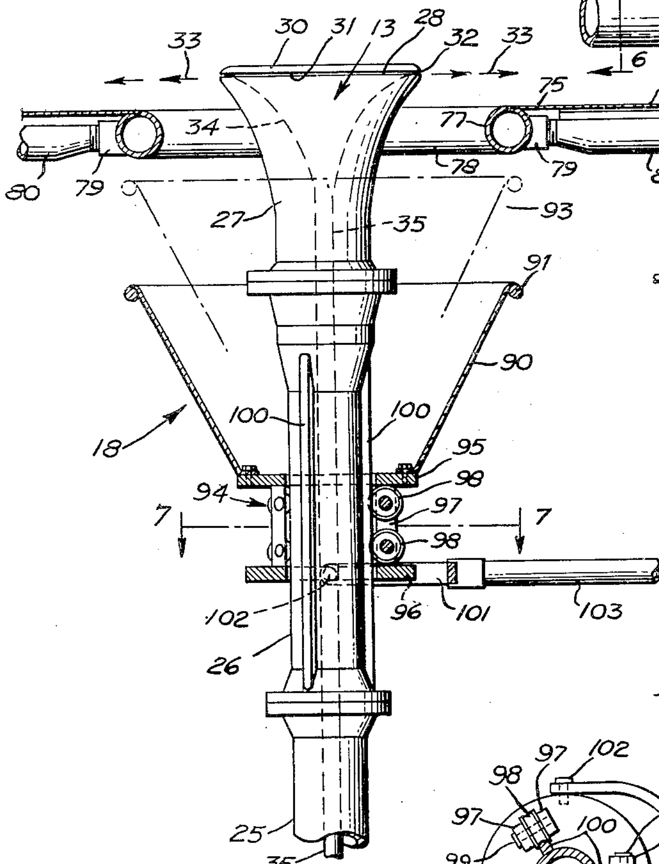


Fig. 6

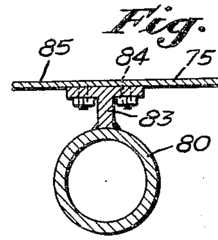
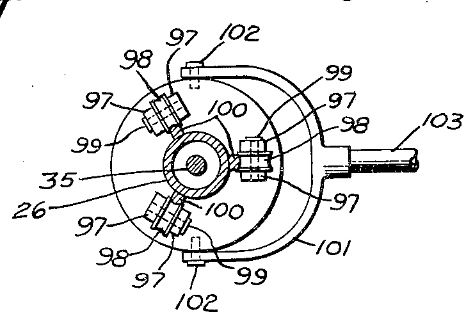


Fig. 7



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ELECTRICAL APPARATUS FOR TREATING EMULSIONS

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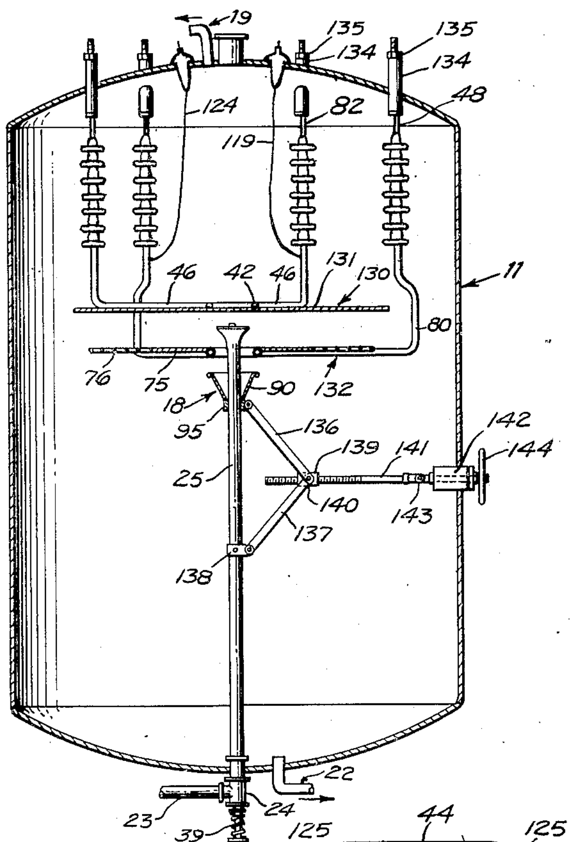

Fig. 8

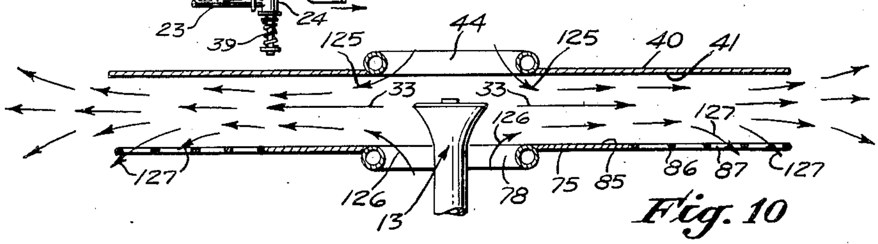

Fig. 9

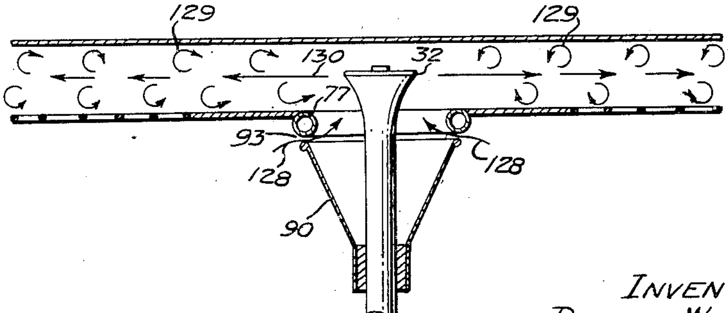

Fig. 10

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2,527,690

UNITED STATES PATENT OFFICE

2,527,690

ELECTRICAL APPARATUS FOR TREATING EMULSIONS

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Application January 25, 1946, Serial No. 643,437

11 Claims. (Cl. 204—302)

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My invention relates to the electrical resolution of various emulsions in which the continuous phase is an oil of relatively high resistivity and the dispersed phase comprises droplets of a relatively immiscible liquid, usually aqueous droplets, the dielectric constants of the two phases differing sufficiently to permit coalescence of the dispersed droplets when the emulsion is subjected to a high voltage coalescing electric field.

