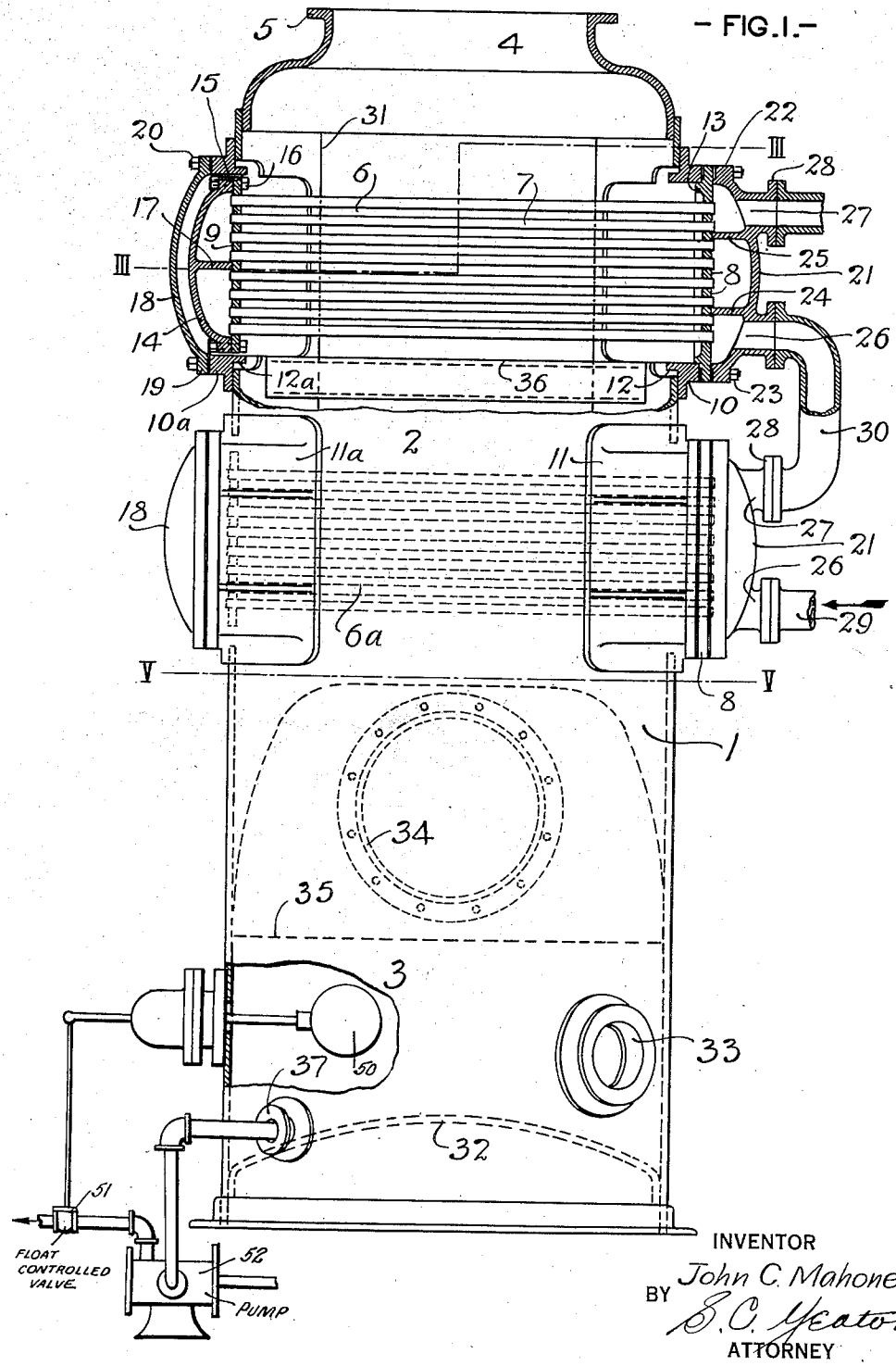
July 18, 1933. J. C. MAHONEY 1,918,608

APPARATUS FOR CONDENSING HYDROCARBONS

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- FIG. 1. -



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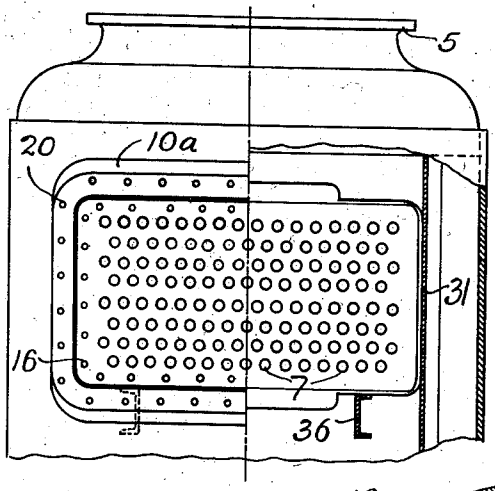
