

Oct. 27, 1942.

H. F. FISHER

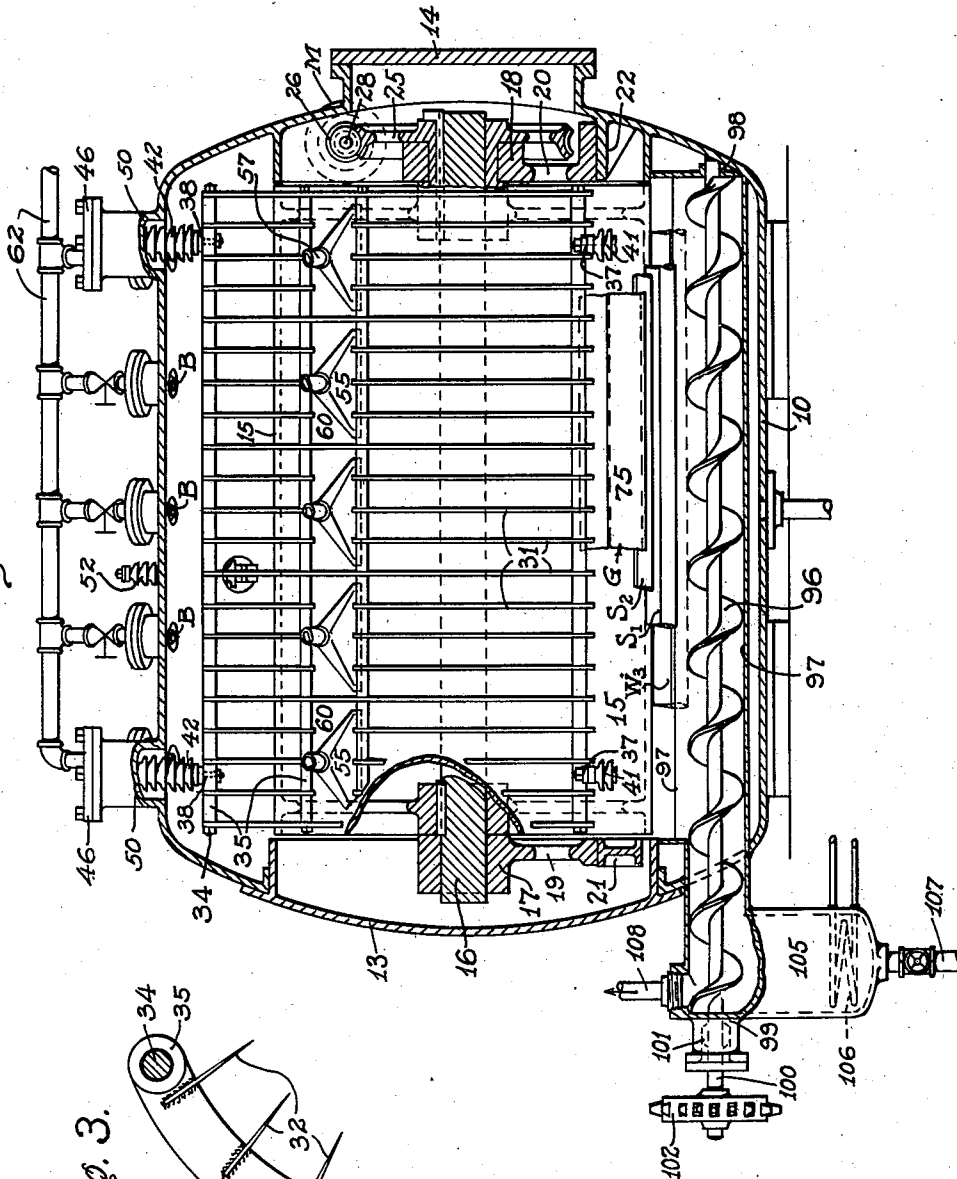
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PROCESS AND APPARATUS FOR DEWAXING OIL

Filed Feb. 21, 1938

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Fig. 2.



