Nov. 3, 1931. J. N. VANDEGRIFT 1,829,949

FRACTIONATING TOWER AND SCRUBBER

Filed Aug. 16, 1928 2 Sheets-Sheet 1

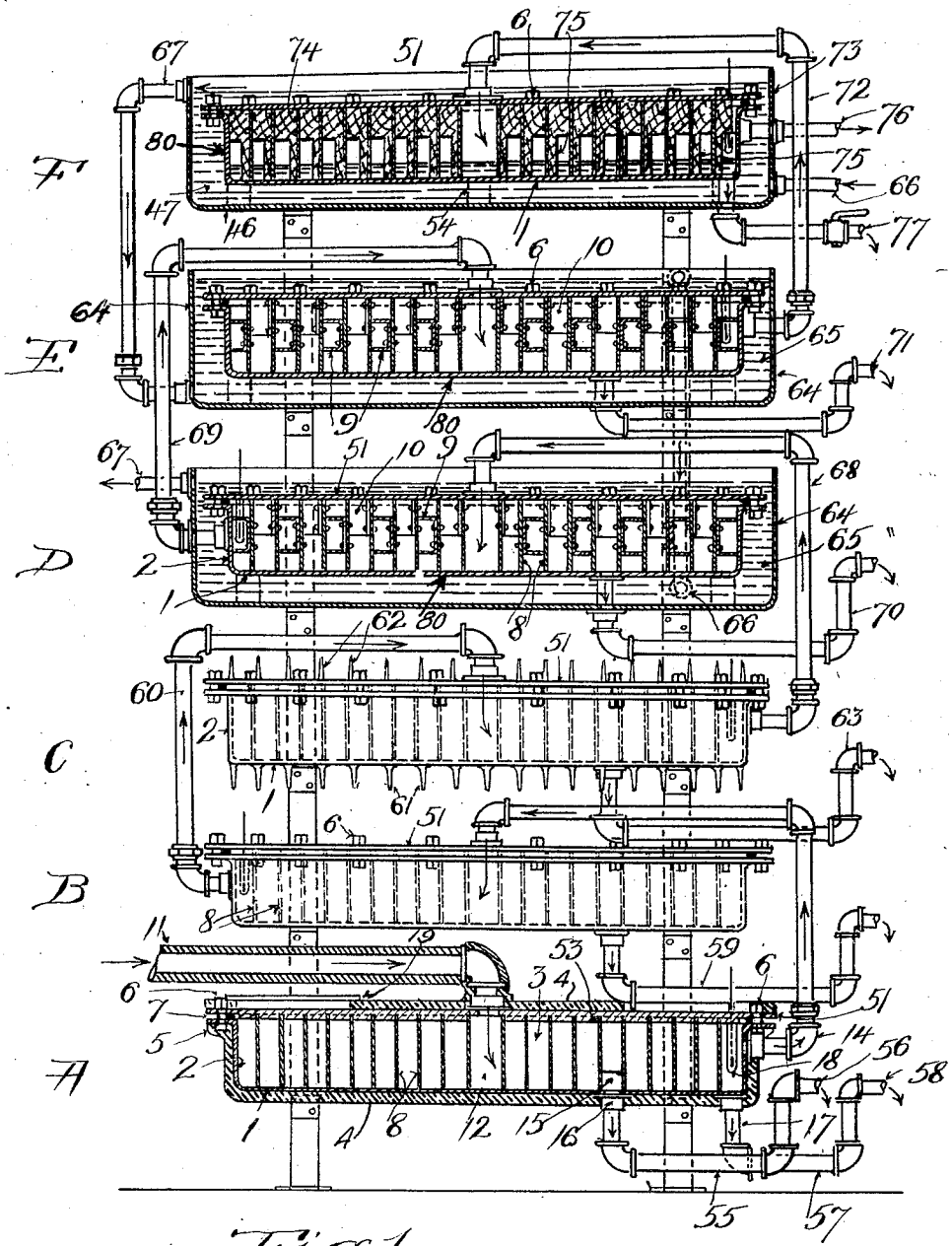


Fig. 1.

