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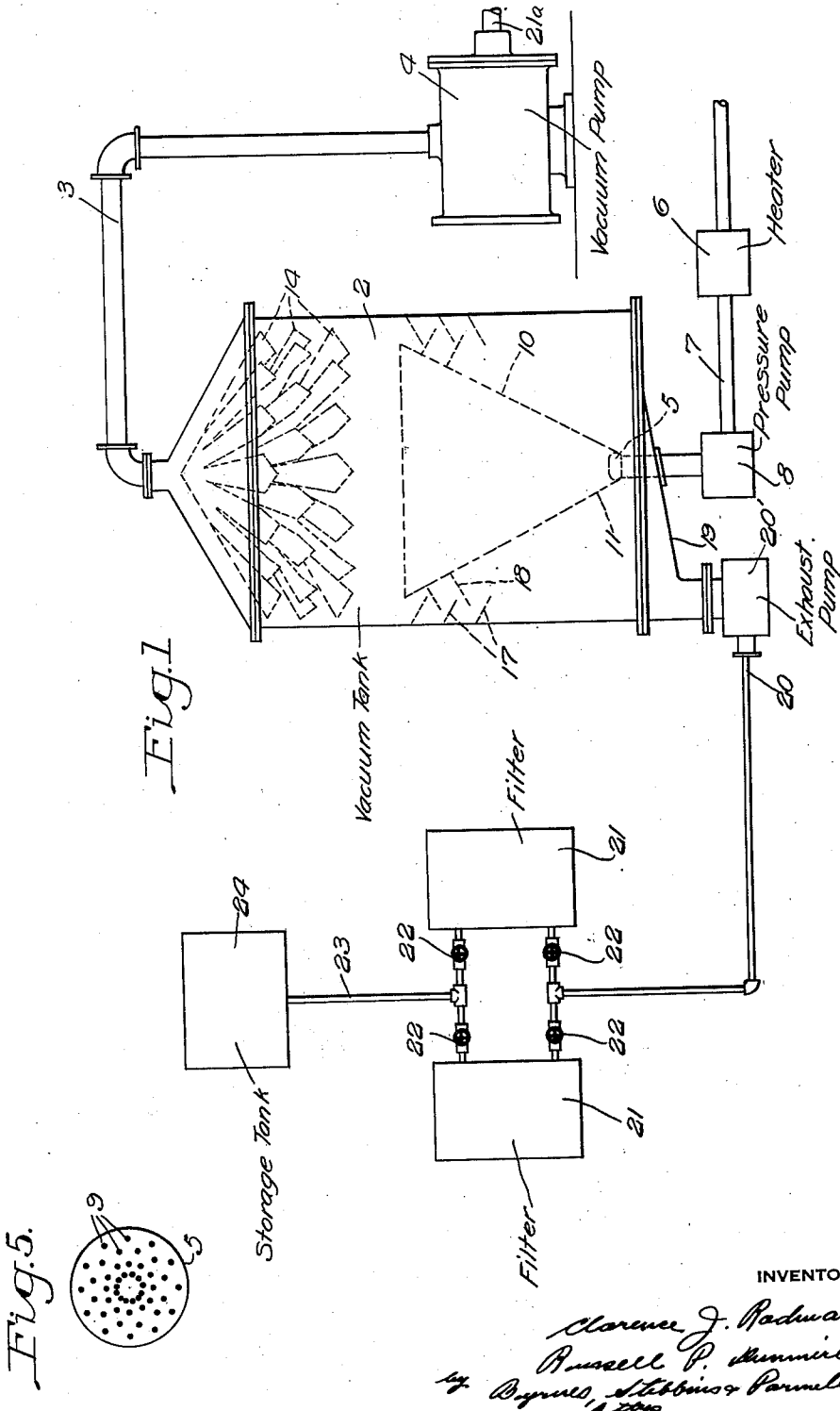
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APPARATUS FOR PURIFYING LIQUIDS