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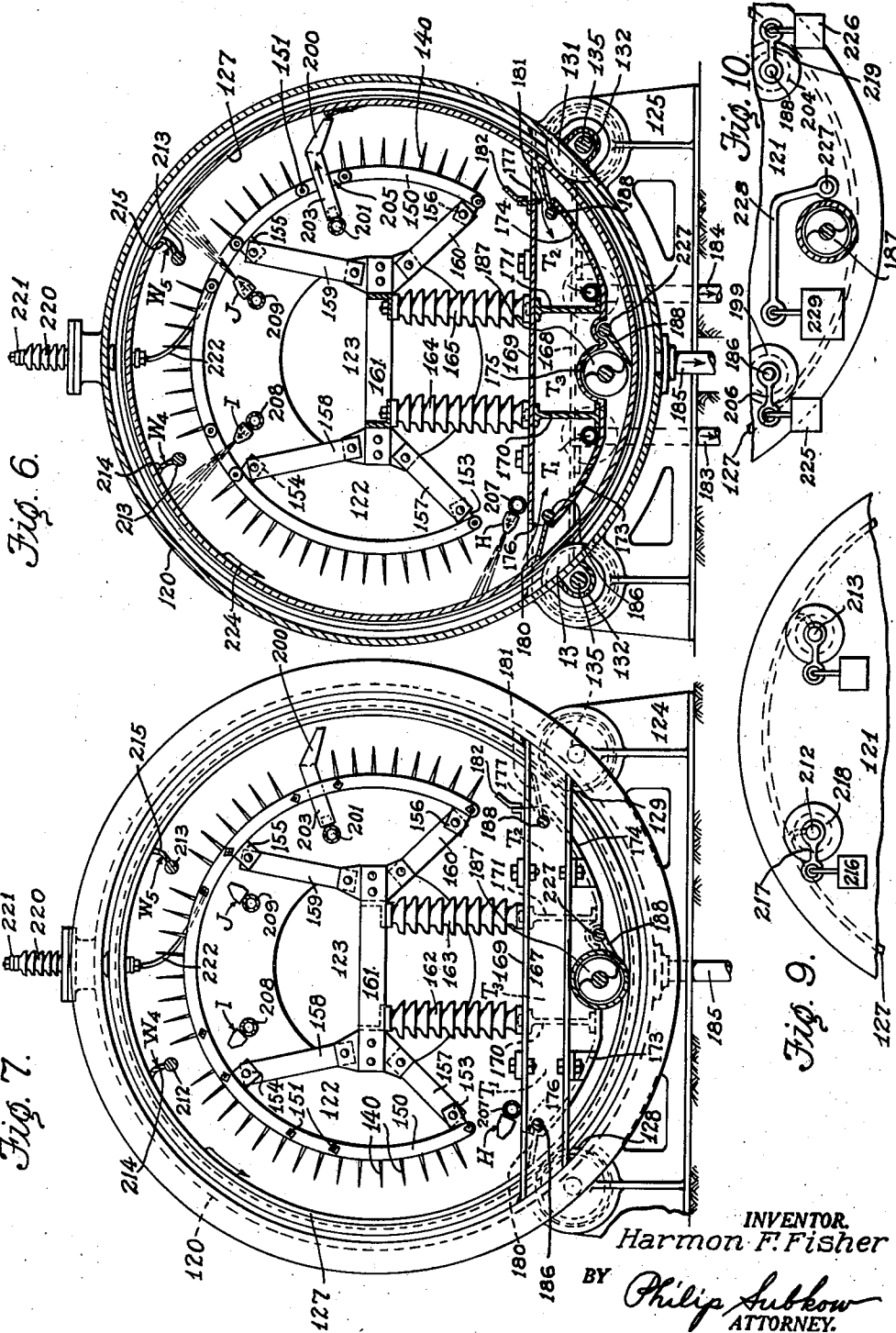
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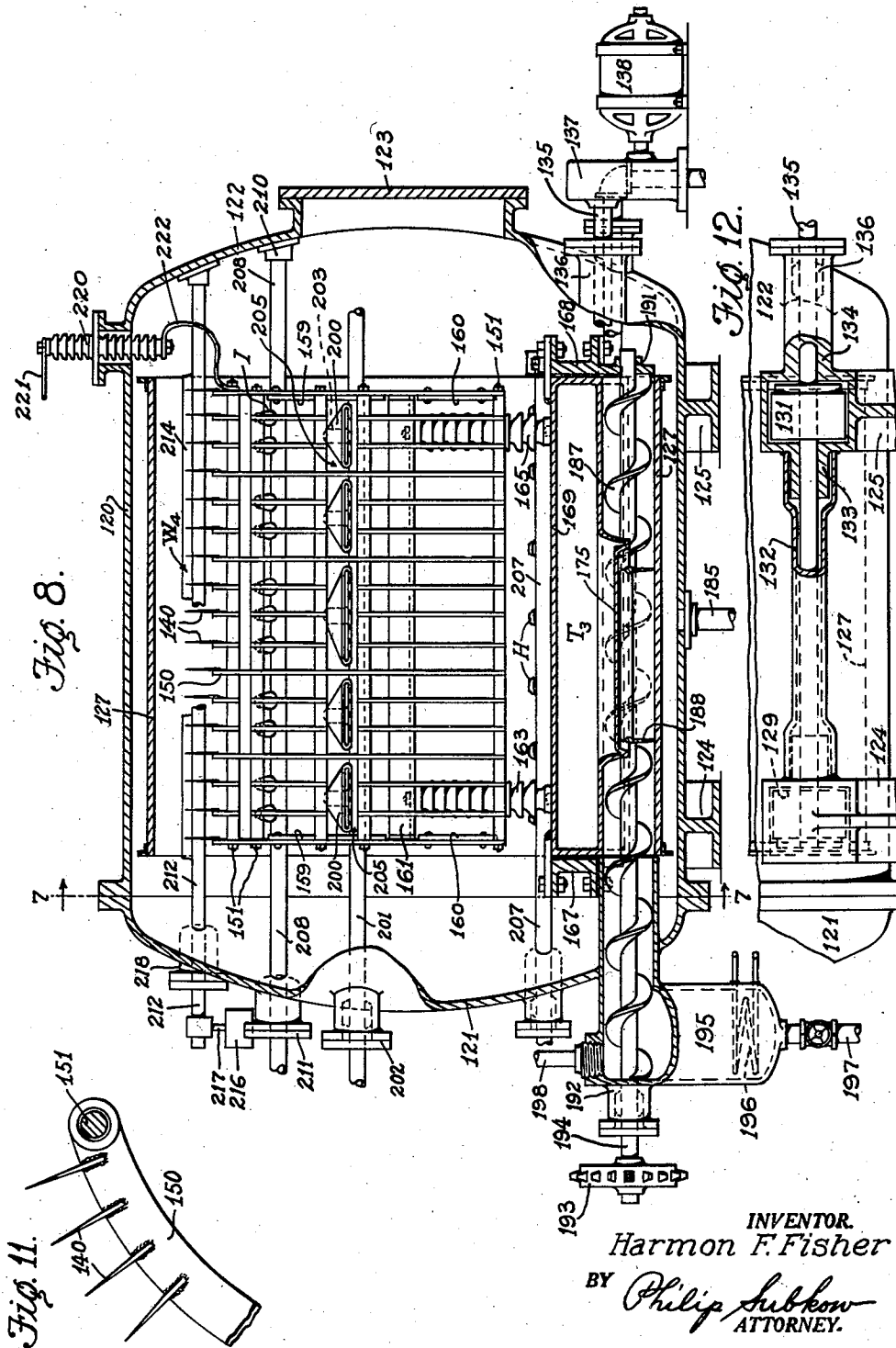
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PROCESS AND APPARATUS FOR DEWAXING OIL

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UNITED STATES PATENT OFFICE

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PROCESS AND APPARATUS FOR DEWAXING OIL

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Application February 21, 1938, Serial No. 191,682

20 Claims. (Cl. 204—184)

This invention relates to the separation of precipitates, such as wax, asphalt, resin and the like substances, from oils and particularly to the electrical separation of hydrocarbon oils from the waxes which they contain to produce relatively oil free, high melting point waxes and low pour point oils.

Many oils, such as lubricating oil, fuel oil, motor fuel and other similar oils, which are derived from crude oils contain paraffinic, waxy, asphaltic and resinous constituents which may appear by reason of having been present in the crude oil formation from which such oils were derived, or by reason of their formation in intermediate treating processes, such as distillation or cracking. The wax-like constituents which may thus be present limit the minimum temperature at which these oils can be used by their solidifying or congealing at low temperatures. The asphaltic or resinous bodies are also objectionable for numerous other reasons well known in the art of lubricating oil and motor fuel refining. Therefore, in the refining of such oils it is common practice to remove a substantial proportion of these waxy or asphaltic and resinous constituents in order to lower the pour point and improve the quality of such oils.

The separation of the undesirable paraffinic and waxy bodies from oil fractions has been accomplished in the past by several processes, the most common and oldest of which are the "cold settling" and "cold pressing" processes. These processes have been inefficient, time consuming, mechanically involved and unsuited to the separation of quickly cooled or flash chilled waxy constituents from oil and have heretofore produced separated constituents having a high percentage of oil contamination.

Asphaltic, resinous and tarry constituents and color bodies have been separated by well known processes employing acid, alkali, clay and other chemical treatment and recently by solvents. In the solvent processes the oil containing the undesirable constituents, such as asphalt, resin, color bodies and the like, is dissolved in a quantity of a suitable diluent, such as liquid propane or other liquid normally gaseous hydrocarbons, which has preferably at normal temperature a low solvent power for these bodies while at the same time retaining substantial solvent power for the desirable fractions of oil. Such solvent treatment results in the rejection of asphaltic bodies from the oil diluent solution in the form of a relatively heavy insoluble precipitate or as a heavy liquid phase, a substantial proportion of which

may be separated from the oil solution by settling in a reasonable length of time. In this solvent process, however, not only a quantity of the precipitated material remains in the oil solution in the form of an unsettled finely divided suspension to cause serious contamination of the final oil product unless special steps are taken for the complete removal, but the separated insoluble precipitate also still contains a high percentage of the oil from which it is desired to separate it.

Objects of this invention are to obviate the disadvantages of the heretofore employed processes for the separation of the said waxy, paraffinic, asphaltic, tarry, resinous and color bodies from oleaginous liquids and to provide an improved process for the separation of these substances from such liquids which is efficient, economical, of high capacity and rapid in action, less costly in time and equipment than processes heretofore. A particular object of this invention is to provide a method whereby the separated constituents, such as wax, will be more thoroughly deoiled and thus freer from contamination by oily constituents, than has heretofore been possible. Another object is to provide a process which accomplishes an improved percentage of recovery of the oleaginous liquids from the separated constituents resulting in a larger unit yield of such separated liquids.