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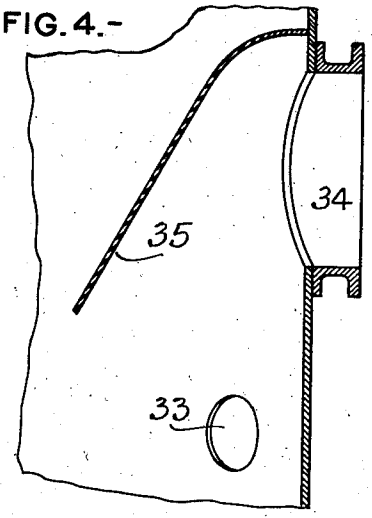
APPARATUS FOR CONDENSING HYDROCARBONS

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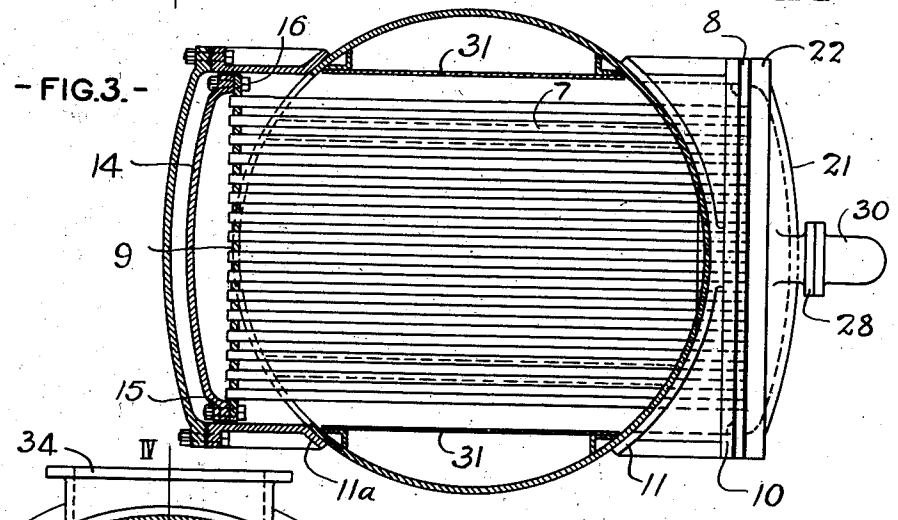
- FIG. 2. -