It has previously been proposed to establish an electric field between upper and lower interstitial electrodes submerged in an oil environment of a tank. If a thin sheet of the emulsion is discharged radially outward between the electrodes, it will tend to aspirate oil-continuous material from above and below the electrodes through central openings or throats thereof. In the inner portion of the inter-electrode space, the sheet of emulsion will flow radially outward between the two aspirated streams. The three streams may mix as they advance through the outer portion of the treating space. If the upper electrode is interstitial in character, some of the oil may rise therethrough before reaching the outer portion of the inter-electrode space. Likewise, if the lower electrode is of interstitial character, some of the coalesced material may separate therethrough before reaching the outer portion of the inter-electrode space. Large amounts of the oil-continuous material can be aspirated into the inter-electrode space, particularly if the inner portions of the electrodes carry annular plates spaced respectively above and below the radially discharging stream of emulsion.

I have found that substantially improved results can be obtained if substantially all of the oil phase of the emulsion is forced to remain in the field and discharged from the outer portion thereof, as distinct from being permitted to move upward through interstices of the upper electrode. It is an object of the invention to provide an upper electrode which is substantially imperforate in its outer zone. Such a structure tends to reduce electrical breakdown between the electrodes by maintaining a higher resistivity material therebetween in the outer portion of the inter-electrode space.

At the same time, I have found it desirable to separate some of the coalesced masses before discharge from the outermost portion of the field, and it is an object of the invention to provide a lower electrode of interstitial character in its outer zone to permit this, the inner zone of the electrode being preferably imperforate.

It is a further object of the invention to treat emulsions in an electric field bounded on opposite sides by a smooth electrode surface and by

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a plurality of members adjacent which the field may concentrate. At the same time, it is an object of the invention to avoid undue concentration of the electric field adjacent the members by employing members having curved surfaces facing the smooth electrode surface. It is also an object of the invention to provide a plurality of small rods disposed side by side and electrically connected together to form at least a part of one of the electrodes.

Heretofore, it has been thought desirable to aspirate into the field relatively large volumes of oil-continuous material of relatively high resistivity from above the upper electrode. It was thought that this liquid, being of higher resistivity than the incoming emulsion, would decrease any tendency to short-circuit between the electrodes. On many oils, I have found that substantially better treatment can be obtained by decreasing or entirely eliminating such aspirated flow from above the upper electrode. It is an object of the invention to decrease or eliminate such aspirated flow and to provide an apparatus for reducing or blocking substantially completely such aspirated flow.

The aspiration of oil-continuous material into the field from below the lower electrode may return to the field substantial amounts of sludge or unresolved emulsion for additional treatment. However, my investigations show that it is often desirable substantially to reduce the volume of this aspirated liquid even though it is not stopped completely. It is an object of the invention to reduce the volume of liquid aspirated from below the lower electrode. Another object is to apply an intense electric field to any remaining aspirated oil-continuous material drawn from below the lower electrode. In many instances, this field may have a voltage gradient at least as high as, or higher than, the voltage gradient between the two main electrodes.

It is another object to provide a novel damper, preferably adjustable from a position outside the tank, to control the aspiration of oil-continuous material from below the lower electrode.

The emulsion may be discharged radially outward into the field through an annular discharge slit of a distributor. If the throats of the upper and lower electrodes are open, any decrease in width of this slit will increase the jet velocity of the emulsion and also the volume and velocity of each of the two aspirated streams. The outward velocity at any given radial position between the electrodes will thus be increased by narrowing the slit and decreased by enlarging the slit, i. e., the average outward velocity between the innermost and outermost portions of the inter-electrode space will change with a change in width of the slit. It is an object of the present invention to provide an electrode system in which such average velocity can be made substantially constant irrespective of changes in the width of this slit.

It is another object of the invention to increase or decrease the turbulence in an electric field without increasing or decreasing the average velocity in the inter-electrode space.

It has heretofore been proposed to purify oils electrically by emulsifying a relatively fresh water therein and subsequently resolving the emulsion. For example, this process can be used to remove water-soluble or water-wettable impurities from an oil of low water content containing not more than a few per cent of water. Thus, the process is widely used in removing inorganic salts from mineral oils before distillation or cracking thereof. By use of the present invention, it has been found possible substantially to reduce the amount of relatively fresh water in such processes, and it is an object of the invention to purify oils electrically by mixing therewith smaller amounts of relatively fresh water than have heretofore been considered necessary.

Still another object is to improve the general operation of an electric treater in a manner to better the electrical treatment, the settling, the amount of residual dispersed material remaining in the treated oil, the amount of residual impurities in the treated oil, etc.

Still further objects and advantages of the invention will be evident to those skilled in the art from the following description of exemplary embodiments.

Referring to the drawings:

Fig. 1 is a vertical sectional view of one embodiment of the invention comprising upper and lower electrode units respectively provided with dampers;

Fig. 2 is a horizontal sectional view, taken along the line 2—2 of Fig. 1;

Fig. 3 is an enlarged vertical sectional view showing certain details of the damper for the upper electrode and the tank-external control therefor;

Fig. 4 is an enlarged vertical sectional view showing certain details of the lower electrode and the adjustable damper therefor;

Fig. 5 is an enlarged fragmentary view of that portion of the lower electrode structure of Fig. 4 within the dotted circle indicated by the numeral **5** of Fig. 4;

Fig. 6 is a sectional view, taken on the line **6—6** of Fig. 5;

Fig. 7 is a fragmentary sectional view, taken along the line **7—7** of Fig. 4;

Fig. 8 is a vertical sectional view of an alternative embodiment of the invention; and

Figs. 9 and 10 are diagrammatic views respectively suggesting certain phases of the operation with and without large aspirated flows from above and below the electrode system.

