METHOD OF PURIFYING OIL

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This invention relates to a method of purifying oil, and more particularly to a method of purifying oil by means of which not only solid and free water are removed, but in which the oil is rendered free from dissolved gases and moisture. The present invention constitutes an improvement on the inventions disclosed in our patents, 1,624,496 patented September 22, 1921; 1,836,338 patented December 15, 1931; 1,890,249 patented December 6, 1932; and 1,919,669 patented July 25, 1933. The invention is applicable to oils of various types, but is particularly adapted for use in treating mineral hydrocarbon oils, especially those used in electrical apparatus. In the purification of mineral hydrocarbon oils, our invention is applicable both to the preparation of new oils and to the conditioning of oils which have been used in oil submerged electrical apparatus.

Mineral hydrocarbon oils are refined for and find a wide application as an insulating medium in oil submerged electrical apparatus because of the dielectric strength characteristics of the oil. The oils are used both as a cooling and insulating medium in transformers, voltage regulators and as an insulating medium in cable joints and the like. When hydrocarbon oils are used for these purposes, they are subjected to oxidation reactions resulting from the combined action of heat absorbed from the electrical apparatus, and the oxygen in the atmosphere which has ready access to the oil. Complex hydrocarbons are chemically altered by such oxidation reactions resulting in the formation of organic acids, volatile hydrocarbons, soap and deposits termed “sludge”. When hydrocarbon mineral oils are used in electrical apparatus such as circuit breakers, the arcing action which takes place results in decomposition of the complex hydrocarbons forming elemental carbon, hydrogen, carbon monoxide, carbon dioxide, methane, and hydrocarbon vapors, all of which reduce the dielectric strength of the insulating medium. Concurrently with the decomposition of a portion of the oil, water may be formed due to the combination of hydrogen evolved in the zone of the arc with oxygen dissolved in the oil. These traces of water may be in true solution in the oil and together with the evolved carbon particles of colloidal size contribute to the deterioration of the insulating value of the oil.

Herefore, it has been attempted to remove water and suspensions by gravity, by centrifugal force, and by filtering. These processes, however, have been only partially successful because they failed to remove water of true solution, volatile hydrocarbons and dissolved gases such as oxygen.

In accordance with the present invention, the oil to be purified is passed through a filter to partially remove solids and free water, is then pumped through a heater, and is sprayed at superatmospheric pressure into a chamber maintained under subatmospheric pressure. The heated oil is sprayed under superatmospheric pressure in order to subject the oil to a sudden shock which releases the dissolved gases and moisture from the sprayed particles. The volatile tiles are removed from the vacuum chamber, but the particles of oil are collected by baffles and caused to flow in a tortuous path while exposed to the reduced pressure toward the bottom of the chamber. From the bottom of the chamber the degasified oil is passed through a heat exchanger counter-current to the flow of incoming contaminated oil and is then filtered to remove the remaining solids and soluble sludges precipitable at low temperature. The passage of the degasified and dehydrated oil from the vacuum chamber through the heat exchanger not only results in economy due to heating the incoming oil, but also cools the degasified oil to substantially the temperature of the oil in the storage tank or other receptacle to which the oil is delivered after filtering. The lowering of the temperature of the oil by reason of the transfer of heat theretofrom to the incoming oil in the heat exchanger also enables the oil to be filtered more effectively, as well as decreases the tendency of the oil in the storage tank to sweat and thereby reabsorb moisture.

In the accompanying drawings which illustrate the present preferred embodiment of our invention,

Figure 1 is a diagrammatic illustration of the oil purifying system,

Figure 2 is a vertical section through a filter used for partially removing solids and free water from contaminated oil,

Figure 3 is a detail perspective illustrating the construction of the filter discs, separators and cleaners employed in the filter shown in Figure 2, the parts being spaced apart for clearness,

Figure 4 is a sectional view of the discs, spacers and cleaners in assembled position, and

Figure 5 is a sectional view of a spray nozzle used for spraying oil into the vacuum chamber.