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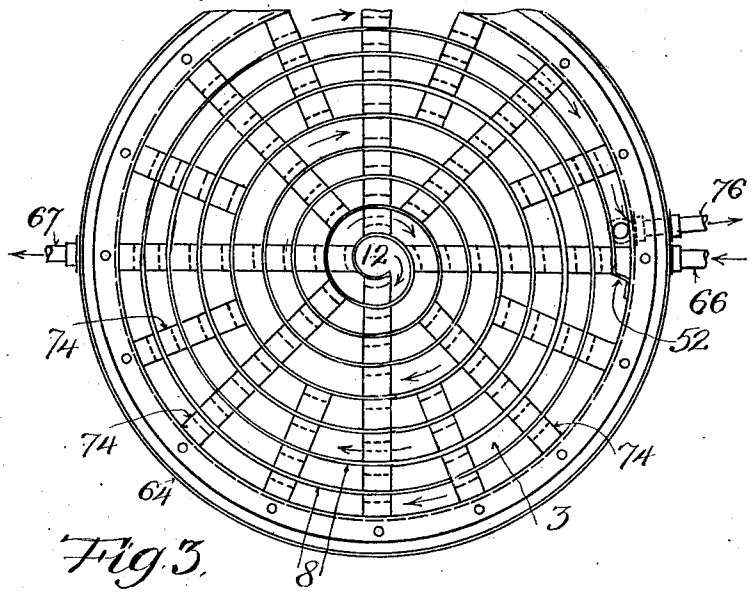


Fig. 3.

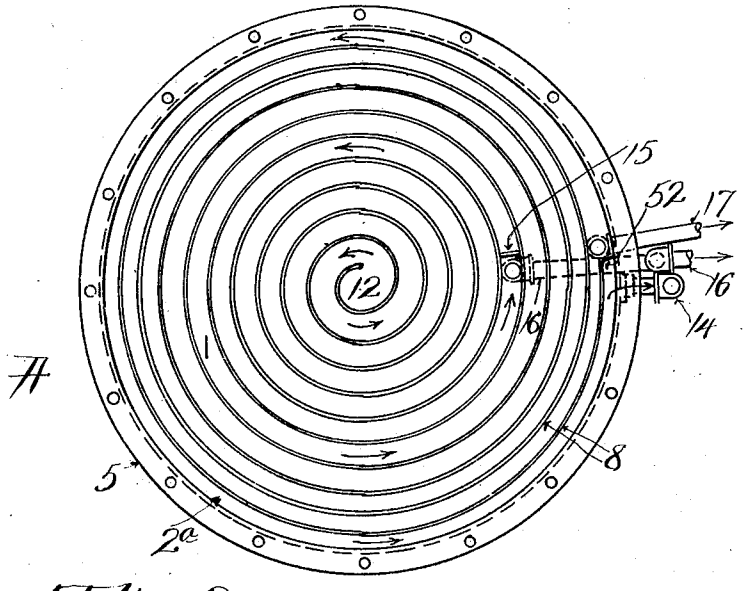


Fig. 2.

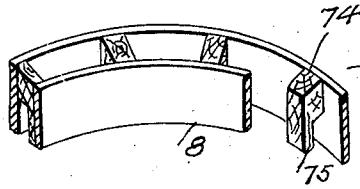


Fig. 4.

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UNITED STATES PATENT OFFICE

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FRACTIONATING TOWER AND SCRUBBER

Application filed August 16, 1928. Serial No. 299,927.

The object of my invention is to provide an apparatus for the fractional condensation of petroleum or hydrocarbon or other vapors from a still or retort into various by-products such as paraffin, lubricating oils, gas or fuel oils, gasoline, kerosene, naphthas, benzols and various other products; and in the fullest embodiment of my invention there is also provided means for scrubbing from the fixed gases any light condensible volatiles. All of these operations are adapted to be carried out in a single tower consisting of a series of preferably superposed spiral condensers similar in principle to the condenser disclosed in my co-pending application Serial No. 232,360.