Referring particularly to Fig. 1, the treater of the invention includes, generally, a tank **11**, usually of the pressure type, to which the emulsion is supplied by a pipe means **12**. The emulsion is delivered to a distributor **13** from whence it discharges as a radially flowing sheet directed along a treating space **14** bounded by an upper electrode structure **15** and a lower electrode structure **16**. In this embodiment, the upper electrode structure **15** is equipped with a flow control means, hereinafter designated as a damper means **17**,

for controlling the amount of oil-continuous liquid aspirated through the upper electrode structure **15**. Likewise, the lower electrode structure **16** is equipped with a flow control means, hereinafter designated as a damper means **18**, for controlling the amount of oil-continuous liquid aspirated through the lower electrode structure **16**. An intense electric field is established in the treating space **14** to coalesce the dispersed phase of the emulsion into oil-dispersed masses of sufficient size to gravitate from the oil. The separated oil is withdrawn from the upper portion of the tank **11** through an outlet means **19**. The coalesced material of the dispersed phase, hereinafter exemplified as a coalesced aqueous material, gravitates to the lower end of the tank **11** to form a body **20** below an interfacial zone **21**, shown between dotted lines, and above which the continuous phase is oil and below which the continuous phase is the dispersed-phase material, e. g., an aqueous material. Such aqueous material is removed from the body **20** through an outlet means **22**. The outlet means **19** and **22** are preferably valved to maintain a pressure within the tank **11**, and the relative flows therethrough are controlled to maintain the interfacial zone **21** below the electrodes and substantially constant in vertical position during continued operation of the treater.

The emulsion is delivered to the pipe means **12** under substantial pressure by any suitable means. This emulsion may be a crude oil emulsion such as produced from wells, in which event the treater will effect dehydration thereof. In other instances, the incoming emulsion may be synthesized by mixing streams of oil and a liquid relatively immiscible therewith. For example, streams of oil and aqueous material, e. g., relatively fresh water, may be mixed to form an electrically treatable oil-continuous emulsion. Various types of emulsions thus formed can be delivered to the pipe means **12** and various mixing means can be employed for forming them, examples of such emulsions and such mixing means being disclosed in the patent to Harold C. Eddy, No. 2,182,145.

As suggested in Figs. 1 and 4, the pipe means **12** may include an inlet pipe **23** connected to a pipe T **24** communicating with a riser pipe **25** which includes a flanged section **26** carrying an outer or stationary member **27** of the distributor **13**. This outer member flares outwardly and upwardly and provides a smooth lip **28** at its upper end. The distributor **13** includes also a movable head member **30** having a smooth lip **31**, the lips **28** and **31** contacting when no emulsion is flowing through the pipe means **12** but separating during, and because of, such flow to provide a narrow annular discharge slit or orifice **32** which discharges a thin radially-flowing sheet of the emulsion into the inter-electrode treating space **14**, the emulsion sheet being indicated by arrows **33** of Fig. 4. The head member **30** provides a tapered portion **34** which spreads the emulsion stream to the discharge orifice **32**.

To permit adjustment of the width of the discharge orifice **32** from a position outside the tank and during continued operation of the treater, a rod means **35** extends from the head member **30** to any suitable means for applying to the head member through the rod means an adjustable resilient force in a direction tending to close the discharge orifice **32**. As diagrammatically suggested in Figs. 1 and 4, the rod means **35** extends downwardly through the riser pipe 25 and through a suitable packing gland structure 36 of the pipe T 24. The lowermost end of the rod means 35 is threaded to receive a nut 37 bearing against a washer 38. A spring 39 is compressed between the washer 38 and a portion of the gland structure 36. This spring exerts a resilient downward force on the rod means 35, this force being adjustable by turning the nut 37. With a given volume of emulsion moving through the pipe means 12, the resilient force can be adjusted to change the width of the discharge orifice 32 and thus change the velocity of the radially discharging emulsion stream, the width of this stream, or the mixing action on the stream during flow through the distributor 13. The particular adjusting means shown is merely exemplary of numerous means for adjusting the resilient biasing force on the movable head member 30 from a position outside the tank 11.

The upper electrode structure 15 is best shown in Figs. 1, 2, and 3. The upper electrode itself is shown as including an imperforate annular plate 40 providing a lower smooth surface 41, preferably extending horizontally and bounding the upper portion of the electric field in the treating space 14. The upper electrode includes also a ring 42. The periphery of this ring preferably meets the surface 41 without sharp edges adjacent which the field might concentrate, and this may be accomplished by cutting an annular groove 43 in the pipe to fit the inner periphery of the plate 40, this plate and the ring being welded together and the junction smoothed to avoid field-concentrating edges. The ring 42 forms a throat 44 which, when uncovered, conducts oil-continuous liquid from above the upper electrode structure 15 into the inner portion of the treating space 14 under the aspirating action of a radially-discharging emulsion stream.

A suitable framework suspends the upper electrode structure 15 in an oil-continuous environment of the tank 11. As shown, this framework includes three equally spaced nipples 45 secured to the ring 42 to receive radial pipes 46 which are bent upward and suspended from three suspension insulators 47 which, in turn, are suspended from rods 48 depending from the upper wall of the tank. The plate 40 is secured to the horizontal portions of the pipes 46 by suitable brackets 49 of the type shown in Fig. 6.