For convenience the process and apparatus of this invention will be hereinafter largely referred to the separation of wax from oil.

The objects of this invention are attained, in brief, by causing the wax to be solidified or precipitated in the oil by any suitable method, such as by chilling, preferably in the presence of a diluent, and electrically treating the wax-bearing oil mixture containing the solidified wax by applying the mixture in the form of a relatively thin film to an electrode surface of extended area and then subjecting said oil film while on said electrode surface to the effect of an intense ionizing electric field and/or an intense gaseous ion stream induced by an adjacent electrode of relatively small area maintained at an opposite electrical potential. This ionizing electric field partakes of the nature of a non-disruptive electrical discharge or a corona discharge from the adjacent electrode of small area through the intervening gas space to the electrode of extended area upon which the waxy-oil film is applied. Such electrical discharge phenomena appear to comprise an intense streaming of gaseous ions from the electrode of smallest area to that of the

largest area, and it is to the effect of this gaseous ion stream impinging upon the intervening wax-oil film that the operation of this method is attributed. Hereinafter, the term "ionizing electric field" shall mean a field of the character above described and an "ionizing electrode" shall mean an electrode capable of producing such a field.

The effect of the ionizing field upon the wax-bearing oil film is to cause the suspended solidified wax therein to be deposited or plated instantly upon the electrode surface in a solid, compact and relatively tenacious thin layer and to adhere there while oil is forcibly separated and exuded therefrom in the form of beads or droplets of apparently greatly altered surface tension characteristics with respect to the wax. The droplets of oil thus separated are caused to be removed from the thus deposited wax layer and the electrode surface carrying it, by coalescence and gravity run off, or preferably by means of subsequently applied fluid washes and mechanical wiping operations.

The continued electrical treatment by the ionizing field of the deposited wax layer from which the oil has been initially electrically separated and/or from which it has been washed, as stated hereinbefore, results in further removal of residual occluded oil and in producing a drier, more oil free wax. It is an important feature of this invention, therefore, that the deposited wax can be so electrically treated by an ionizing electric field and mechanically scrubbed and wiped to produce a dry, relatively oil free wax.

Accordingly, therefore, one aspect of this invention, broadly stated, comprises subjecting a body of wax-bearing oil or similar oils containing suspended solid wax or the like to the effect of an ionizing electric field whereby the suspended wax is caused to be deposited upon an electrode under the influence of said electric field and whereby the wax is separated from the oil. Another aspect of the invention, broadly stated, comprises subjecting the deposited layer of wax to the continued effect of an ionizing electric field whereby it is compacted and the occluded oil is expelled from the wax.

The invention also comprises jetting, washing or scrubbing the electrically deposited wax layer either prior to, during or subsequent to electrical treatment by the ionizing electric field, with a suitable liquid and wiping the thus treated wax layer to remove occluded and adhering oil.

Accordingly, the invention resides more specifically in an improved process and apparatus for the electrodeposition of the suspended precipitate from oils wherein the oil precipitate mixture, preferably in the presence of a diluent, is placed in the form of a relatively thin layer upon a horizontal drum type electrode and subjected there to an intense ionizing electric field whereby the precipitate is deposited and held in a dense layer upon the moving drum electrode surface, thus effecting the separation of a major portion of the oil from the precipitate and whereby the precipitate layer thus separated from the oil may be subsequently thoroughly washed and further electrically treated to remove occluded and adhering oil to produce a relatively oil free precipitate and a maximum recovery of purified oil. The invention also resides in the process and apparatus wherein the electrically deposited precipitate is vigorously washed or scrubbed by a hard spray of a large quantity of recycled wash solvent to produce a relatively oil free precipitate. The invention also resides in washing the pre-

cipitate at a plurality of points and in the recycling and introduction of a portion of the wash oil to the oil feed prior to the precipitation step and the electrodeposition of the resultant suspended materials.

Another aspect of the invention resides in subjecting the wax which has been electrically deposited in a thin layer upon the electrode surface to wiping or scraping at a plurality of points to remove occluded oil and wash oil and, if desired, a portion of the soft superficial layer of the deposited wax layer whereby the remaining portion of the deposited wax will be of a high density and relatively free from occluded oil and whereby the removed oil and soft wax may be recycled to the wash jets and/or to the wax-bearing oil feed for further treatment.

This process is particularly adapted and finds one of its major industrial applications to processes for the separation of waxes from lubricating oil to produce high pour point oils relatively free from wax and high melting point waxes relatively free from oil. It is a particular advantage of the process that in contradistinction to processes of settling, centrifuging or filtering, a careful preparation of the wax precipitate as to crystal structure or plasticity, is unnecessary and avoided. In fact, all that is required is to separate the wax as a solid phase by chilling or otherwise precipitating it by reducing the solubility of the wax in the solvent or oil. I have found that the process works particularly well with flash chilled waxes, that is, those waxes formed by such rapid chilling that the wax is in a very finely divided condition and usually difficult to separate by other methods heretofore employed.

Other objects, advantages and novel features of the invention will be evident hereafter.

In the accompanying drawings, which illustrate preferred embodiments of the invention with which the process of this invention may be performed, Fig. 1 is a typical cross-section of the electric treater.

Fig. 2 is a partial longitudinal sectional elevation of the electric treater.

Fig. 3 is an enlarged detail of a portion of one of the ionizing electrode supporting segments.

Fig. 4 is a fragmentary detail in partial section of the removed lower right end portion of the treater of Fig. 2 showing the stuffing boxes for the various wiper, scraper and liquid gathering mechanisms shown in sections in the lower portion of Fig. 1.

Fig. 5 is a fragmentary right end view of that portion of the treater shown in Fig. 4.

Fig. 6 is a typical cross-section of an optional arrangement of the electric treater.

Fig. 7 is an open end elevation of the optional arrangement of the electric treater as viewed from line 7-7 in Fig. 8 with the treater head removed.

Fig. 8 is a side sectional elevation of the optional arrangement of the electric treater.

Figs. 9 and 10 are fragmentary details of an upper and lower portion, respectively, of the treater head showing the stuffing boxes through which the controls and piping for the various jets, wipers and wax scrapers extend.

Fig. 11 is a typical enlarged fragmentary detail of a number of the pointed ionizing electrodes and a supporting segment; and

Fig. 12 is a fragmentary side view partly in section of a pair of the rotating drum electrode supporting rollers and drive shaft.