The simplicity of the present construction of condenser makes it possible to provide a fractionating tower for condensing by-products, in which the tower will cost approximately one-fifth that of previous constructions, and will occupy but a fraction of the space occupied by fractionating towers formed of pipes or of dephlegmator baffle construction. By providing a plurality of separate units, each in itself composing a condenser, various temperatures may be maintained in the several units by air circulation and by water cooling, so that different fractions or condensates having specifically different characteristics may be withdrawn from the several units while the product is progressing successively through the several units of the complete tower.

Other advantages will be set forth in the following detailed description of my invention.

In the drawings forming part of this application,

Figure 1 shows an elevation with parts broken away, of a fractionating tower composed of six different units in superposed relation, one of which includes a scrubber,

Figure 2 is a plan view of the paraffin or heaviest oil condenser with the cover removed, and

Figure 3 is a plan view of the unit which is employed as a scrubber, showing it with the cover removed.

Figure 4 is a perspective view of the interior of the scrubber unit.

In the drawings I have shown a fractionating tower with the several units arranged in superposed relation and composed of six units A, B, C, D, E and F. In operation the oil or other vapors and fixed gases are delivered from the petroleum refining still or retort, in the case of a low temperature carbonization plant, to the lower condenser A, and they are, preferably, introduced at the center thereof through the pipe 11. These vapors and fixed gases travel through a spiral conduit 3. The unit A is shown composed of a receptacle consisting of a bottom wall 1 and a cylindrical wall 2 having a removable cover 51 secured to the receptacle by bolts 6 with a packing ring 7 interposed between the cover and upper flange 5 of the receptacle. Preferably, the receptacle and its cover are insulated by a covering 4 of insulating material, so that only a partial reduction in temperature of the products will take place in the unit A, leaving the products still in a heated condition when they pass into the unit B as hereinafter described.

The spiral channel 3 through which the volatiles delivered from the pipe 11 flow, is formed by a curved strip of metal 8 which starts near the center of the unit A and is coiled about itself in the form of a spiral having gradually increasing convolutions, so that this spiral strip gradually expands until its outer convolution approaches the cylindrical wall of the unit; and its outwardly turned end is preferably fastened to this wall as shown at 52.

While the spiral strip 8 may have its convolutions separated from each other in the manner shown in my said co-pending application I have shown in the present construction a spiral slot 53 formed in the under surface of the cover 51 to receive one edge of the spiral strip 8, so that the groove acts as a pocket for this edge of the strip 8 and holds the several convolutions in definite spaced relation. When the cover 51 is applied to the flange 5 of the receptacle and clamped in place by the bolts 6, the strip 8 will rest in close contact with the bottom wall 1 and will

extend at the top into the spiral groove 53 so that the entire interior of the unit A will be formed into a spiral channel into which the volatiles enter at the center, and thence travel a spiral course in contact with the several convolutions of the strip 8, and with the cover and bottom wall of the unit. I prefer that this first unit be air-cooled; that is to say, the air circulating around the unit reduces the temperature of the volatiles in the spiral channel 3 sufficiently to reduce the temperature of the volatiles for condensing the first product. The volatiles passing through this spiral channel come into contact with large radiating surfaces composed of the strip 8 and the bottom wall 1 and the cover 51, so that even though the products are in this condenser a comparatively short period, they are reduced in temperature sufficiently to remove by condensation certain of the products. While I prefer to remove two different fractions of oil of different boiling points and densities in the unit A, the invention is not limited to this method of operation. While the volatiles are passing through the spiral channel 3, some of them are precipitated by condensation into a liquid accumulating in the bottom of the spiral channel 3 and at 15 I have provided a dam consisting of a metal wall between two of the convolutions of the strip 8 extending only partway of the height of the strip 8, so that the liquid precipitated on one side of this dam may be drawn off through the outlet pipe 16.

In the treatment of petroleum products the material removed through the pipe 16 will generally be paraffin or heavy oil condensed from the hot vapors by cooling and while traveling up to the point of the dam 15.