In this embodiment of the invention, it is desirable to be able to close partially or completely the throat 44 to restrict or eliminate the oil-continuous material aspirated into the treating space. The damper means 17 serves this function and is shown as including a damper member 50 comprising an annular plate of sufficient size to seat on the ring 42 and providing a central opening 51 of smaller size than the throat 44 to form a more restricted throat for the aspirated material when the damper member is seated. The damper means 17 includes also a damper member 53 which may be lowered to close the central opening 51. This damper member 53 is shown of inverted cup shape providing a lip 54 engageable with the damper member 50. The inverted cup is imperforate, whereby lowering of both damper members will prevent any liquid from being aspirated through the throat 44.

Suitable means is provided for vertically moving the damper members from a position outside the tank while maintaining these damper members at the potential of the upper electrode. In this connection, Figs. 1, 2, and 3 show a guide member 55 fixed to the upper electrode structure at a position vertically above the center of the throat 44 by three rods 56 attached to the guide member and the nipples 45. A rod 56 slides through the guide member 55 and carries the cup-shaped damper member 53. A suspension insulator 57 suspends the rod 56 and, in turn, is supported by a vertically movable rod 58 which extends to the exterior of the tank 11 through a stuffing box 59. A plate 60 is supported by arms 61 above the stuffing box and journals an internally-threaded sleeve 62 which receives the upper threaded end of the rod 58. By turning the sleeve 62 and holding the rod 58 against rotation, the rod and its affixed damper member 53 will be moved up and down. The rod 58 is steadied and guided in this movement by a guide member 63 centered with respect to the vertical axis of the tank by rods 64 suitably secured to the upper end of the tank. A cover 65 protects the adjustment means from the atmosphere and may be removed when adjustment is desired. The rod 58 may be held in fixed adjustment by jam nuts 66 threaded to the rod above and below the sleeve 62.

It is preferred that movement of the rod 58 shall also adjust the position of the damper member 50. This may be accomplished by suspending the damper member 50 from three rods 67 bent inward and secured to an operating member 68 below the guide member 55 and providing an opening 69 which slidably receives the rod 56. The lower end of this rod is threaded to receive a nut 70 and a jam nut 71 adapted to engage the operating member 68 when the rod 56 is lifted, thus lifting the damper member 53.

The damper members 50 and 53 can be moved sequentially into closing relationship with the throat 44. Thus, when the members are in the relative position shown in Fig. 3, any lowering of the rod 58 while the damper member 50 is suspended by the nut 70 will move this damper member toward the ring 42. When seated on this ring, the weight of the damper member 50 will be supported thereby and any further downward movement of the rod 58 will move the damper member 53 downward relative to the damper member 50, the nut 70 moving away from the operating member 68. When the rod 58 is in its lowermost position, the damper member 53 will engage the damper member 50 which, in turn, will engage the top of the ring 42, and substantially all aspiration through the throat 44 will stop. When the rod 58 is lifted, the damper member 53 will first lift from the damper member 50 to open the throat formed by the opening 51. As soon as the nut 70 engages the operating member 68, further upward movement of the rod 58 will lift both damper members as a unit, opening the throat 44 to the aspirated material.

The lower electrode structure 16 and its damper means 18 are best shown in Figs. 1 and 4. Referring thereto, the lower electrode structure includes an inner portion comprising an imperforate annular plate 75 positioned below an inner portion of the plate 40 to form an inner or first treating zone. The lower electrode structure includes also an outer interstitial portion positioned below an outer portion of the plate 40 to form an outer or second treating zone. This outer interstitial portion preferably comprises a plurality of concentric rings 76. A ring 77 secured to the annular plate 75 provides a throat 78 through which liquid may be aspirated into the treating space 14. The periphery of the ring 77 may be notched to receive, and be welded to, the inner edge of the annular plate 75, the junction being smooth to avoid any protruding sharp edge adjacent which the electric field might concentrate.

The lower electrode is supported on a suitable framework of which the ring 77 is a part. For example, the ring 77 may carry three outwardly-extending nipples 79, respectively receiving three pipes 80 which are bent upwardly and are hung from three suspension insulators 81 which, in turn, are suspended from rods 82 depending from the top of the tank 11. The suspension insulators 47 and 81 are preferably disposed alternately in a circular pattern to be equidistant from the vertical axis of the tank and equidistant from each other as suggested in Fig. 2.

The annular plate 75 is rigidly secured to the pipes 80 by T-shaped brackets 83, best shown in Figs. 4, 5, and 6. The central leg of each bracket may be welded to the pipe 80. The arms of the bracket may be bolted to the plate 75 by use of bolts 84, suggested in Fig. 6, the heads of the bolts being countersunk in the plate so that the plate provides a smooth surface 85 without exposed or projecting edges adjacent which the field might concentrate. Correspondingly, the inner treating zone of the inter-electrode space is between the smooth surfaces 41 and 85 of the upper and lower annular plates 40 and 75. Such a field is of substantially uniform voltage gradient in the inter-electrode space.

On the other hand, the outer treating zone is desirably of a different character, namely, a field which is more concentrated adjacent one electrode than the other. This is most desirably accomplished by bounding the outer zone of the field on one side by a flat surface and on the other side by a plurality of rings 86 disposed side by side. In the construction shown in Figs. 4 and 5, these rings are of circular cross section and may be either solid or tubular. They are drilled to receive screws 88 threaded into the pipes 80, being thus held in concentric relationship to provide annular spaces 87 which make the lower electrode structure interstitial to permit separation of some of the coalesced material from the outer zone of the electric field. The innermost of the rings 86 is preferably welded to the outer edge of the annular plate 75 to form a smooth junction without protruding sharp edges.

The rings 86 are of sufficiently small diameter to concentrate the field thereadjacent but not to the extent as would the edges of thin concentric rings formed of upstanding ribbon-like material. This has been found advantageous in the present treater, although it should be understood that it is the contour of the upper portions of the rings which determines the degree of field concentration and not the circular cross section thereof, wherefore other cross sections may be employed. By way of example, the radius of curvature of the portions of the rings facing the annular plate 40 may desirably be about $\frac{1}{32}$ to $\frac{1}{8}$ of the inter-electrode spacing.