The apparatus is as follows:

The main elements of the electric treater are housed within a vapor tight shell 10, resting upon supports 11 and 12 and having a removable end head 13 and flange 14 by means of which access to the interior of the treater is had. An elongated drum 15, the outer surface of which constitutes the depositing electrode surface, is fixed to a shaft 16 which is in turn rotatably supported on bearings 17 and 18 located at the apex of supporting A frames 19 and 20, respectively. These A frames 19 and 20 are in turn supported by an I beam 21 and bracket 22, respectively, connected at their ends in a suitable manner, such as by welding, to the permanent portions of the bumped heads of the treater container surrounding the removable head 13. A worm gear 25, keyed to the shaft 16 and meshing with a worm pinion 26 which is in turn driven by the motor M through the reduction gear 27 and shaft 28, serves to rotate the said drum 15. The said shaft 28 passes laterally out of the treater container through a stuffing box 30 attached to the curved portion of the bumped head of the treater container. Spaced intermediate the outside surface of the drum 15 and the inside surface of the container 10 are a plurality of circular ionizing electrode supporting segments 31, as best shown in Figs. 1 and 2 and in the enlarged detail of Fig. 3, carrying a large number of spaced ionizing electrode points 32. The pointed ionizing electrodes 32 are thus supported adjacent to and directed substantially radially toward the outside surface of the drum 15, as shown. The ionizing electrode segments 31 are supported at their ends by the longitudinal rods 34 and are uniformly spaced thereon by means of tubular spacers 35. The ionizing electrode assembly thus built up of the plurality of segments 31 upon the rods 34 forms a cage-like structure the whole of which is supported at 37, 38 and 39 by means of the insulators 41, 42 and 43, respectively, which are in turn attached to the flanges 45, 46 and 47, respectively. The insulators 41, 42 and 43 thus, as shown on the drawings, extend through the treater container walls and into the cylindrical recesses 49, 50 and 51 which are closed by the said flanges 45-47 whereby the size of the container 10 may be a minimum necessary to provide adequate spacing from the ionizing electrode cage structure without having to provide additional clearance of the insulators.

Electrical connection is made from a suitable source of high voltage unidirectional current to the ionizing electrode cage assembly through the lead-in insulator 52 and conductors 53 and 54. The electrical connection of opposite polarity to that of the ionizing electrodes is completed from the depositing electrode drum 15 through the treater structure and the ground or other suitable conductors connected to the treater container. Thus the high potential unidirectional electric field may be maintained between the ionizing electrode points 32 and the outer surface of the depositing electrode drum 15.

A plurality of flared triangular shaped nozzles 55 are supported adjacent one another along the length of the surface of the drum 15 and serve to apply the wax-bearing oil mixture to be treated upon the rotating drum surface in the form of a wide layer of uniform thickness. These nozzles 55 are supplied with the wax-bearing oil mixture by means of a manifold 56 and the interconnecting branch pipes 57 which extend

through the container wall and through flanges 58 which close the outer ends of the flanged nipples 59. The said nozzles 55 are positioned and supported centrally within the open sections 60, provided through the ionizing electrode supporting cage structure at suitable intervals said open sections being formed by omitting portions of certain of the supporting segments 31.

A to F are jets provided for spraying wash liquid upon the surface of the drum 15 and they are spaced at suitable intervals along the length of the container 10. As in the case of the nozzles 55 suitable openings are provided through the ionizing electrode cage structure by omitting portions of the segments 31 to allow the sprays of wash liquid from the side jets A to F to reach and impinge upon the surface of said drum 15. The jets A to F are supplied with wash liquid by means of suitable manifold pipes, as shown at 62 in Figure 2.

W₁, W₂ and W₃ are wipers for the purpose of removing liquid films and/or soft wax from the drum surface. Each comprises a shaft, such as shown at 64, extending the length of the treater container and carrying a metal blade, as shown at 65, along the outer edge of which is attached, by suitable means, a strip of felt, as shown at 66. The felt only makes light contact with the moving surface of the drum 15 and the contact pressure between said felt on the wipers and drum surface is maintained by torsion applied to their shafts by means of suitable weights, as shown at 68, attached to the ends of cranks, such as 69, which in turn are attached to the exposed end of the shafts which extend through suitable stuffing boxes, such as that shown at 70, in the curved portion of the bumped head of the treater container. All of the wipers are similarly controlled.

G is a treated liquid gathering device comprising a pipe 75 extending along the length of the treater container and slotted along the upper edge portion thereof which is adjacent to the drum surface. As in the case of the wipers, W₁-W₃, the liquid collecting pipe 75 carries a metal blade 76 along the edge of which is attached a strip of felt which makes light contact with the moving drum surface. Another metal strip 77 parallel with and adjacent to 76 is provided along the opposite side of the slot in the pipe 75 and serves to prevent any liquid, other than that removed by the wiper felt, from entering the pipe 75. Also, as in the case of the wipers, W₁-W₃, the liquid removing device G, and its associated blade 76 and felt strip, is maintained in contact with the drum surface by means of torsion applied to the end of the pipe 75 which extends through the bumped head of the treater container at the stuffing box 78. The torsion is applied by means of weight 79 acting through crank 80. The angle of the jets F may be similarly adjusted by rotation of the manifold pipes to which they are connected, the typical arrangement of which is best shown at 82 in Fig. 4. The said manifold pipe 82 extends through the length of the treater shell and out through the stuffing box 83 and is supported at the opposite end in a suitable socket, not shown.

The wipers W₁-W₃, the jets F and the liquid collector G may each be withdrawn intact from the treater through the head by removing the flanges to which their respective manifold pipe stuffing boxes are attached. A typical arrangement of these stuffing boxes and flanges is best shown in Figs. 4 and 5. These said apparatus

assemblies may thus be readily removed from the container for adjustment, renewal or repair without otherwise opening the treater container and thus with a minimum of labor and lost time.

S₁ and S₂ are wax removing scrapers comprising shafts 85 and 86 extending through the length of the treater and carrying sharp edged metal blades 87 and 88, respectively, bearing upon the length of the drum surface. The sharp edges of the metal scraper blades 87 and 88 are pressed with considerable force against the drum surface by means of torsion applied to their shafts 85 and 86 by means of cranks 90 and 91 and the attached weights 92 and 93, respectively. The cranks 90 and 91 and weights 92 and 93 act upon the outwardly extending ends of the shafts 85 and 86 where they pass through stuffing boxes in the bumped heads of the treater shell, as best shown in Fig. 5.

A wax screw 96 extends throughout the length of the bottom of the treater shell and in the bottom of the trough 97 and is rotationally supported at bearings 98 and 99 and rotated by means of shaft 100 which passes through a stuffing box 101 by means of the attached sprocket 102. The said wax screw 96 extends from the treater shell, as best shown in Fig. 2, into the upper portion of a wax collecting chamber 105. The said wax collecting chamber 105 is provided with a heating coil 106, a bottom outlet 107 and a vapor vent 108.

The treater shell 10 is provided with a wash liquid outlet connection 110 at the bottom.

The operation of the apparatus is as follows: Wax-bearing oil containing solidified wax in suspension, the wax having been precipitated by some method, such as chilling to a temperature below the normal cloud point or pour point of the oil together with a suitable diluent if desired, is introduced into the treater through the manifold pipe 62, thence through the branch pipes 57 and is applied in a wide, relatively thin layer over substantially the entire width of the rotating drum electrode surface 15 by means of the series of flared nozzles 55. During the application of the wax-bearing oil in this manner the drum 15 is rotated in a counterclockwise direction, as viewed in Fig. 1, and as indicated by the arrow 23. The thus applied wax-bearing oil layer flows downwardly under the force of gravity over the electrode drum surface toward the liquid collector G and countercurrent to the upward movement of the rotating drum surface, during which time it is subjected to high potential ionizing electric fields from the points of the adjacent ionizing electrodes. The high potential ionizing electric fields in this area below the point of application of the nozzles causes an immediate electrodeposition of the solidified wax from the downwardly flowing oil film upon the upward moving drum surface in the form of a dense, relatively thin layer and this deposited wax is eventually carried with the rotation of the drum to the scrapers S₁ and S₂ where it is forcefully removed and allowed to drop on the wax screw 96 in the bottom of the trough 97, and then carried thereby out of the treater container and into the wax collecting chamber 105 where it is subjected to the heat introduced through coil 106 and finally withdrawn as a liquid at 107. The evaporated diluent when it is employed in the process is vented from the wax collector chamber at 108. The said deposited wax layer intermediate the point of deposition below the waxy-oil application nozzles 55 and the said wax

scraper S₁ and S₂ is subjected to the high potential ionizing electric fields from the adjacent pointed ionizing electrodes surrounding that portion of the treater drum with the result that oil occluded and entrained in the deposited wax layer is "sweated" to the outer surface thereof. The deposited wax layer while being subjected to this said continued electric treatment may be subjected to a number of washing or scrubbing operations before being removed by the scrapers S₁ and S₂, the washing liquid being introduced through any of the plurality of systems of jets A to F, as desired, and for the purpose of best removing the "sweated" oil from the surface of the wax layer.