The pipe 16 forms part of a trap 55 which will entrap part of the fluid and prevent the escape of vapors through the pipe 56 which conducts the liquid away from the unit A. The vapors which pass beyond the dam 15 and traverse the course of the spiral channel 3 will be subject to further condensing action and additional liquid will be precipitated before the vapors pass out of the discharge pipe 14. Such liquids as may be condensed beyond the dam 15 will be conveyed from the unit through the pipe 17 and the trap 57 and will be conducted away by the discharge pipe 58. The condensates removed through the pipes 16 and 17 will be different fractions having different boiling points. If it is desired to remove only a single fraction or condensate in the unit A the dam 15 may be omitted as well as the pipe 16 and in that case all of the condensate in the unit A will be carried off through the pipe 17.

I have shown a covering or jacket 4 of refractory material covering only that portion of the cover 51 of the unit A up to the convolution of the strip 8 where the dam 15 is located, leaving the portion of the cover outside of and concentric therewith uncovered, and subject to the cooling effect of the air circulating over the cover. The effect of leaving the cover partially protected by the refractory material and the other exposed to the circulating air will cause a more definite demarcation between the fraction or condensate taken off through the pipe 16 from that taken off through the pipe 17.

I have provided a thermometer 18 projecting into the unit A and having a reading portion extending out of the cover, and if the temperature at this discharge end is below the desired low end point the insulating material 4 may be extended out to partially cover the unit A beyond the point of the dam 15 in order to regulate the condensation and to secure the discharge of the desired condensate through the pipe 17.

The vapors which are not condensed while passing through the unit A discharge from this unit through the pipe 14 which latter conducts the vapors into the unit B which I have shown superposed directly over the unit A. The unit B is constructed similar to the unit A except that I have eliminated the insulating or refractory material. This unit has a strip 8 arranged in the form of a spiral, the same as in the unit A, and the vapors admitted to the central point of the channel 3 circulate through this channel and these vapors are further cooled while passing therethrough, so that part is precipitated in the form of a liquid. The condensate precipitated in the unit B will consist of lubricating oils of lower boiling point than the condensate formed in the unit A. This condensate is withdrawn from the unit B through the pipe and trap 59 and is conveyed away. I have shown the unit B as air-cooled and a lower boiling point condensate will be condensed in the unit B than that formed in the unit A.

The products which still exist as volatiles after passing through the unit B are conducted through the pipe 60 and are fed into the center of the unit C which is shown superposed above the unit B. In most respects the unit C is like the unit B and it has the same spiral channel 3 formed by the strip 8 coiled about itself and dividing the space between the shell and the cover to form this spiral channel.

I have shown the unit C provided with a number of fins or flanges 61 distributed across the bottom of the bottom wall 1 and a similar set of fins or flanges 62 projecting from the cover 51. These flanges may be cast integrally with the cover and the bottom wall 1. The flanges or projections, acting on the principle of convection serve to rapidly dissipate the heat from the product while traveling through the spiral channel 3 in the unit C and by reason of the increased cooling action effected with these flanges the temperature

of the products in the condenser C may be brought down to the desired end point, so that gas oil or light lubricating oil fractions may be condensed in the unit C where the device is being used for petroleum products. The liquid precipitated in the unit C is drawn out through the pipe and trap 63.

The unit D is shown superposed above the unit C and the unit E is shown superposed above the unit D, and as both of these units are shown similar in construction and operation they may be collectively described. Each of these units comprises a receptacle 80 corresponding with the receptacles contained in the previously described units, together with a cover and gasket and having the spirally arranged metal strip 8 between the bottom and the cover to divide the chamber into a spiral channel 3. The vapor chamber 80 in this case is submerged in water to secure the desired cooling action. For this purpose I have shown the chamber 80 arranged in a water tank 64, so that the chamber and its cover are submerged within the water 65 contained within the tank. This water is perfectly circulated, the pipe 66 connected with the tank serving as an inlet for the water, and the pipe 67 arranged at the opposite point of the tank serves to carry off the water and thereby maintain circulation around the chamber 80. The parts thus described are the same for the units D and E.