The oil to be purified generally contains solids, free water, dissolved water and dissolved gases. This contaminated oil is delivered through a
pipe 2 provided with a flow indicator 3 to a filter indicated generally by the reference numeral 4. The detailed construction of the filter is shown in Figures 2, 3 and 4. It consists essentially of a stack of round thin discs 5 provided with perforations 6 through which the filtered liquid passes, spacers 7 disposed between adjacent filtering discs 5, and cleaners 8. The filter discs, spacers and cleaners are illustrated in Figure 3 as spaced apart, while in Figure 4 these elements are shown in their assembled position. A hexagonal post fits into corresponding openings 10 in the discs and spacers, and the post is provided with a handle 11, by means of which the discs and spacers may be rotated as a unit. The discs and spacers are maintained in assembled position by a top washer 12 and a bottom washer 13, the washers having a screw extending therethrough. The discs and spacers are assembled and the nut 15 is tightened to maintain the parts in assembled position. Between each pair of discs 5 and opposite each of the spacers 7, is a cleaner 8. Each of the cleaners has a hexagonal opening 18, into which fits a hexagonal post 19. This post is non-rotatable and accordingly maintains the cleaners in fixed position.

The oil to be filtered flows in through the inlet opening 20 and passes between the edges of the discs 5 and then through the openings 6 in the discs flowing downwardly, and is delivered from the outlet opening 21. The thickness of the spacers 7 determines the fineness of the filtering operation. The solids which collect at the exposed edges of the discs are removed by turning the handle 11, which rotates the stack of discs and spacers relative to the stationary cleaners 8. The solid material flows downwardly through a passage 22 controlled by a valve 23 in a sump 24 from which it may be removed by opening the cover 25. A drain opening 26 and plug 27 are also provided in the sump. The material in the sump may be cleaned out without stopping the operation of the filter, if the valve 23 is first turned to closed position.

The filtered oil is pumped by a pump 30 through conduits 31 and 32 to a heat exchanger indicated generally by the reference numeral 33. The oil is provided with a by-pass connection 34 controlled by a valve 35, in order to prevent excessive pressure on the pump. If the pressure tends to become too great, such as might be the case, for example, if the filter press, hereafter more fully described, should become clogged, the oil flows from the outlet side 36 of the pump through the by-pass 34, and returns to the inlet side 37 of the pump.

In the normal operation of the apparatus, the oil flows through conduit 33 controlled by a three-way valve 39 into the first unit 40 of the heat exchanger 33. The oil flows through the unit 40 on the outside of a conduit 41, then through a second three-way valve 42 and conduit 43 into a second heat exchange unit 44. It then flows through conduit 45, heat exchanger unit 46, conduit 47, heat exchanger unit 48 and conduit 49, into a heater 50. During the normal operation of the apparatus, the three-way valves 39 and 42 are disposed so that their passages are in the positions indicated by full lines in Figure 1.

The heater 50 has a heating coil 51 which is connected by electrical conduits 52 to an automatic temperature control switch 53. The automatic temperature control switch 53 operates in accordance with the temperature of the oil in the conduit 54, through which the oil flows on its way from the heater 50 to a vacuum tank 55. The particular construction of the temperature control switch 53 and the electrical circuits connecting it to a source of electrical energy are described and shown in the accompanying patent, 1,899,265. The particular construction of the switch and electrical connections are shown only in a diagrammatic manner in this application, since the construction is not here claimed. The arrangement of these connections is such, however, that the temperature of the oil flowing through the conduit 54 prior to being delivered to the vacuum chamber 55 is automatically maintained at the desired temperature. This temperature is indicated by a thermometer.

The oil flowing through conduit 54 is delivered to a spray nozzle indicated generally by the reference numeral 57 and by means of which it is broken up into a fine spray. The spray nozzle comprises a holder 58 which is connected by a pipe 59 to the conduit 54. Screwed into the holder 58 are several individual nozzles 60 constructed as shown in detail in Figure 5. The nozzle has a stem 61, the lower end of which is screwed into the holder 58. A cap 62 provided with a spray opening 63 is screwed onto the upper end 64 of the stem. The cap 62 has a plug 65 threaded therein, the plug being provided with two openings 66 extending therethrough. The plug 65 is conveniently screwed into the cap 62 by providing the plug with a groove 67, so that the plug may be turned by a screw-driver. The oil flows through the stem 61 and then through the passages 69 into a chamber 68 from which it is delivered through the opening 63. In this manner the oil is sprayed into the vacuum chamber under super-atmospheric pressure, so that when the particles are released in the vacuum chamber, they are subjected to a sudden shock or impact which liberates the dissolved gases and moisture from the oil particles.