In the absence of the damper means 18 for the lower electrode structure, a substantial amount of oil-continuous material will be aspirated into the treating space 14 through the throat 78 from a position below the lower electrode structure. Heretofore, it has been thought desirable to maximize such aspiration, particularly as the oil-continuous material contains some sludge or unresolved emulsion aspirated from a position above the interface or zone 21. I have found that better results can be obtained by limiting the recirculation of such oil-continuous material into the treating space 14, particularly in handling emulsions which do not contain excessively large amounts of dispersed-phase material. Depending upon operating conditions, the oil-continuous material aspirated from below the lower electrode structure may have a relatively low resistivity, in some instances lower than the incoming emulsion due to a high concentration of the dispersed-phase material which may comprise sludge. The damper means 18 can advantageously be used to control the amount of oil-continuous material thus recirculated.

The damper means 18 is best shown in Figs. 1, 4, and 7. It includes a damper member 90, desirably of conical form to surround the lower portion of the distributor 13. The upper end of the damper member 90 provides an annular lip 91 disposed below, and movable toward and away from, the ring 77 to provide a variable-area passage 93 through which the aspirated material passes. The lower end of the damper member 90 is fixed to a carriage 94, shown as including upper and lower plates 95 and 96 closely surrounding the flanged section 26 of the riser pipe 25 and six arms 97 holding the plates in spaced relationship. The arms are paired to form three equally spaced groups and a pair of rollers 98 is journalled on pins 99 extending between the arms of each pair. These rollers provide grooved peripheries rolling vertically on three track members 100 extending outward from the periphery of the flanged section 26.

The vertical position of the damper member 90 relative to the lower electrode structure is preferably adjustable from a position outside the tank 11. One way of accomplishing this is suggested in Figs. 1 and 7 and includes a yoke 101 pivoted by pins 102 to the lower plate 96 of the carriage 94, this yoke being carried by an arm 103. A post 104 extends upward from the bottom of the tank and carries rollers 105 which permit the arm 103 to rock or slide relative to the fulcrum formed by the rollers 105. The end of the arm 103 pivotally carries a nut 106 threaded on a rod 108 which can be turned from a position outside the tank. For example, this rod 108 may extend through a suitable stuffing box 109 to the exterior of the tank to be turned by a handwheel 110. A universal joint 111 is preferably interposed in the rod 108. When the handwheel 110 is turned in one direction, the nut 106 will rise and the carriage and its attached damper member 90 will move downward to increase the size of the passage 93. Opposite movement of the handwheel 110 will raise the damper member 90 to restrict the passage 93.

A high potential difference is maintained between the upper and lower electrode structures 15 and 16 during operation of the treater to establish a coalescing electric field in the treating space 14. Any suitable source of potential can be used. Because both electrode structures are insulated from the tank, it is desirable to apply above-ground potentials to each in such manner that the potential between the electrode structures is substantially greater than the potential between either electrode structure and any grounded portion of the equipment. A typical energizing system is suggested in Fig. 1 as comprising a transformer 112 providing a primary winding 113 connected to a source of alternating potential through the usual choke coil 114. This transformer provides a secondary winding 115, one terminal of which is connected to the tank through conductor 116 and thus to ground in view of the grounding of the tank, as indicated by the numeral 117. The high potential terminal of the transformer is connected through a bushing 118 and a lead-in wire 119 to the upper electrode structure. Similarly, another transformer 120 provides a primary winding 121 connected to the same source of alternating potential. This transformer provides a secondary winding 122, one terminal of which is grounded and the other terminal of which is connected through a bushing 123 and a lead-in wire 124 to the lower electrode structure 16. The transformers 112 and 120 are usually identical in output characterstics and are properly phased so that the voltage between the electrode structures is twice the voltage developed by either transformer and twice the voltage between either electrode and any grounded portion of the equipment.

The operation of the invention and additional differences from other electrode structures can best be understood from Figs. 9 and 10. Fig. 9 diagrammatically suggests operating conditions when the damper means 17 and 18 are completely open or not used. The outwardly-directed high velocity sheet of emulsion from the distributor 13, indicated by the arrows 33, will move outward in the inter-electrode space to aspirate through the throat 44 a stream of oil-continuous material, the flow being indicated by arrows 125. Similarly, oil-continuous material will be aspirated through the throat 78, the flow being indicated by arrows 126. In the innermost zone of the inter-electrode space, the three streams will flow sandwich-like. However, during continued outward movement, these streams will more or less mix to form a composite stream. The electric field established between the electrodes will tend to coalesce the dispersed-phase material into masses of sufficient size to gravitate from the oil.

Due to the imperforate nature of the upper electrode 40, no oil can move through the upper electrode and is restrained to flow from the outer portion of the inter-electrode space. Even with the damper means open to produce the flows suggested in Fig. 9, such a substantially imperforate upper electrode is desirable and tends to reduce electrical breakdown or flashover between the electrodes by maintaining a higher resistivity material therebetween. It is desirable, however, that the upper electrode be bounded by the smooth surface 41 without projections adjacent which the field might concentrate or which might extend into the path of the streams indicated by arrows 33, 125, or 126.

On the other hand, it is distinctly preferable that the outer zone of the lower electrode structure be interstitial to permit separation of some of the coalesced masses from the inter-electrode space before reaching the outermost portion of this space. If the lower electrode is made imperforate throughout its radial dimension, coalesced masses will tend to settle thereon and arcing or unstable electrical conditions will result. On the other hand, by providing the spaces 87 in the outer region of the lower electrode, some of the coalesced masses can move therethrough as suggested by the arrows 127. In all instances, I have found it preferable to use a lower electrode imperforate in its inner region and interstitial in its outer region. The relative extent of these regions depends in part upon the velocity of the stream 33 if both dampers are open, and upon the volume rate of flow if both dampers are substantially closed. In most instances, the diameter of the outer edge of the annular plate 75 should not be much more than 60% of the diameter of the outer edge of the annular plate 40 of the upper electrode. An arrangement in which the annular plate 75 is about one-half the diameter of the annular plate 40 will be found satisfactory in most instances.