For example, a preferred method is to subject the deposited wax layer to vigorous washing or scrubbing by means of hard sprays of wash diluent from jet systems A, B and F. Jet system A has been found to be of particular importance in serving to dilute the waxy oil film which adheres to and is carried over with the rotation of the drum upon the deposited wax layer surface and it is important to supply a sufficient quantity of wash diluent through the jets A to carry the thus diluted waxy oil downward countercurrent to the movement of the drum surface toward the points of application of the wax-bearing oil feed whereby it commingles with the said applied wax-bearing oil and continues downward to the treated liquid collector G. The oil which is carried on over the top of the drum past the point of impingement of the jets A is thus reduced in amount and greatly diluted which is important in reducing the amount of oil removed with the deposited wax and hence is important in increasing the over-all recovery of dewaxed oil from the separated wax.

The wiper W₁ has also been found useful in reducing the carryover of adhering oil with the rotation of the drum by acting as a dam against which the oil which is wiped from the wax surface by the felt strip 66 builds up to sufficient depth to force it to run back down the slope of the drum against the rotation thereof and to be finally collected together with the balance of the dewaxed oil in the liquid collector G.

Thus the deposited wax which is carried by the rotation of the drum past the jets A and wiper W₁ is relatively free from adhering oil or, in other words, has a relatively dry surface. Upon continuing with the rotation of the drum between the wiper W₁ and the point of impingement of the jets F the thus dried deposited wax layer is subjected to a continued ionizing electric field from the adjacent pointed ionizing electrodes which causes additional occluded oil to "sweat" from the wax layer and to appear on its surface in a thin film or in the form of minute droplets.

By the application of a sufficient quantity of wash liquid to the thus "sweated" wax layer by means of jets B the oil which is drawn to the surface of the deposited wax layer by the electric field may be washed away and withdrawn from the wax layer and the drum surface by means of the wiper W₂ and the thus removed wash solvent and removed oil drops from the wiper W₂ to the bottom of the treater container and is finally removed therefrom through the outlet connection 110. The thus treated deposited wax layer after it passes over the wiper W₂ is advantageously subjected to another vigorous washing by means of a spray of wash solvent from the jets F for the purpose of remov-

ing any remanant of the adhering oil which has been "sweated" from the deposited wax layer and which has passed by the wiper W_2 or that which has been subsequently removed by the continued electric treatment. The thus washed wax layer is finally dried by the action of the wiper W_3 and immediately thereafter removed from the drum surface by means of the scrapers S_1-S_2 , as before described. The wax thus removed from the depositing electrode surface and which is conveyed from the treater container by means of the wax screw 96 is then a substantially dried wax relatively free from oil.

The dewaxed oil from which the solidified wax has been deposited is removed from the drum surface and collected in the collector G and removed from the treater container through pipe 75 and conveyed to a suitable still for the evaporation and recovery of the solvent and the production of a solvent and wax free oil.

While the operation has been described as employing solvent wash sprays from jets A, B and F only, additional scrubbing may be effected by employing additional wash jets C, D and E. The additional wash jets are particularly effective when treating a heavy lubricating oil which is somewhat more difficult to remove from the deposited wax than the lighter oils. The alternate subsection of the deposited wax as it moves with the rotating drum surface first to ionizing electric fields to "sweat" the occluded oil to the surface and then subjecting it to a hard spray of wash solvent, results in a more oil free recovered wax.

The scraper W_2 may be made to bear against the deposited wax layer upon the moving depositing electrode surface by means of application of torsion to the shaft to which it is attached sufficient to actually remove the superficial layer of soft spongy wax when it is present leaving only the hard dense underlying portion of the wax to continue with the rotation of the drum to be subjected to the wash spray issuing from nozzles F and to be finally removed by the scrapers S_1 and S_2 . The soft wax when removed by the wiper W_2 is aided in its removal from the wiper surface by means of the added flushing action of the added wash solvent applied by jets D and the thus removed soft wax drops to the bottom of the treater container and is withdrawn therefrom along with the wash oil through the outlet 110, as before described.

The wash liquid which is withdrawn from the bottom of the treater through the outlet 110 may be recycled to any one or all of the wash solvent jets A-F and recycled at any desired rate necessary to maintain the desired flow of wash solvent and the desired force of sprays impinging upon the deposited wax layer on the drum surface. The wash solvent removed at 110 may also be pumped to the flash chamber and utilized as a portion of the diluent for the waxy-oil feed or the wash solvent thus removed at 110 may be split and a portion of it recycled to the wash sprays and another portion of it pumped to the said waxy-oil feed flash chamber, all as described and best shown in Fig. 3 of my co-pending application, Serial No. 119,998. When the wash solvent removed at 110 from the treater is employed as a diluent for the waxy-oil feed the fresh diluent is preferably introduced into the system through one or any of the wash sprays.

As stated hereinbefore, an optional arrangement of the electrical dewaxing apparatus of

this invention is shown in Figs. 6 to 12 and comprises: A gastight container 120 having a flanged bumped head 121, fixed bumped head 122 and removable flanged manhole 123. The whole being supported by the webbed supporting structures 124 and 125. An open ended cylindrical depositing electrode 127 is co-axially and rotatably supported within treater container 120 by means of rollers 128-131 which are in turn supported upon suitable bearings carried by said supports 124 and 125, as shown at 133 and 134 in Fig. 12. One or both pairs of the rollers may be connected together by means of a suitable shaft, as shown at 135, which passes through a gas tight tunnel enclosure 132 and extends from the head of the treater container through the stuffing boxes 136. The shaft 135 is driven through a suitable gear reduction unit 137 by means of the motor 138. Power is thus applied through the supporting rollers to effect rotation of the depositing electrode cylinder 127 which freely rests upon them.

Inside of the depositing electrode drum are a plurality of pointed ionizing electrodes 140 directed toward the inside surface thereof and supported upon a plurality of circular segments, as shown at 150, in a manner similar to those in Fig. 1, hereinbefore described. These pointed electrodes thus supported on the circular segments form a semi-cylindrical cage-like structure tied together with a plurality of longitudinal tie rods 151 extending substantially through the length of the inside of the said drum electrode. These electrodes are thus preferably supported on approximately four inch centers and directed substantially perpendicularly to and adjacent portions of the inside surface of the said depositing electrode drum. The said cage-like pointed ionizing electrode structure is in turn supported by suitable clips, as shown at 153-156 through supporting arms, as shown at 157-160 which are in turn connected to a rectangular angle iron structure 161 which extends through the length of the ionizing electrode structure and the depositing electrode drum. This rectangular structure 161 is supported near its corners upon four vertically disposed high voltage insulators 162-165 which are in turn supported near the end portions of a cylindrical segment-like structure extending through the length of the lower inside portion of the depositing electrode drum and supported at its ends by means of a pair of longitudinal channel iron beams 167 and 168. These channel arms extend across and are attached at their ends to the inside surface of the treater container at a point opposite and above the before described treater container supports 124 and 125. The said semi-circular structure comprises an upper deck 169 extending throughout the length and width thereof which is supported upon the I beams 170 and 171 which also extends through the inside lower portion of the depositing electrode drum and are fastened at their ends to the longitudinal supporting channel irons 167 and 168. The before described pointed ionizing electrode cage structure is thus supported from the bases 124 and 125 through the longitudinal channels 167 and 168, the axial I beams 170 and 171 and the high voltage insulators 162-165.