The baffles 70 are of general grough shape and, as shown in the drawings, there are three series 71, 72 and 73 of the baffles. The series of baffles 72 are disposed in staggered relation to the series of baffles 71 and 73. The baffles in the series 71 and 72 are disposed with their apaxes extending upwardly while the baffles in the series 72 have the apaxes extending downwardly.

The gases liberated in the vacuum chamber 55 flow upwardly in tortuous paths between the baffles 70, and are delivered through a conduit 75 to the vacuum pump 76. The gases flow from the vacuum pump through a conduit 77 into a separator 78 provided with baffles 79. The gases in flowing through the vacuum pump absorb part of the oil used to lubricate the pump. The volatiles containing a portion of the lubricating oil are caused to impinge against the baffles 79 in the separator, which allows the volatiles to pass upwardly and be exhausted through the outlet 80. The baffles 79, however, collect the lubricating oil which has been absorbed by the volatiles and then the oil flows downward toward the bottom 81 of the separator. The bottom 81 of the separator slopes downwardly and outwardly from its center, thereby acting to collect the oil which is returned by the baffles. The oil collected at the bottom of the separator is returned to the
vacuum pump 76 through a pipe 82. The bottom of the separator is provided with a drain pipe 83, by means of which any water collected at the bottom of the separator can be removed. The bottom of the separator extends upwardly into the separator for a short distance, so that it acts to return oil only and not any water which may have collected in the bottom of the separator.

The oil sprayed from the nozzle 87 in the vacuum chamber is prevented from flowing out of the top of the chamber by the baffles 70. The oil particles collect in the trough shaped baffles 70, from which they flow downwardly in tortuous paths while exposed to the vacuum in the chamber 55. The tortuous flow of the oil streams is caused by baffles 90 arranged as indicated in Figure 1 adjacent the side of the vacuum chamber and supported by frames 91 and 92. During the downward tortuous passage of the films of oil over the baffles 90, a further amount of volatiles are liberated from the oil and the volatiles escape from the top of the vacuum chamber through the conduit 75.

The particular temperature pressure and degree of vacuum used in the process varies according to the type of oil which is being treated. In treating transformer oil, we have found that before spraying it in the vacuum chamber it should be heated to a temperature of from 90 to 160°F, preferably from 140 to 160°F. The optimum temperature generally is about 150°F. The pressure to which the oil is raised before being sprayed from the nozzle 87 may vary between sixty and two hundred pounds per square inch, a pressure of one hundred to one hundred and fifty pounds per square inch being the usual range which is employed. A pressure of about one hundred and twenty-five pounds per square inch is generally preferred for treating transformer oils under most circumstances. A vacuum in the vacuum chamber 55 should be maintained equivalent to from 20 to 30 inches of mercury, as referred to a 30 inch barometer. The best results have been obtained by employing a vacuum of between 29.5 to 29.7 inches of mercury.

The degasified oil collected in the bottom of the vacuum chamber 55 is forced by an oil pump 95 through conduit 41, which passes through the units 48, 44, 46 and 40 of the heat exchanger 33. The hot oil entering the unit 48 is cooled by its passage through the heat exchanger to a temperature such that it may be effectively filtered in a filter press 100, to which the oil is delivered from the heat exchanger. The oil passing through the conduit 41 in the heat exchanger also raises the temperature of the incoming contaminated oil which surrounds it in the units 40, 44, 46 and 48. The passage of the degasified heated oil from the vacuum chamber 55 through the heat exchanger 33 accomplishes several very desirable results. It is economical because it raises the temperature of the incoming oil so that less heat is required to be furnished by the heater 50, in order to raise the temperature of the oil to the desired degree before spraying it in the vacuum chamber.