If the aspirated flows are blocked by complete closing of the upper damper means 17 and almost complete closing of the lower damper means 18, the flow conditions will be substantially altered and are suggested in Fig. 10. With no oil-continuous material aspirated from above the upper electrode and only a small amount of oil-continuous material aspirated from below the lower electrode through the now-restricted passage 93, as suggested by the arrows 128, the average outward velocity in the inter-electrode space and the turbulence therein will differ substantially from the conditions suggested in Fig. 9.

Considering first velocity relationships, it should be recognized in both instances that the radial velocity in the inter-electrode space will progressively decrease toward the outer portion thereof due to the increasingly large cross-sectional area. With a system as in Fig. 9, if the narrow annular discharge slit or orifice 32 of the distributor is decreased in width, the jet velocity of the emulsion will increase, as will also the volume and velocity of each of the two aspirated streams indicated by the arrows 125 and 126. The overall result is that the velocity at any given radial position will be increased by a small closing of the discharge orifice and decreased by a slight enlargement of this orifice. Stated in another way, the average outward velocity between the innermost and outermost portions of the inter-electrode space will change with a change in width of the discharge orifice. On the other hand, with a system operating in accordance with Fig. 10, the average velocity in the inter-electrode space can be made substantially constant irrespective of changes in the width of the orifice. If there is little or no aspiration into the inter-electrode space, the average outward velocity therein will vary almost entirely with the volume of the emulsion introduced and not its jet velocity. Velocity relationships in the inter-electrode space determine the length of time that an increment of emulsion is within the field. By reducing or eliminating the aspirated flows, the time that such increment of emulsion is in the field can be increased, with the result that more complete or better treatment is obtained.

As to the turbulence in the inter-electrode space, the flow conditions suggested in Figs. 9 and 10 produce quite different effects. In Fig. 10, emulsion is jetted into a body of partially treated, freshly-discharged emulsion constituents in the inter-electrode space, with the result that the type and intensity of the turbulence is quite different from that resulting when operating in accordance with Fig. 9. There, very little turbulence is produced by the sandwich-like flow in the inner region of the inter-electrode space and there is a relatively small difference in outward velocity between the emulsion stream, indicated by the arrows 33, and the aspirated flows indicated by the arrows 125 and 126. The aspirated material flows in the same direction and in confining relationship with the emulsion stream. On the other hand, in Fig. 10, the radial jet of emulsion sets up localized, ring-type, or eddy-like turbulence suggested by arrows 130. As compared with the mode of operation suggested in Fig. 9, such eddy-like circulations produce a greater degree of turbulence. With a given emulsion velocity, operation in accordance with Fig. 10 will produce a greater and more desirable type of turbulence than that suggested in Fig. 9. Operation as suggested in Fig. 10 gives a greater turbulence in the inter-electrode space with lower emulsion velocities, a very advantageous feature in the electrical resolution of emulsions, and makes possible a wide range of turbulent conditions with a relatively small change in emulsion velocity from the distributor.

Turbulence in the electric field is desirable as decreasing any tendency for short-circuiting between the electrodes. In addition, turbulence is desirable as randomly bringing the individual dispersed droplets closer to each other. As such droplets are in large measure destabilized by the electric field, any mechanical contact between droplets because of turbulence may produce coalescence. In addition, if the spacing of two droplets along a line joining the electrodes is transiently reduced by turbulence, there is greater likelihood of electrically induced contact therebetween resulting in coalescence. The eddy-type circulation of Fig. 10 is particularly desirable in facilitating mechanical or electrically induced coalescence.

In operating in accordance with Fig. 10 and if the lower electrode structure **16** is maintained above ground potential, the throttled flow of oil-continuous material indicated by the arrows **123** moves at relatively high velocity through the passage **93** and is subjected to an intense auxiliary electric field therein before reaching the main treating space. The intensity of this auxiliary electric field will vary with the position of the damper member **90** but I have found that this auxiliary field can be made unexpectedly intense without causing short-circuiting. In fact, the average voltage gradient in the auxiliary field can usually be made equal to, and sometimes substantially greater than, the average voltage gradient between the annular plates **60** and **75**. For example, in resolving emulsions containing relatively small amounts of dispersed aqueous material, e. g., about 6–10%, and with voltage gradients of about 16,000–18,000 volts per inch in the treating space **14**, voltage gradients of about 33,000 volts per inch can usually be maintained in the passage **93**. While the lower electrode structure can be short-circuited to ground if the damper member **90** is moved too close to the ring **77**, I have found it desirable that this spacing should be a minimum to maximize the field intensity in the passage **93**. In fact, I prefer to operate with such a narrow passage **93** that the lower electrode structure will short-circuit to the damper member **90** if the emulsion flow from the distributor is stopped. Even with electrode spacings of 3½–4″, I have found it possible to move the lip **91** of the damper member **90** to within 1″ of the ring **77** when treating many emulsions.

Additionally, the spacing of the main electrodes of the invention can be reduced and power consumption of the treater decreased as compared with older types of electrode structures in which both the upper and lower electrodes were formed of ribbon-like concentric rings. Where a spacing of 4–4½″ was conventionally employed with the older electrode system, the spacing in the instant invention can be in the neighborhood of 3½″ on the same oils, and the applied voltages can be proportionally decreased to give the same voltage gradient, thus correspondingly decreasing the power requirements even while producing the improved electrical resolution hereinbefore mentioned.