The before mentioned semi-cylindrical segment structure in the inside lower portion of the depositing electrode drum is divided into three main compartments or tanks T_1 , T_2 and T_3 , having bottom sheets 173, 174 and 175, respectively, and partitions therebetween formed by the be-

fore mentioned axial supporting I beams 170 and 171. Two slots or openings 176 and 177 are provided extending along the length of the outer edges of the said compartments T₁ and T₂, respectively, between the deck and bottom sheets which form inlet ports for liquids removed from the right and left inside surfaces of the depositing electrode drum, as viewed in Fig. 6. The removal of liquids from the inside surface of the depositing electrode drum is accomplished by wipers 180 and 181, respectively, which extend along the length of the said ports 176 and 177 and are attached to and hinged at the lower edges thereof. The sheet iron baffle 182 extends outwardly and upwardly from the edge of the deck 169 along the edge of the said port 177 to prevent splashing within the treater and liquid dropping from the ionizing electrode structure from flowing into the port 177. Liquid falling from the treating surfaces within the treater upon the deck 169 will thus be forced to flow across the deck and drop through port 176 into the tank T₁.

Outlet pipes 183 and 184 are provided for the tanks T₁ and T₂, respectively, and a drain pipe 185 is provided in the bottom of the treater container for draining out slops or extraneous accumulation of liquids in the bottom thereof. For reference to the description of the operation hereafter, the tanks T₁ and T₂ are for the accumulation of wash liquid and dewaxed oil, respectively.

The bottom of compartment T₃ is arched in two places to form a semi-cylindrical housing for the wax screw 187 and for the shell of the wax scraper 188. The said wax screw 187 extends throughout the length of the bottom of the depositing electrode drum and is rotatably supported at the bearings 191 and 192 and rotated by means of a sprocket 193 keyed to the wax screw shaft 194. The said wax screw extends from the depositing electrode drum through the treater shell, as illustrated in Fig. 8, into the upper portion of a wax collecting chamber 195. The said wax collecting chamber 195 is provided with a heating coil 196 and a bottoms outlet 197 and a vapor vent 198.

A plurality of flared triangular shaped nozzles, as shown at 200, are placed adjacent one another along the inside surface of the depositing electrode drum 127 and provided for the application of the wax-bearing oil mixture to be treated upon the inside surface of the rotating drum in the form of a wide layer of uniform thickness. These nozzles 200 are supplied with the wax-bearing oil mixture by means of a manifold pipe 201, extending through the treater head through a flanged inlet 202. Said manifold pipe 201 and nozzles 200 being joined by means of a plurality of interconnecting branch pipes 203. The said nozzles 200 are positioned and supported centrally within suitable open sections provided through the ionizing electrode cage structure at suitable intervals along the length thereof, as shown at 205, said open sections being formed by omitting portions of certain of the segments 150. Sufficient clearance is maintained between the nozzles 200 and the inside edges of the said openings through which they extend, to prevent breakdown of the gas space therebetween when in operation it is under a high potential difference. H, I and J are rows or systems of jets provided for spraying wash liquid upon the inside surface of the depositing electrode drum 127 and they are spaced at suitable intervals along the

length thereof upon manifold pipes 207—209. These spray manifold pipes are rotatably supported at their far ends by means of suitable sockets, as shown at 210 in Fig. 8, and extend through the head of the treater container through suitable flanged connections and stuffing boxes, as shown at 211. As in the case of the nozzles 200, suitable openings are provided through the ionizing electrode cage structure by omitting portions of the segments 150 to allow the sprays of wash liquid from the rows of jets H, I and J to reach and impinge upon the inside surface of said depositing electrode drum 127. The jet systems H, I and J are supplied with wash liquid by means of suitable piping making connection with the manifold pipes carrying the said rows of jets. The direction of the jets may be adjusted by rotating the interconnecting manifold piping from the outside of the treater. W₄ and W₅ are wipers for the purpose of removing liquid films from the inside surface of the depositing electrode drum each comprising a shaft 212 and 213 extending the length of the treater and carrying a felt blade as shown at 214 and 215. The felt blade only makes light contact with the moving surface of the drum electrode and the contact pressure between said felt and the drum surface is maintained at the desired value by torsion applied to the shaft, for example, shaft 212 by means of a suitable weight 216 attached to the end of a crank 217 which is in turn attached to the exposed end of the shaft 212 which extends through a suitable stuffing box, as shown at 218, on the curved end portion of the treater container head. As described hereinbefore, wipers 180 and 181 are similar to wipers W₄ and W₅ and serve to gather the wash liquid and the dewaxed oil, respectively, from the inside surface of the rotating drum electrode and to deliver such gathered liquids into the tanks T₁ and T₂, respectively. These wipers 180 and 181 are attached to shafts 186 and 188 which rest upon the upper edges of the tank bottoms 173 and 174 at the lower edges of the ports 176 and 177, respectively, and the shafts 186 and 188 extend through the head of the treater, as shown in Fig. 10, through suitable stuffing boxes 199 and 204 and carry cranks 206 and 219 to which are attached suitable weights 225 and 226, respectively. The torsion thus applied to the said shafts 186 and 188 is transmitted to the wipers 180 and 181 to force them against the inside surface of the depositing electrode drum with sufficient pressure to collect the liquid film running down the said surface but in the case of wiper 180 with insufficient force to remove the deposited wax layer. Force is similarly applied to the wax scrapers 188 through the shaft 227, crank 228 by means of the weight 229.

In all cases the stuffing boxes through which the wipers and spraying nozzle shafts and pipe extend are attached to flanged openings in the head of the treater container sufficiently large to allow their withdrawal therefrom intact without the necessity of dismantling the treater or removing the main heads thereof. For example, the opening through which the shaft 212 passes through the treater container and which is closed by the flange 218 is of sufficient diameter to allow the withdrawal of the entire wiper W₄. The same may be said of the opening through which the nozzle manifold piping 209 passes and which is closed by flange 211, that is, it is large enough to allow the removal of the entire assembly of

the jets J from the treater container by merely removing the said flange 211.

Electrical connection is made from a suitable source of high voltage unidirectional current to the ionizing electrode cage assembly through the lead-in insulator 220 and conductors 221 and 222. The return electrical connection of opposite polarity to that of the ionizing electrode is completed from the depositing electrode drum 127 through the supporting rollers 129—131, the associated supporting structure and the ground, or other suitable conductors connected to the treater container. Thus the high potential unidirectional electric field may be maintained between the ionizing electrode points 140 and the inner surface of the depositing electrode drum 127.