Filed April 30, 1929

2 Sheets-Sheet 1



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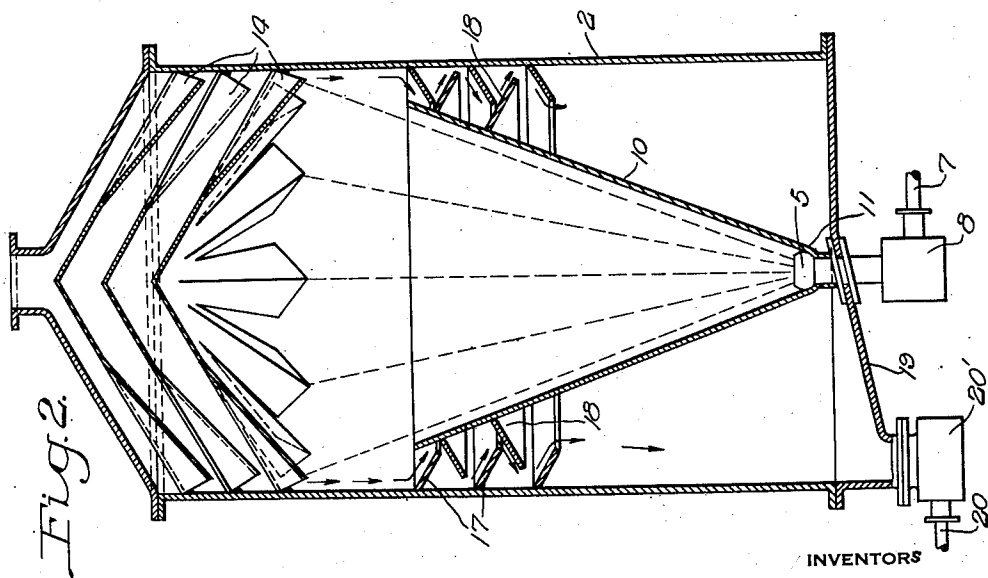
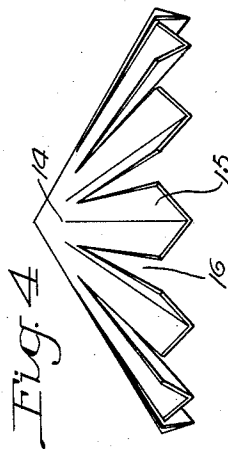
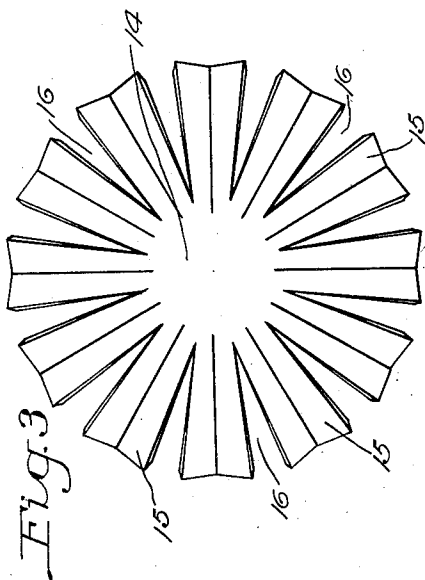
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## UNITED STATES PATENT OFFICE

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## APPARATUS FOR PURIFYING LIQUIDS

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This invention relates to an apparatus for purifying liquids, and more particularly to an apparatus for rendering non-aqueous liquids such as mineral hydrocarbon oils anhydrous, free from dissolved gases, volatiles and volatile hydrocarbons which result from oxidation of the oil when in use.

It also relates to the breaking up of emulsions and to the removal of true water of solution.

Although in this specification only the purification of mineral hydrocarbon oils is described in detail, it is to be understood that the apparatus embodying our invention is applicable to the purification of any non-aqueous liquid. In the purification of mineral hydrocarbon oils our invention is applicable both to the preparation of new oils and to the conditioning of oils after use, for example, 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.

Heretofore 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 we spray the liquid to be purified into a vacuum. The liquid introduced into the vacuum chamber is preferably under a pressure of from 50 to 150 pounds per square inch, and the vacuum within the vacuum chamber is maintained at as low a pressure as is practicable. We prefer to maintain the vacuum in the vacuum chamber at a pressure of less than one-half pound per square inch. When the liquid under pressure is introduced into the vacuum chamber the dissolved water and gases are subjected to a sudden pressure drop or shock which causes the water and gases to escape from the liquid. The liquid after having water and gases removed therefrom is pumped through suitable filters and delivered to a storage tank.

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

Figure 1 shows in a diagrammatic manner the arrangement of the purifying apparatus,

Figure 2 is a vertical section of the vacuum tank,

Figure 3 is a plan view of one of the baffles for collecting and deflecting the liquid,

Figure 4 is an elevation of the baffle shown in Fig. 3, and

Figure 5 is a detail of the spray nozzle.