The transfer of heat from the degasified oil to the incoming oil cools the degasified oil to such an extent that any remaining solids may be efficiently removed in the subsequent filtering operation. In some cases there are soluble sludges present in the degasified oil which cannot be filtered effectively unless the temperature of the oil is below about 85°F. In such cases it is preferred to cool the degasified oil to about this temperature so that it may be effectively filtered.

We prefer to cool the degasified oil to substantially the ambient temperature of the oil in the storage tank or other receptacle to which it is delivered after filtering. The temperature of the degasified oil prevents sweating or breathing of the tank which would tend to cause the formation of water, and thereby result in reabsorption of the water by the oil. If absorption were to take place it would, of course, decrease the insulating properties of the oil.

The portion of the conduit 41 between the filter press 100 and the heat exchanger unit 40 is provided with a thermomter 101 and also with a pressure limit switch indicated generally by the reference numeral 102. If the blotters in the filter 100 tend to become clogged with solids, the pressure in the conduit 41 will be increased. The pressure limit switch 102 is employed for the purpose of preventing the building up of excessive pressures which might break the blotters in the filter press. The construction and electrical connections for the pressure limit switch 102 are shown and described in our copending patent, 1,890,365, previously referred to.

If the blotters of the filter press tend to clog, it raises the pressure in the conduit 41. This raises a diaphragm 103 against the action of a spring 104. The diaphragm has an arm 105 connected thereto at one end. The arm is pivoted intermediate its ends as indicated at 106 and 107. The upper end 107 of the arm is disposed so as to close and open the electric circuit of which the wires 108 form a part. The circuit including the leads 108 controls a switch (not shown), which shuts off the current from the motors for the pumps 30, 76 and 95, and also shuts off the current supplied to the heating coil 51 in the oil heater 50. Accordingly, if the pressure in the conduit 41 raises above the limit at which the pressure limit switch 102 is set, the switch is operable to stop the operation of the pumps 30, 76 and 95 and also to break the electrical connection for the heating element 51.

Under certain conditions it is desirable to cool the oil flowing through the conduit 41 to a greater degree than can be accomplished by simply transmitting heat from the oil in the conduit 41 to the oil which surrounds it in the heat exchanger elements 40, 44, 46 and 48. Accordingly, we have provided a by-pass connection by means of which we can by-pass the contaminated oil around the unit 40 of the heat exchanger, and have provided means for additionally cooling the oil by using water as the cooling medium in this unit. This is accomplished by turning the three-way valves 39 and 42 so that their passages are disposed in the dotted line positions indicated in Figure 1, and by opening the valve 115, which in the normal practice is maintained closed. With the valves disposed in the dotted line positions and the valve 115 open, the contaminated oil is forced by the pump 30 through conduit 32, valve 115, conduits 111 and 43 to the heat exchanger unit 44. From the unit 44 the oil flows as previously described. The heat exchanger unit 40 is supplied with water which flows from a suitable source through conduit 112 and valve 39 into the unit 40.
The water surrounds the oil contained in the conduit 41, thereby cooling it and the water then flows out of the unit through conduits 113 and 114. This enables us to give an additional cooling effect to the oil in the conduit 41 if such oil is not cooled to the desired temperature by the simple transmission of heat therefrom to the incoming contaminated oil which surrounds it in the units of the heat exchanger 33.

The treatment of the oil in the vacuum chamber 55 as herein described eliminates substantially all dissolved gases and moisture. This treatment of the oil in the vacuum chamber combined with the cooling thereof in the heat exchanger 33 enables the oil to be very efficiently filtered. Since the water has been substantially removed, soap sludges cannot be formed. These sludges may be formed if the oil is not substantially completely dehydrated. They tend to clog the blotters of the filter press, cause the building up of excessive pressures, and prevent the proper filtering of the oil. According to our method the precipitate resulting from cooling the degasified and dehydrated oil is in the nature of a loose granular precipitate which actually aids the filtering of the oil due to its deposition on the blotter papers to form an additional filtering surface.