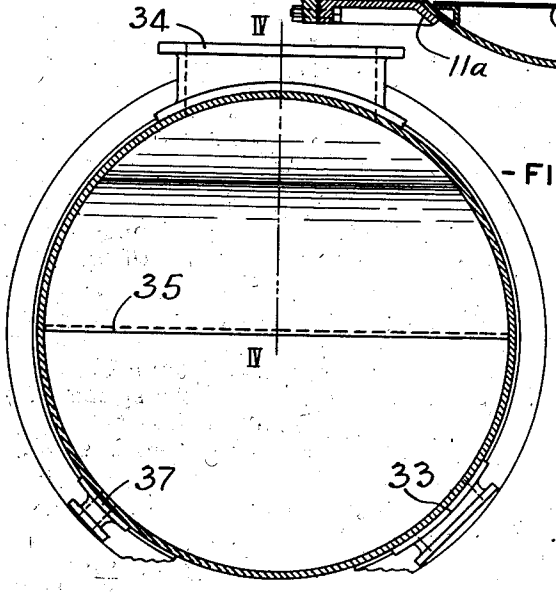
- FIG. 4. -



- FIG. 3. -



- FIG. 5. -



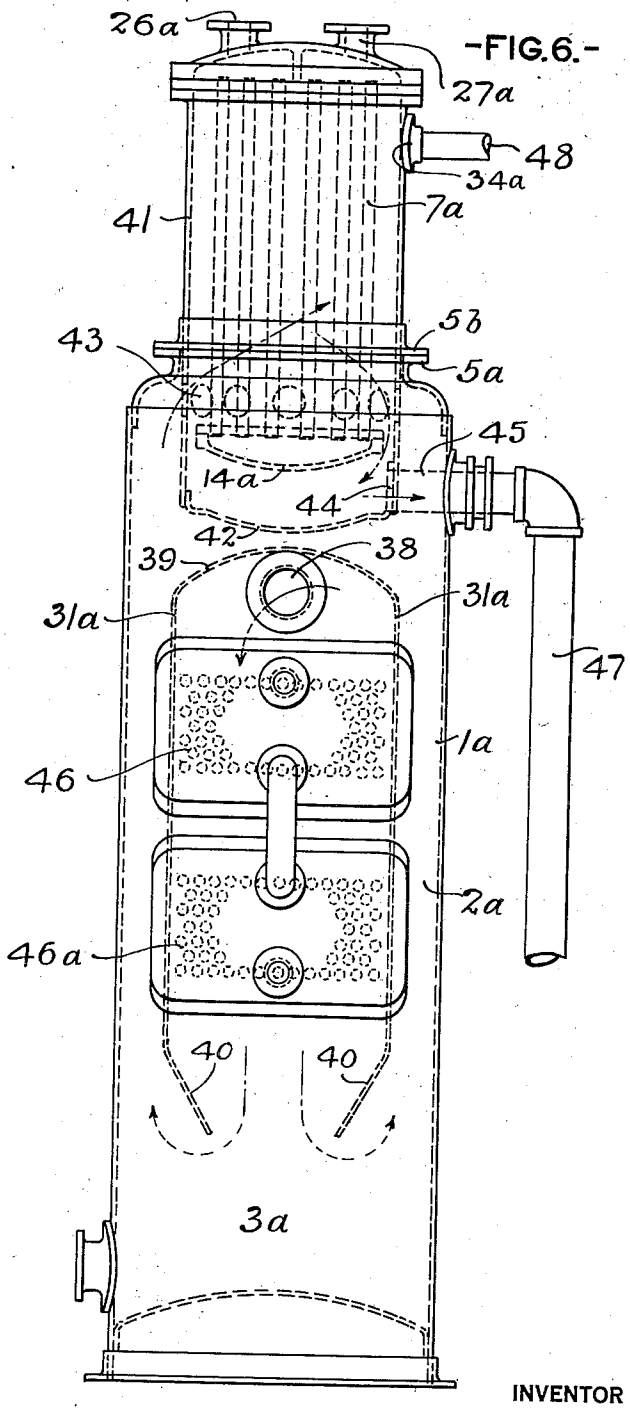
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APPARATUS FOR CONDENSING HYDROCARBONS

Filed March 4, 1931 3 Sheets-Sheet 3

-FIG.6.-



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UNITED STATES PATENT OFFICE

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APPARATUS FOR CONDENSING HYDROCARBONS

Application filed March 4, 1931. Serial No. 520,073.