The operation of the above described optional arrangement of the electrical dewaxing apparatus is as follows: Wax-bearing oil containing solidified wax in suspension, the wax having been previously precipitated by some method, such as chilling to a temperature below the normal cloud point or pour point of the oil, together with a suitable diluent if desired is introduced into the treater through the manifold pipe 201, the branch pipes 203 and is applied in a wide, relatively thin layer over substantially the entire width of the inside surface of the rotating drum depositing electrode 127 by means of the series of flared nozzles 200. During the application of the wax in this manner the drum electrode 127 is rotated at from approximately 7 to 10 revolutions per minute in a counter-clockwise direction, as viewed in Figs. 6 and 7 and as indicated by the arrows 224. The thus applied wax-bearing oil layer flows downwardly under the force of gravity upon the electrode surface toward the liquid collecting wiper 181 and countercurrent to the upward movement of the inside surface of the drum at this point, during which time it is subjected to a high potential ionizing electric field from the points of the adjacent ionizing electrodes, as shown at 140. The high potential ionizing electric field at this point causes an immediate electrodeposition of the solidified wax from the downwardly flowing oil film upon the upwardly moving drum surface in the form of a dense, relatively thin layer and this deposited wax is carried with the rotation of the drum to the scraper 188 where it is forcefully removed and allowed to accumulate between the blades of the wax screw 187 which extends along the bottom of the drum electrode and is finally carried by said wax screw along the bottom of the drum and into the wax collecting chamber 195 where it is subjected to the heat introduced through coil 196 and finally withdrawn as a liquid at 197. The evaporated diluent when it is employed in the process is vented from wax collector chamber at 198. The said deposited wax layer intermediate the points of deposition below the waxy oil application nozzles 200 and the said wax scraper 188 is subjected to the high potential ionizing electric fields from the adjacent pointed ionizing electrodes supported within that portion of the rotating drum with the result that oil occluded and entrained in the deposited wax layer is electrically "sweated" to the outer surface thereof. The deposited wax layer while being subjected to this continuous electric treatment may be subjected to a number of washing or scrubbing operations before being removed by the scraper 188, the washing liquid being introduced through any of the plurality of jets at H, 75

I or J, as desired, for the purpose of best removing the electrically "sweated" oil from the exposed surface of the wax layer.

For example, a preferred method is to subject the deposited wax layer on the inside surface of the rotating drum electrode to vigorous washing or scrubbing by means of hard sprays of wash diluent from jets H and J. Jet J has been found to be of particular importance in serving to dilute the waxy-oil film which adheres to and is carried over with the rotation of the drum upon the wax depositing wax layer surface and it is important to supply a sufficient quantity of wash diluent through the jet J to carry the thus diluted waxy oil downward countercurrent to the movement of the drum surface toward the points of application of the wax-bearing oil feed whereby it commingles with the said applied wax-bearing oil and continues downward to the treated liquid collector 181. The oil which is carried on over the top of the drum past the point of impingement of the jet J is thus reduced in amount and greatly diluted which is important in reducing the amount of oil removed with the deposited wax and hence is important in increasing the over all recovery of dewaxed oil from the separated wax.

The wiper W₅ has also been found useful in reducing the carry over of adhering oil with the rotation of the drum by acting in effect as a dam against which the oil which is wiped from the wax surface by the felt strip 215 builds up to sufficient thickness and density to force it to run back down the drum against the rotation thereof or to drop therefrom upon the deck 169 and to be drained therefrom through the ports 176 and into the wash liquid tank T₁.

Thus the deposited wax which is carried by the rotation of the drum past the jet J and the wiper W₅ is relatively free from adhering oil or, in other words, has a relatively dry surface. Upon continuing with the rotation of the drum between the wiper W₅ and the points of impingement of the jet H the thus dried deposited wax layer is subjected to a continued ionizing electric field from the adjacent pointed ionizing electrodes which causes the occluded oil to electrically "sweat" from the wax layer and to appear on its surface in a thin film or in the form of minute droplets. The application of additional wash oil by means of a hard spray from jets H upon the thus electrically "sweated" wax layer serves to remove the resultant oil film from the wax layer and to allow it to flow therefrom downward to the wiper 180 by means of which it is removed and caused to flow through the port 176 and into wash oil collecting tank T₁ from which it may be subsequently or continuously removed through the outlet pipe 183. The deposited wax layer from which the electrically "sweated" oil has thus been washed continues down with the rotation of the drum and is finally removed from the inside surface of said drum by means of the wax scraper 188, as hereinbefore described.

The dewaxed oil from which the wax has been deposited, as hereinbefore described, is likewise removed from the drum surface by means of wiper 181 and allowed to flow therefrom through the port 177 and into the dewaxed oil collecting tank T₂ from which it may be subsequently or continuously removed through the dewaxed oil outlet pipe 184.

The wiper W₄ may be operated when desired in a manner similar to W₅ to prevent the carry over of oil from the point of application of the

wax-bearing oil to the deposited wax washing and "sweating" stage of treatment. The pressure of wipers W_4 and W_5 and 180 may be adjusted as, hereinbefore described, in connection with the apparatus of Fig. 1, to a value sufficient not only to remove the oil film but also to remove the superficial layer of relatively soft wax which has been found to adhere to the underlying densely deposited wax layer. The soft wax layer contains a relatively greater amount of oil as compared to the underlying more dense layer of wax. The thus removed soft wax from the wipers W_4 and W_5 will drop upon the deck 169 and may be washed therefrom by suitable means into the wash oil collecting tank T_1 . The soft wax layer which is removed by the wiper 180 will be carried with the wash oil removed from the drum surface into the wash oil collecting tank T_1 . The wash oil containing the small percentage of wax which has been washed and scraped from the deposited wax layer and which collects in tank T_1 may be recycled to the wax-bearing oil feed and may thus constitute a portion of the wax-bearing oil diluent and/or it may be recycled to any one or all of the wash jets H, I and J. Additional washing and scrubbing of the deposited and subsequently electrically treated wax layer may be accomplished by jets I and it has been found to be advantageous in some cases to thus simultaneously electrically treat and wash the deposited wax layer in order to remove a substantial proportion of oil occluded in or adhering to the said wax layer. It has been found to be particularly advantageous to subject the deposited wax layer to scrubbing by sprays from the wash jets which are sufficiently hard to substantially momentarily dislodge the wax from the electrode surface. The thus dislodged wax is immediately redeposited under the electric field and the effect is thus substantially that of redispersion and redeposition of the wax which greatly reduces its oil content and produces a drier wax.

The temperature of the contents of the treater when employing liquid normally gaseous diluents in the wash jets and/or in the waxy-oil feed is regulated by varying the pressure therein by means of a suitable valve on the withdrawal pipe 185 which governs the amount of evaporation of the propane. The treater is thus maintained at a temperature approximately equal to that of the chilled waxy-oil feed mixture.

In the operations described in which propane diluents and washes are employed, the treater operates in an atmosphere of propane vapor confined within the treater container. When other volatile diluents are employed the atmosphere within the treater shell will consist of vapors of such diluents. The operativeness of the apparatus is not limited, however, to the use of volatile diluents, certain substantially non-volatile diluents, such as kerosene and gas oil and medium and heavy hydrocarbon fractions being frequently employed under some conditions. When such materials are employed refrigeration thereof is accomplished by any suitable means of heat exchange. The character of the gaseous atmosphere maintained within the treater shell although having some bearing thereupon is not of primary importance insofar as the electrical ionization effects of the electric treating fields are concerned. It is, of course, necessary to avoid inflammable gaseous mixtures.