Instead of disposing the strips 8 in grooves in the cover member of the units D and E I have shown channel pieces 9 bolted at intervals to the strip 8, so that the flanges of these channel members serve to hold the adjacent convolutions of the strip 8 in the desired spaced relation. I have also shown members 10 attached at intervals to the strip 8 to act as baffles. Both the members 9 and 10 serve to deflect or baffle the vapors passing through the spiral channel 3 so that they are brought into contact with the bottom wall 1 and the cover 51 and with various portions of the strip 8. The same members 9 and 10 correspond with similar members shown and described in my said co-pending application. The vapors are taken from the unit C through the pipe 68 and are delivered to the center of the unit D so that these vapors pass through the spiral channel 3 and while so traveling they are reduced in temperature to a point where the liquid formed by condensation of part of the vapors in the unit D will result in a fraction which will consist, say, of kerosene. The condensate from the unit D is drawn off through the pipe and vapor trap 70. The products still remaining in the form of vapors after passing through the condenser D are conducted by the pipe 69 and are delivered to the central part of the unit E, so that the vapors pass through the spiral channel 3 in this unit and part of the vapors are condensed into liquid and are drawn off through the pipe and trap 71. The fraction thus removed from the unit E, where petroleum is the product under treatment, will be, say, gasoline.

The fixed, non-condensible gases carrying with them a percentage of light oil vapors, pass out of the unit E through the pipe 72 and are conducted to the center of the scrubber F.

The scrubber comprises, in the embodiment shown hereof, an outer tank 73 through which water is circulated in the same manner as in the units D and E. The cooling water enters this tank through the pipe 66 and is drawn off through the pipe 67 which, preferably, delivers the water which has served for cooling in the scrubber into the tank of the unit E, in order that in the latter the temperature of the water will be slightly raised by reason of the fact that it has previously served for cooling in the scrubber. In addition, the scrubber consists of a chamber 80 corresponding with the unit A and it is provided with a cover and the strip 8 coiled in the form of a spiral is also present in this unit. Instead of the baffles or separators used in the other units, I have shown here a number of blocks 74 which may be made of soft wood or asbestos, of sufficient strength to act as spacers to maintain the convolutions of the strip 8 in spaced relation, and sufficiently porous to become saturated with the heavy oil in the bottom of the scrubber channel. This material must also be adapted to stand the heat and preferably it withstands the heat applied at intervals to drive off the lighter volatiles absorbed by the heavy scrubber oil placed in the bottom of the chamber. I have shown these blocks wide at the top to extend across the full width of the space between the convolutions of the strip 8 and below the blocks are cut away to form the narrow extensions 75 which project to the bottom of the shell 80. These blocks, in addition to forming spacers for the convolutions of the strip 8, act by capillary attraction to absorb the heavy, high boiling point oil which is admitted into the spiral channel 3 of the scrubber by means of the pipe 72 so that a layer of high boiling point oil is always present in the lower part of the channel 3.

The high boiling point oil absorbs the light oil condensate from the fixed gases which are caused to travel through the long spiral channel 3 which are not only in contact with the oil at the bottom of the spiral channel but with the oil saturating the baffle blocks 74. The scrubbed gases may be withdrawn through the pipe 76 and may be stored in a gas holder (not shown). From time to time the scrubbing chamber may be removed from its position in the water tank 73 and be subjected to heat for the purpose of distilling off the light volatiles absorbed by the oil and by the

absorbing blocks and the spiral conduit. It will be understood that while the scrubber is removed for this purpose, another one is substituted in its place to maintain continuous service of the tower.

One of the advantages of the present apparatus for fractional condensation of petroleum and other vapors over previous towers, is that the present device is self-cleansing even in the units where the heaviest oil fractions are present. This eliminates the necessity of frequent cleansing which has always been necessary in the pipe forms of condensers, where the latter were of return bend construction arranged in tanks, or constructed of a series of nests of pipes and towers. In the present device the vapors from the still up to the time they pass through the scrubber have a continuous travel in contact with large metallic condensing surfaces and the units may be of uniform construction, compact, inexpensive and of efficient design. Each unit may be easily maintained at the end point temperature for recovering the desired by-product fraction. By employing a partial or complete refractory covering for the first unit and by using air and water for circulation in subsequent units, the desired temperatures may be obtained for recovering all of the desired fractions, each uniform in itself.

The present fractionating tower may occupy about one-fifth the space of the towers heretofore used and the cost of the same, as well as its operating and maintenance cost are much less than the previous forms of towers.