When used in the electrical purification process mentioned above, the invention produces markedly superior results. For example, in electrically desalting a low-water-content oil, a relatively fresh water may be mixed therewith and the resulting emulsion resolved by the treater and the methods of the present invention. It is often desirable that the volume of relatively fresh water employed be a minimum. In prior electrical desalting practice, the amount of relatively fresh water was usually 10–20% or more by volume of the impure oil, and infrequently as low as 8%, these minimums depending upon the oil being desalted. By use of the present invention, the amount of relatively fresh water employed can be substantially reduced and in some instances halved.

When the oil-continuous liquids aspirated from above and below the electrodes are reduced in accordance with the present invention, the volume of liquid passing outward between the electrodes is less and the velocity is correspondingly reduced, with the result of favoring settling of the coalesced material, lengthening the time of application of the electric field, reducing the residual water and the residual salt in the purified oil discharging through the outlet means **19**, increasing the capacity of the treater, and generally increasing the treater efficiency. For example, if the total volume of aspirated material is equal to the total volume of emulsion, the outward velocity at any radial position of the inter-electrode space will be substantially halved by substantially eliminating the flows of aspirated material.

In addition, as appears to be the case in many instances, a given percentage of water relative to oil is desirable or requisite for electric treatment. By substantially eliminating the aspirated material, the amount of relatively fresh water used in the process can be reduced as compared with operation with large aspirated flows, while still maintaining a fixed percentage of water relative to oil in the inter-electrode space.

Many of the above advantages can be obtained, though in lesser degree, if the flow of oil-continuous material is throttled but not completely stopped by adjustment of the upper damper means **17**. Thus, in treating oils of widely differing character, I prefer to use the upper damper means and adjust it for best operating conditions. In most instances, however, best operation results from severe throttling of such oil-continuous material. In other instances, and particularly in installations in which the character of the emulsion does not change widely, the treater shown in Fig. 8, providing an entirely imperforate upper electrode, can be employed.

Referring particularly to Fig. 8, the upper electrode structure **130** comprises an imperforate plate **131** secured to and extending beneath the ring **42** and the pipes **46** previously described. The lower electrode structure, indicated by the numeral **132**, is constructed as previously described, including the annular plate **75** and its coplanar concentric rings **76**. The imperforate plate **131** is shown as of a diameter somewhat larger than the outermost ring **76** so that the oil of the emulsion is prevented from rising until it is relatively close to the wall of the tank **11**. The pipes **80**, supporting the lower electrode structure, are offset opposite the imperforate plate **131** to prevent any short-circuiting therebetween. The upper ends of rods 48 and 82 are shown as extending through stuffing box structures 134 and as having upper ends threaded to receive nuts 135 for adjustment of the vertical spacing of the electrodes from a position outside the tank 11.

The lower damper means 18, including the damper member 90, is employed in this embodiment. However, here the plate 95 provides an opening which slidably receives a section of the riser pipe 25. Operating arms 136 and 137 are respectively pivoted to the plate 95 and to a bracket 138 secured to the riser pipe. The remaining ends of the operating arms 136 and 137 are pivoted relative to each other and relative to a nut 139 by a pin 140. A threaded rod 141 extends into the nut 139 and extends to the exterior of the tank through a stuffing box structure 142. It preferably contains a universal joint 143 and is turned by a handwheel 144. As this handwheel is turned in one direction, the nut 139 is moved closer to the tank and the damper member 90 is lowered. Movement of the handwheel in the other direction will raise the damper member 90 toward the lower electrode structure 132.

In the embodiment of Fig. 8, no oil-continuous material is aspirated from above the upper electrode structure 130 due to its impervious nature. A throttled flow of oil-continuous material can be aspirated into the inter-electrode space from below the lower electrode structure 132, the volume of this aspirated material being adjusted by turning the handwheel 144. As before, it is usually desirable to raise the damper member 90 as close to the lower electrode structure 132 as possible, this adjustment being made during the time that emulsion is being delivered to, and resolved in, the treater.

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

I claim as my invention:

1. In an electric treater for oil-continuous emulsions, the combination of: a tank adapted to contain a body of oil-continuous material; a pair of electrode structures within said tank and spaced from each other to define a treating space therebetween; means for electrically insulating said electrode structures from each other; means for discharging the emulsion into said treating space in a manner to aspirate oil-continuous material into said treating space; a damper means for restricting the aspirated flow of oil-continuous material into said treating space; and means for adjusting the flow-restricting action of said damper means.

2. An electric treater as defined in claim 1, in which said damper means includes a damper member movable relative to one of said electrode structures, and in which said means for adjusting the flow-restricting action includes means for mounting said damper member to move toward and away from said one of said electrode structures.

3. In an electric treater for oil-continuous emulsions, the combination of: a tank adapted to contain a body of oil-continuous material; a pair of electrode structures within said tank and spaced from each other to define a treating space, at least one of said electrode structures providing a central opening; means for electrically insulating said electrode structures from each other; means for discharging the emulsion into said treating space in a manner to aspirate oil-continuous material into said treating space through said central opening; a damper member; and means for moving said damper member toward and away from said central opening to restrict the aspirated flow of oil-continuous material through said central opening.

4. An electric treater as defined in claim 3, in which said one of said electrode structures extends around a vertical axis passing through the center of said central opening thereof, and in which said damper member is movable along said axis.

5. In an electric treater for oil-continuous emulsions, the combination of: upper and lower electrode structures spaced from each other to define an outwardly-extending treating space, said lower electrode structure providing a central opening, said electrode structures being adapted to be submerged in an oil-continuous material; means for electrically insulating said electrode structures from each other; means for discharging the emulsion outwardly into said treating space in a manner to aspirate oil-continuous material into said treating space through said central opening of said lower electrode structure; a damper member for restricting the aspirated flow of oil-continuous material through said central opening of said lower electrode structure; and means for establishing an electric field between said damper member and said lower electrode structure and through which must pass any oil-continuous material aspirated into said treating space.