This invention relates to the art of distilling hydrocarbons and particularly to the condensation of oil vapor and the disengagement of entrained condensate from uncondensed vapor. In certain processes of distillation, a vapor mixture comprising hydrocarbons, and which may include steam or other non-miscible gases, is taken off from a vaporizer or distillation zone and introduced into a condenser, the condensable hydrocarbons are condensed, the condensate is separated from the uncondensed vapor, and the condensate and the uncondensed vapor are withdrawn from the condenser. The products after leaving the condenser are then treated in the various manners well known in the art.

An object of the present invention is to provide an improved process and apparatus for condensing oil vapor, and disengaging the entrained condensate from the uncondensed vapor as aforesaid, which method and apparatus will be more economical as well as more efficient than those previously known in the art, both as to the cost of manufacture and maintenance of the apparatus, and as to the resultant product. A further object is to provide an improved process and apparatus of the character and for the purpose aforesaid in which the uncondensed vapor may be directed to a separate zone forming a part of the condenser unit, where the same may be separately condensed before leaving the unit. Other objects will appear from the description hereinafter set forth.

The objects are attained by the provision of the unique and improved condenser apparatus and the new and improved process hereinafter described.

The invention is illustrated in the accompanying drawings, in which: Fig. 1 is a side view, partly in section, of the apparatus embodying the invention; Fig. 2, at the left side, is a front view of a part of Fig. 1, with the shell cover and cooling unit head cover removed, and at the right side, is a section of a part of the same; Fig. 3 is a section on the line III—III of Fig. 1; Fig. 4 is a section on the line IV—IV of Fig. 5; Fig. 5 is a section on the line V—V of Fig. 1; and Fig. 6 is a front elevation of a modified form of the apparatus.

Referring descriptively to the drawings, wherein preferred embodiments of this invention are illustrated, the condenser, (Fig. 1), comprises a vertical substantially cylindrical shell 1, having an upper portion 2, which comprises a condensing zone, and a lower portion 3, which comprises a condensate receiving zone.

The upper end of the cylindrical shell 1, is provided with an opening 4, having a peripheral flange 5, adapted for attachment to a duct from a vaporizer or distillation zone (not shown). Cooling units 6 and 6*a*, are disposed within the upper portion or condensing zone of the shell, each unit being of the same general construction and comprising a tube bundle, consisting of a plurality of spaced horizontal tubes 7, held in position by tube sheets 8 and 9, at their opposite ends. In the opposite sides of the cylindrical shell openings are formed, and saddles 10 and 10*a* are disposed thereabout, said saddles having curved flanges 11 and 11*a*, respectively, embracing the sides of the shell and welded or riveted thereto, and said saddles also having inwardly projecting ledges 12 and 12*a* extending part way across the openings, top and bottom.

The tube sheet 8 is provided with an inwardly extending flange 13 spaced from its periphery and adapted to fit within the saddle 10. The tube sheet 9, fits within the saddle 10*a*, and a head cover 14, having a peripheral outwardly extending flange 15, is attached to the tube sheet by bolts 16, passed through said flange and tube sheet to form a header. The inside of the head cover 14, is divided in half by a centrally disposed partition or baffle 17, extending from its inner side and joining the tube sheet 9, thus providing compartments at the outer side of the tube sheet 9, which are in communication, each with a selected number of the tubes, 7. A convex shell cover 18, is disposed over the opening at this end of the cooling unit, and is provided with an outwardly extending flange, 19, by means of which the cover is bolted to the saddle 10*a*, by the bolts, 20.

It will be noted that this end of the cooling unit is a floating end, that is to say, is not in any way attached to the saddle or either directly or indirectly to the cylindrical shell, but is held in its position in the saddle free for longitudinal movement upon expansion or contraction of the tubes of the cooling unit, as the same are effected by variations in temperature during the operation of the apparatus.