Having described my invention, what I claim is:

1. In a device for condensation of vapors the combination of a shell forming a chamber, a cover for closing said chamber, one of said members having a spirally formed groove in one of its surfaces, and a strip having one edge seated in said groove and disposed in spiral convolutions and adapted to extend between said cover and the bottom of said shell to form a spiral channel, and means for delivering vapors to and from said channel whereby they are caused to travel spirally therethrough.

2. In a device for condensation of vapors, means forming a chamber having a strip disposed in convolutions and forming in said chamber a spiral channel, means for conducting vapors to and from said channel whereby they are caused to travel spirally therethrough, a liquid tank in which said chamber is disposed and means for circulating liquid in said tank for cooling the vapors traveling through said chamber, and means for withdrawing liquid condensate from said chamber.

3. In a scrubbing device for separating volatiles from non-condensible gases the combination of means forming a chamber, a strip disposed therein in convolutions and forming a spiral channel through which the vapors are adapted to be conducted, means for conducting vapors to and from said channel whereby they are caused to travel spirally therethrough, and blocks of absorbent material disposed in said channel for absorbing condensible volatiles from non-condensible gases.

4. In a scrubber for separating volatiles from non-condensible gases, means forming a chamber, a strip disposed therein in convolutions and forming a spiral channel in said chamber, means for conducting vapors to and from said channel whereby they are caused to travel spirally therethrough and blocks of absorbent material disposed in said channel and having passages therethrough for the circulation of vapors.

5. In a scrubber for separating condensible volatiles from fixed gases, means forming a chamber, a strip disposed therein in convolutions to form a spiral channel, means for conducting vapors to and from said channel whereby they are caused to travel spirally therethrough, means for supplying a layer of absorbent liquid in the lower portion of said chamber and blocks of absorbent material disposed in said channel and extending substantially across the upper portion of said channel and having narrower portions projecting into the liquid in the lower portion of said chamber.

6. In a device of the character described the combination of a plurality of separate units in which vapors are adapted to be cooled, each unit comprising a chamber having a spirally formed channel, a scrubber comprising a chamber having a strip therein disposed in convolutions to form a spiral channel, absorbent material in said channel for collecting condensible volatiles by absorption, and means for conducting vapors successively through the spiral channels of said condensing units and said scrubbing unit.

7. A device for the condensation of vapors into liquid, comprising means forming a chamber, a strip disposed between the bottom and top of the chamber, and spiral convolutions to form a spiral channel, means for conducting vapors to and from said channel whereby they are caused to travel spirally therethrough, a dam in said channel extending partway of the height thereof whereby liquids may be condensed on either side of said dam and vapors may pass over the dam, and separate means for withdrawing liquid condensed on different sides of said dam.

8. In a device for the fractional condensation of vapors the combination of a plurality of separate units, each unit having a spiral channel for the travel of fluid, one of said units comprising a chamber having a cover-

ing of heat insulating material, and another comprising a chamber without insulating covering whereby it will be subjected to the direct cooling action of the surrounding air, means for causing vapors to travel through the channels of said units in series, and means for withdrawing the condensates separately from said units.

9. In a device for the fractional condensation of vapors the combination of a plurality of separate units, each having a spiral channel for the travel of fluid, one of said units comprising a chamber exposed to the cooling action of the surrounding air, another of said units comprising a chamber, a liquid tank in which said chamber is disposed, means for circulating liquid in said tank for cooling the vapors traveling through said second chamber, means for causing vapors to travel through said chambers in series, and means for withdrawing the condensates separately from said units.

10. In a device for fractional condensation of vapors, the combination of a plurality of separate units, each unit having a spiral channel for the travel of fluid, means for causing vapors to travel through the several units in series, and means for withdrawing the condensates separately from the several units, one of said units comprising a chamber, having a covering of heat insulating material to retard the radiation of heat from said unit, another unit comprising a chamber without insulation whereby said chamber will be subject to the direct cooling action of the surrounding air, and a third unit comprising a chamber, a liquid tank in which said chamber is disposed, and means for circulating liquid in said tank for cooling the vapors in the chamber of said third unit.

Signed at the city, county and State of New York, this 26th day of May, 1928.

JAMES N. VANDEGRIFT.