6. An electric treater as defined in claim 5 adapted for connection to a high-voltage source of potential, including means for connecting said upper and lower electrode structures to said source to establish an electric field therebetween of sufficient intensity to coalesce the dispersed phase of the oil-continuous emulsion into gravitationally separable masses, said upper electrode structure comprising a flat plate having inner and outer portions, said lower electrode structure comprising a smaller flat plate positioned below said inner portion and providing said central opening, said lower electrode structure including also an outer interstitial portion below said outer portion of said plate of said upper electrode structure and having spaces through which some of said masses may settle during the outward flow of said emulsion in said treating space, said damper member being spaced below said plate of said lower electrode structure and partially closing said central opening thereof to restrict said aspirated flow of oil-continuous material, and including means for connecting said damper member to said source to establish said field between said damper member and said lower electrode structure, the spacing of said damper member and said lower electrode structure being substantially less than the spacing of said upper and lower electrode structures.

7. In an electric treater for oil-continuous emulsions, the combination of: upper and lower electrode structures spaced from each other to define an outwardly-extending treating space, said upper electrode structure providing a central opening, said electrode structures being adapted to be submerged in an oil-continuous material; means for electrically insulating said electrode structures from each other; means for discharging the emulsion outwardly into said treating space in a manner tending to aspirate oil-continuous material through said central opening into said treating space; a damper member above said central opening of said upper electrode structure; and means for mounting said damper

member to move toward and away from said upper electrode structure to restrict in varying degrees the aspirated flow of oil-continuous material into said treating space.

8. An electric treater as defined in claim 1, in which said damper means includes a damper member adjacent one of said electrode structures, said means for adjusting the flow-restricting action of said damper means including means for mounting said damper member to move toward and away from said one of said electrode structures and means for moving said damper member relative to said one of said electrode structures from a position outside said tank.

9. In an electric treater for oil-continuous emulsions, the combination of: an upper electrode structure including an imperforate plate closed at its center and providing a downwardly-facing smooth surface having an inner portion and an outer portion; a lower electrode structure including a plate providing a central opening and positioned below said inner portion of said smooth surface to cooperate therewith in defining an inner treating zone, said lower electrode structure including a plurality of rings disposed side-by-side below said outer portion of said smooth surface, there being intervening spaces between said rings, said rings being electrically connected together and providing upper surfaces facing but spaced below said outer portion of said smooth surface of said upper electrode structure to define therebetween an outer treating zone; means for establishing inner and outer electric fields in said treating zones, said inner electric field being bounded at its upper end by said inner portion of said smooth surface and at its lower end by said plate of said lower electrode structure, said outer electric field being bounded at its upper end by said outer portion of said smooth surface and at its lower end by said upper surfaces of said rings whereby said inner field is of substantially uniform voltage gradient and said outer field concentrates at said surfaces of said rings; means for discharging a stream of the oil-continuous emulsion into said inner treating zone to flow through said inner field and discharge into said outer treating zone to flow along said outer field, said fields coalescing the dispersed phase of said emulsion into masses of sufficient size to gravitate from the oil phase of the emulsion, a portion of said coalesced masses gravitating from said outer field through said intervening spaces between said rings, the discharging emulsion stream tending to aspirate material into said inner field through said central opening; a damper member partially closing said central opening to restrict the flow of such aspirated material; and means for adjusting the position of said damper member relative to its adjacent plate.

10. An electric treater as defined in claim 9 including means for establishing an auxiliary electric field between said damper member and its adjacent plate to subject the aspirated material to an intense electric field before entry into said inner field, the spacing of the damper member and its adjacent plate being about 1" with an inter-electrode spacing of about 3½–4".

11. An electric treating unit for an electric treater adapted to treat oil-continuous emulsions electrically in a tank containing a body of oil-continuous material, said electric treatment resulting from subjection of said emulsion to an electric field established by a high-voltage source of potential, said electric field coalescing the dispersed-phase material of the emulsion into masses of sufficient size to gravitate from the oil, said electric treating unit including in combination: an upper electrode structure comprising a large imperforate plate having a downwardly-facing smooth and continuous surface extending imperforately from the center of said plate to the periphery thereof, said upper electrode structure and said surface providing an imperforate central circular zone, an imperforate inner annular zone immediately around said central zone and an outer imperforate annular zone immediately around said inner annular zone and terminating in a peripheral edge forming the periphery of said upper electrode structure; a lower electrode structure comprising a plate having a central opening below said imperforate central circular zone and having an inner annular portion below said inner annular zone of said upper electrode structure and cooperating therewith in defining an inner treating zone communicating with said oil-continuous material solely by way of said central opening, said lower electrode structure also comprising an outer annular portion below said outer imperforate annular zone of said upper electrode structure and cooperating therewith in defining an outer treating zone, said outer annular portion of said lower electrode structure being interstitial to provide spaces through which said coalesced masses may gravitate from said outer treating zone; means for insulating said upper and lower electrode structures from each other and for connecting at least one of said electrode structures to said source to establish inner and outer electric fields in said inner and outer treating zones; and an emulsion-discharge means comprising a pipe extending through said central opening of said lower electrode structure and an emulsion distributor connected to said pipe, said distributor being below said imperforate central circular zone of said upper electrode structure and providing an orifice means for discharging a stream of the emulsion outwardly into said inner treating zone to flow through said inner field and into and along said outer field toward the periphery thereof, said fields coalescing the dispersed phase of said emulsion to form said masses, said spaces of said lower electrode structure forming a means for removing some of such masses from said outer field before discharging from the periphery thereof, said impervious plate of said upper electrode structure guiding and confining all of the oil of said emulsion to flow outwardly beneath said plate to said periphery of said upper electrode structure to flow completely through said inner and outer fields as distinct from rising through said upper electrode structure before reaching said periphery thereof.

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