Referring to the drawings, there is shown a vacuum tank 2 connected by a pipe 3 to a vacuum pump 4 which maintains the vacuum chamber under reduced pressure. The tank 2 has a nozzle 5 arranged in its bottom for spraying the liquid which is to be purified. The liquid is heated in a heater 6 and is supplied to the nozzle 5 through a pipe 7 and a pressure pump 8. The pressure pump raises

the pressure of the liquid supplied to the nozzle so that as the liquid is sprayed into the vacuum tank it is subjected to a sudden shock which releases dissolved gases and water therefrom. The nozzle 5 is formed with a series of concentric openings 9 which spray the liquid upwardly in the vacuum tank in a series of concentric cones. The spray is guided in its travel upwardly through the vacuum tank by a conical baffle 10 having its apex 11 extending downwardly and surrounding the nozzle. A series of conical baffles 14 are arranged in the tank above the baffle 10. These baffles are shown in detail in Figs. 3 and 4. They are formed from a circular piece of metal which is slit to form segments 15. Each of these segments is then bent into a trough shape as indicated in Fig. 4. After the segments have been bent to form the troughs, the baffle consists of trough-like segments 15 separated by spaces 16. As shown, three of these conical baffles are arranged one above the other in the vacuum tank. They are arranged so that the segments of the middle baffle are in alignment with the spaces 16 between the segments of the upper and lower baffles. The liquid sprayed from the nozzle 5 impinges upon the series of baffles 14.

Due to the arrangement of the baffles as described, a tortuous path is formed between the segments of adjacent baffles. The liquid impinges upon the segments of the baffles and drops down into and is collected by the segments of the next lower baffle. The liquid flows in the downwardly and outwardly extending troughs and is collected by annular baffles 17 secured to the inside of the vacuum tank. Other baffles 18 connected to the conical baffle 10 cooperate with the baffles 17 to cause the liquid to follow the tortuous path indicated by the arrows in Fig. 2, after which the liquid flows to the bottom of the tank. The bottom 19 of the tank slopes downwardly so as to cause the liquid to collect and be delivered to the pipe 20 by means of an exhaust pump 20'.

As the liquid sprayed from the nozzle 5 impinges against the baffles 14 and is collected thereby as above described, the gases and moisture removed from the liquid by the vacuum flow out of the top of the tank through the pipe 3 and vacuum pump 4 and are exhausted through a pipe 21a.

The provision of the cone 10 prevents the formation of eddy currents within the vacuum tank 2. If the cone were not present, eddy currents might be formed which would cause the spray from the nozzle 5 to be carried to the outlet of the vacuum tank without the liquid first impinging against the baffles 14 and being delivered therefrom to the baffles 17 and 18. The liquid would not be forced to follow a tortuous path between the baffles 17 and 18, and would not be subjected to the

action of the vacuum in order to remove the moisture and gases from the liquid. The cone 10 also provides a convenient means for fastening the baffles 18 thereto.

The purified liquid from which the moisture and gases have been removed flows from the vacuum tank through the pump 20' and pipe 20 to one of the filters 21. The filters remove any suspended particles which may have been present in the liquid. In the drawings two filters 21 are shown and the system is provided with valves 22 so that one of the filters may be used while the other is being cleaned. The filtered material flows through a pipe 23 to a storage tank 24.

We have found that by raising the pressure of the liquid before it enters the vacuum tank, and then introducing it into the tank which is maintained at a very low pressure, we accomplish the removal of water and gases more efficiently than if the liquid were introduced into the vacuum under atmospheric pressure. We find that the sudden drop in pressure gives a jarring or cracking action to the liquid which causes the water and dissolved gases to be expelled therefrom. The apparatus hereinabove described causes the liquid sprayed from the nozzle 5 after having impinged against the conical baffles 14 to follow a tortuous path before it leaves the vacuum tank. In this manner the liquid is subjected to the action of the vacuum for a relatively long time, so that the dissolved gases and water have an opportunity to escape from the oil. The apparatus causes the efficient removal of moisture and gases from oils so as to increase their dielectric properties. The apparatus is of simple construction involving the use of no revolving parts.

We have found that oil purified in accordance with our invention has certain desirable properties which are not present in oil produced by other methods. For example, we have found that oil treated in accordance with our process, after having been allowed to stand in contact with the atmosphere, has an increased insulating value. It would ordinarily be expected that if oil were allowed to stand in contact with the atmosphere, particularly moist atmosphere, the insulating value of the oil would be decreased. We have found further that an oil treated in the above described apparatus has a greater insulating value after having stood in contact with the atmosphere, even if the atmosphere is moist, than it had when it was first delivered from the purifying apparatus. A sample of oil was tested soon after it had come from the apparatus. This sample was found to have an insulating value of 35 kilovolts measured at the standard one-tenth inch gap using parallel electrodes one inch in diameter. The oil was allowed to stand in contact with the atmosphere for about three weeks and a second sample was tested under the same con-

ditions. The second sample gave an insulating value of considerably over 40 kilovolts.