The ionizing electrodes 140 are constructed

preferably of pointed wires which may be $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and from six to twelve inches long. They are supported upon the electrode supporting segments, as shown at 31 in Fig. 3 and 150 in Fig. 11, by any suitable means, such as by welding as hereinbefore described, extending toward and with their axis substantially perpendicular to the depositing surfaces of the drum electrode. These pointed electrodes are preferably spaced from one another at distances of approximately two to four inches on centers and their pointed ends spaced from the depositing surface of the drum electrode at a distance just sufficient to prevent continuous spark over therebetween at the operating potentials. The operating potentials which have been found to be effective for efficient dewaxing of the oil and efficient deoiling of the deposited wax are in the neighborhood of 50,000 to 100,000 volts and under these conditions of voltage of electrode spacing a silent electric discharge or corona is observed at the ends of the pointed electrodes and extending toward the adjacent depositing surface of the drum electrode upon which the wax-bearing oil to be treated is flowed and upon which the wax-bearing oil is washed or scrubbed and electrically "sweated" or dried. This electric potential applied to the pointed ionizing electrodes is preferably unidirectional and preferably of a constant potential whereby the maximum average potential may be maintained between the electrodes without the spark over. The ionizing electrodes are also preferably maintained at a negative polarity while treating the majority of waxy oil although in some cases when treating refined oils a positive potential is effective.

Advantages of the process of this invention reside primarily in the improved effectiveness of the wax deoiling stage by employing washing or scrubbing sprays and mechanical wipers and advantages of the process whereby the deposited wax layer upon the depositing electrode surface may be improved in "dryness" or freedom from oil over that heretofore possible.

The advantages of the apparatus of this invention reside in the compactness and efficient utilization of space per unit of effective treating area and in the simplicity and small number of moving mechanical parts. Where the operation of the apparatus has been described for the separation of wax from wax-bearing oil it is understood to be equally applicable, as hereinbefore stated, to the separation of asphalt, resin, color bodies, fats and carbonaceous materials from oleaginous or the like liquids.

The foregoing is merely illustrative of the apparatus and process of the invention and it is not intended to be limiting. The invention includes any method and apparatus which accomplishes the same results within the scope of the appended claims.

I claim:

1. A process for dewaxing oil comprising precipitating wax in wax-bearing oil, subjecting the mixture to an electric field and electrically depositing the wax from the oil in a layer upon an electrode surface and wiping said depositing wax layer while on said electrode surface to remove adhering and occluded oil and to thereby produce a relatively dry waxy layer and removing the thus treated wax layer from the electrode surface.

2. A process for dewaxing oil comprising precipitating wax in wax-bearing oil, subjecting the mixture to an electric field and electrically depositing the wax from the oil in a layer upon an

electrode surface, washing said deposited wax layer with a spray of wash solvent while under the influence of the electric field and wiping said washed wax layer while on said electrode surface to remove adhering and occluded oil and wash solvent and to thereby produce a relatively dry wax layer and removing the thus treated wax layer from the electrode surface.

3. A process for dewaxing oil comprising precipitating wax in wax-bearing oil, subjecting the mixture to an electric field and electrically depositing the wax from the oil in a layer upon an electrode surface, and alternately washing and wiping said deposited wax layer while on said electrode surface in a plurality of stages to remove adhering and occluded wash solvent and oil and thereby producing a relatively dry wax layer and removing the thus treated wax layer from the electrode surface.

4. A process according to claim 2 with subsection of the deposited wax layer to an electric field between the washing and wiping stages.

5. A process according to claim 3 with subsection of the deposited wax layer to a further electric field intermediate the washing and wiping stages.

6. A process for dewaxing oil comprising precipitating wax in wax-bearing oil, subjecting the mixture to an electric field and electrically depositing the wax from the oil in a layer upon an electrode surface and first removing a superficial layer of the electrically deposited wax and then finally removing the relatively dried underlying deposited wax layer from the electrode surface.

7. A process according to claim 6 in which the wax removed from the superficial layer of the deposited wax is recycled with wash solvent to the wash jets and re-applied to the depositing electrode from which it is removed.

8. A process according to claim 6 in which the wax removed from the superficial layer of the deposited wax is recycled with wash solvent to the first mentioned wax-bearing oil.

9. Apparatus for separating solids from oil comprising a depositing electrode surface, means to apply oil containing solids to said electrode surface, means to subject said oil on said electrode surface to an ionizing electric field whereby the solids are deposited in a layer on said depositing electrode surface and means to remove only a superficial portion of said deposited layer of solids from said depositing electrode surface.

10. Apparatus for separating solids from oil comprising a depositing electrode surface, means to apply oil containing solids in a film on said electrode surface, means to subject said film of oil to an ionizing electric field whereby solids are deposited in a layer from said oil upon said depositing electrode surface and wiper means for removing the separated oil from said layer of deposited solids and means to remove said layer of deposited solids from said depositing electrode surface.

11. Apparatus for separating solids from oil comprising a horizontal drum shaped depositing electrode surface and a plurality of ionizing electrodes surrounding said depositing electrode sur-

face and means to apply oil containing solids to said drum shaped depositing electrode surface whereby the solids are electrically deposited on the drum surface and separated from the oil.

12. Apparatus according to claim 11 with means to subject the horizontal drum shaped depositing electrode surface to a forceful spray of wash solvent.

13. Apparatus according to claim 11 with means to subject the horizontal drum shaped depositing electrode surface to a forceful spray of wash solvent and means to wipe oil from the deposited layer of solids on said depositing electrode surface.

14. Apparatus according to claim 11 with a plurality of wipers adapted to remove liquid from the surface of the depositing electrode.

15. Apparatus for separating solids from oil comprising a drum supported on a horizontal axis, a pointed ionizing electrode adjacent the surface of said horizontal drum, means to apply said oil containing solids to a portion of said drum surface in the form of a downwardly flowing relatively thin layer whereby it is subjected to an electric field between said drum surface and said ionizing electrode and solids are deposited upon said drum surface, means to subject deposited solids on said drum surface to scrubbing with a wash spray and means to separately remove wash liquid and oil from which solids have been deposited from said drum surface.

16. In apparatus for dewaxing oil the combination of a moving depositing electrode surface, a container for said depositing electrode, an elongated blade normally contacting said depositing electrode surface for removing material from said depositing electrode surface and means operative from the exterior of said container for withdrawing said blade intact from said container.

17. In apparatus for dewaxing oil an ionizing electrode structure comprising a plurality of spaced circular segments forming an open cage-like supporting structure and a plurality of electrode points supported and radially disposed upon said cage-like structure.

18. Apparatus according to claim 17 with a drum shaped depositing electrode substantially coaxially disposed with respect to said ionizing electrode cage structure, said drum surface being adjacent and spaced from said electrode points.

19. A process for separating solids from suspension in oil comprising subjecting the oil containing the suspended solids to an electric field and electrically depositing the solids from the oil in a layer upon an electrode surface and wiping said deposited layer while on said electrode surface to remove adhering and occluded oil and to thereby produce a relatively dry deposited solid layer and removing the thus treated solid layer from the electrode surface.

20. A process according to claim 6 in which the superficial layer of the electrically deposited wax and the relatively drier underlying deposited wax layer are separately removed and separately conveyed away from the electrode surface.

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