We have illustrated and described a present preferred embodiment of our invention and have described the present preferred method of carrying out the process and have indicated certain preferred temperatures. It is to be understood, however, that the invention may be otherwise embodied or practiced within the scope of the following claims.

We claim:

1. The method of purifying oil which has been used in electrical apparatus, comprising heating the oil, spraying it under super-atmospheric pressure into a chamber maintained at super-atmospheric pressure to release gases and moisture, collecting the degasified oil, cooling it to below about 85° F., by transferring heat therefrom to incoming oil to precipitate solid sludges, and thereafter filtering the cooled oil.

2. The method of purifying oil which has been used in electrical apparatus, comprising heating the oil, spraying it under super-atmospheric pressure into a chamber maintained at super-atmospheric pressure to release gases and moisture, collecting the degasified oil, cooling the degasified oil to a temperature sufficient to precipitate soluble sludges by transferring heat therefrom to incoming oil, and thereafter filtering the cooled oil.

3. The method of purifying oil which has been used in electrical apparatus, comprising heating contaminated oil by heat exchange with degasified oil, spraying it under superatmospheric pressure into a chamber maintained at superatmospheric pressure to release gases and moisture, collecting the degasified oil, cooling it by counter-current heat exchange with contaminated oil to cool the degasified oil to a temperature sufficient to precipitate soluble sludges, and thereafter filtering the cooled degasified oil.

4. The method of purifying oil which has been used in electrical apparatus, comprising heating the oil, spraying it under super-atmospheric pressure into a chamber maintained at superatmospheric pressure to release gases and moisture, collecting the degasified oil, cooling it to below 85° F. and to about the ambient temperature of the container to which the oil is to be delivered after filtering, and then filtering the oil.

5. The method of purifying oil, comprising heating the oil, spraying it under super-atmospheric pressure into a chamber maintained at superatmospheric pressure to release gases and moisture, collecting the degasified oil, cooling the degasified oil by transferring heat therefrom to incoming contaminated oil to a temperature sufficient to precipitate dissolved sludges, and thereafter filtering the oil to remove the precipitated sludges.

6. The method of purifying oil which has been used in electrical apparatus, comprising filtering the impure oil to partially remove solids and free water, heating the oil, spraying it under super-atmospheric pressure into a chamber maintained at superatmospheric pressure to release gases and moisture, collecting the degasified oil, cooling the degasified oil to a temperature sufficient to precipitate soluble sludges by transferring heat therefrom to incoming impure oil, and thereafter filtering the cooled oil to separate the precipitate.

7. The method of purifying oil for electrical insulation purposes, comprising heating the oil, spraying it under pressure of at least 60 pounds per square inch into a vacuum chamber maintained under a vacuum of from 28 to 30 inches of mercury as referred to a 30 inch barometer, collecting the degasified oil, cooling it by transferring heat therefrom to incoming contaminated oil, and filtering the cooled oil.

8. The method of purifying oil for electrical insulation purposes, comprising heating it to a temperature of between 90 and 160° F., spraying it under pressure of between 60 and 200 pounds per square inch into a vacuum chamber maintained under a vacuum of from 28 to 30 inches of mercury as referred to a 30 inch barometer, collecting the degasified oil, cooling it by transferring heat therefrom to incoming oil, and filtering the cooled oil.

9. The method of purifying oil for electrical insulation purposes, comprising heating it to a temperature of about 150° F., spraying it under pressure of about 125 pounds per square inch into a vacuum chamber maintained under a vacuum of from 29.5 to 29.7 inches of mercury as referred to a 30 inch barometer, collecting the degasified oil, cooling it by transferring heat therefrom to incoming oil, and filtering the cooled oil.

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CERTIFICATE OF CORRECTION.

Patent No. 1,951,739. CLARENCE J. RODMAN, ET AL.

March 20, 1934.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, line 87, claim 5, after "oil" insert the words which has been used in electrical apparatus; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of May, A. D. 1934.

Bryan M. Battey
(Seal)
Acting Commissioner of Patents.