The exact theory which causes oil purified in accordance with our invention to increase in insulating value has not yet been definitely determined. We believe, however, that it is due to the fact that in our purification process certain impurities in the oil which tend to absorb water from the atmosphere are substantially entirely removed from the oil. After oil has been so purified it will not absorb moisture from the atmosphere so as to decrease in insulating value, but will, on the contrary, actually increase in insulating value upon exposure to the atmosphere. The reason for the increase in insulating value may be accounted for by the oil absorbing certain gases without, however, absorbing moisture. Whether or not our theories are correct, we have found that there is an actual increase in the insulating value of oil purified in accordance with our invention, and we do not limit ourselves to the theories which we have advanced to account for the increase in insulating value of the oil.

We have illustrated and described the present preferred embodiment of our apparatus and have described the present preferred manner of practicing the process. Changes in the pressures employed and in the details of carrying out the process may be made within the scope of the following claims.

We claim:—

1. In an apparatus for purifying liquids, a tank, means for creating a partial vacuum therein, means for supplying liquid under pressure to the tank, means for atomizing the liquid supplied to the tank, a conical baffle extending upwardly from said atomizing means and defining a liquid expanding chamber, and baffles disposed transversely of the tank for collecting and deflecting the liquid toward the sides of the tank, and other baffles for providing a circuitous path for the flow of liquid collected by said second mentioned baffles toward the bottom of the tank through a liquid collecting chamber defined by said conical baffle and the wall of said tank.

2. In an apparatus for purifying liquids, a tank, means for creating a partial vacuum therein, means for supplying liquid under pressure to the tank, atomizing means for the liquid supplied to the tank, a conical expansion chamber for the atomized liquid, a series of baffles for collecting and deflecting the atomized liquid toward the sides of the tank, the baffles being of general cone shape and having their sides sloping downwardly and outwardly, said conical expansion chamber and the side wall of the tank defining a chamber for providing a path for the collected liquid different from that of the sprayed liquid.

3. In an apparatus for purifying liquids,

a tank, means for creating a partial vacuum therein, means for supplying liquid to the tank under pressure, a nozzle for atomizing the liquid supplied to the tank, an expansion chamber surrounding said nozzle, a series of baffles arranged to collect and deflect the liquid toward the sides of the tank, the baffles being of general cone shape having their sides divided into segments of trough shape, said expansion chamber defining, with said side walls, a path for outflow of collected liquid different from that of the sprayed liquid.

4. In an apparatus for purifying liquids, a tank, means for creating a partial vacuum therein, means for supplying liquid to the tank under pressure, an atomizing spray for the liquid supplied to the tank, an atomizing chamber surrounding said spray, a series of baffles arranged one above the other to collect and deflect the liquid sprayed from the nozzle through said atomizing chamber, the baffles being of general cone shape, having their sides divided into spaced segments of trough shape, the segments of one baffle being aligned with the spaces of adjacent baffles to form a circuitous path for the gases released from the sprayed liquid, said atomizing chamber and the wall of said tank defining a path for the outflow of collected liquid toward the bottom of the tank different from that of the sprayed liquid.

5. In apparatus for purifying liquids, a tank, means for maintaining a sub-atmospheric pressure therein, a spray nozzle adjacent the bottom of the tank, means for raising the pressure of the liquid supplied to the nozzle, a cone shaped baffle having its apex extending downwardly and surrounding the nozzle for guiding the spray upwardly in the tank, and a series of baffles having their apices extending upwardly arranged one above the other in the tank above the nozzle, the last mentioned baffles being of general cone shape having their sides divided into spaced segments of trough shape, the segments of one baffle being aligned with the spaces of adjacent baffles.

6. In apparatus for purifying liquids, a tank, means for maintaining a sub-atmospheric pressure therein, a spray nozzle adjacent the bottom of the tank, means for raising the pressure of the liquid supplied to the nozzle, a cone shaped baffle having its apex extending downwardly and surrounding the nozzle for controlling the spray upwardly in the tank, and a series of baffles having their apices extending upwardly arranged one above the other in the tank above the nozzle, the last mentioned baffles being of general cone shape having their sides divided into spaced segments of trough shape, the segments of one baffle being aligned with the spaces of adjacent baffles, and other baffles on the inside of the tank for receiving the liquid

from said series of baffles and causing it to follow a tortuous path downwardly in the tank.

7. Apparatus for purifying oil, comprising  
5 a tank, means for creating a partial vacuum therein, means for spraying oil upwardly into the tank under pressure, an expansion chamber for confining said sprayed oil,  
10 baffles disposed transversely of the tank for collecting and deflecting the oil toward the sides of the tank, said expansion chamber defining, with the wall of said tank a path for the outflow of collected oil separate from that  
15 of the inflowing sprayed oil, and other baffles in said path for causing the circuitous flow of the collected oil toward the bottom of the tank.

In testimony whereof we have hereunto set our hands.

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