A head cover 21 is disposed over the tube sheet 8. This cover is provided with an outwardly extending flange 22, by means of which it is secured to the outer edge of the tube sheet 8 and the saddle 10, by bolts 23. The head cover 21 is divided by inwardly extending partitions or baffles 24 and 25, thus providing three compartments at the outside of the tube sheet 8, which are in communication each with a selected number of the tubes 7. The lower compartment of the head cover 21 is provided with an inlet port 26, and the upper compartment is provided with an outlet port 27, the ports being provided with flanges 28, adapting the same for connection with communicating ducts or pipes. As aforesaid both of the cooling units are the same in general structure and one is disposed above the other within the cylindrical shell. While in the embodiment illustrated only two units are shown, it will be understood that in many instances the employment of a greater number may prove desirable, and that any number of units may be employed without departing from the spirit and scope of this invention.

The cooling medium, constituting a liquid which it is desired to preheat, or else cooling water, is supplied through a flanged pipe 29, to the lower cooling unit 6*a*, and enters said unit through its inlet port 26. The lower cooling unit is connected to the upper unit by means of a flanged connecting duct 30, which is joined to the upper, outlet port 27, of the lower cooling unit, and the lower inlet port 26, of the upper cooling unit. It will thus be seen that the cooling medium having entered the lower unit, as aforesaid, is confined to the lowest compartment of the head cover 21, and said medium will pass horizontally and transversely of the condenser shell through the tubes communicating with said compartment, to the lower compartment of the head cover 14. The cooling medium then passes back through the tubes which communicate with the upper part of the said lower compartment of the head cover 14, to the central compartment of the head cover 21, thence back through the tubes which communicate with the upper part of said central compartment to the upper compartment of the head cover 14, and from this compartment back through the uppermost tubes of the unit to the upper compartment of the head cover 21, and out of the unit through the port 27. The cooling medium then passes through the connecting pipe 30, to the upper cooling unit 6, and through said unit in the same manner as described for the lower unit, passing out of said upper unit through its outlet port 27.

It will be understood that while in the apparatus illustrated the cooling medium passes back and forth through each unit only twice, it is contemplated as a part of this invention to employ head covers with any number of compartments that may prove desirable, thus in the same manner as heretofore described, effecting any desired number of back and forth passages of the medium through the units. (As hereinafter referred to, in the vertical cooling unit disposed at the top of the modified form of condenser (Fig. 6), the cooling medium passes back and forth through the unit only once.) By varying the horizontal spacing of the tubes, the free area may be increased or decreased and the velocity of the vapor in its downward passage thus controlled so that the highest efficiency in condensing may be attained.

The tube units are rectangular in cross section, thus providing spaces between their sides and the adjacent sides of the cylindrical shell 1, as clearly seen in Fig. 3. To direct the flow of the mixture over the tubes, baffle plates 31 are fixed to the inner sides of the cylindrical shell, forming vertical walls along the said sides of the tube units. Beneath each of the tube units beams 36, are extended across the cylinder, and are secured to the sides thereof by studs or bolts (not shown), said beams providing support for the units when the same are being inserted or withdrawn from the cylinder. It will be apparent that by virtue of the construction of the shell covers and head covers and their manner of attachment, the same may be readily removed from their closed positions and access to the interior of the said shell and units will be thereby permitted, in order to make any necessary repairs or to clean the same. And it will also be seen that the tube units may thus be withdrawn from the shell without removing the head or shell covers at the floating end by simply removing the shell cover 21.

The lower portion of the cylinder 1, comprising the condensate receiving zone 3, is provided with a convex bottom plate 32. The bottom portion of the said zone provides a receiver for condensate, and a flanged outlet port 33 is provided in the wall thereof. A baffle plate 35 is disposed within the upper half of the receiving zone and inclines from one side of the cylindrical shell inwardly and downwardly substantially one-half the distance across the diameter of the shell, and substantially one-half the length of the cooling zone. A second flanged outlet port 34 is provided in the condensate receiving zone portion of the shell, adjacent the under side of the baffle plate 35. A third flanged port 37,

is provided near the bottom of the receiver, by means of which a liquid level regulator for controlling and indicating the level of the condensate, of any suitable type, may be connected in the usual manner.

For example, a ball float 50 may control valve 51 through any suitable connecting means to permit pump 52 to pump away any excess condensate when the level passes a predetermined point. When the condensate level falls, the reverse actions takes place.

In the operation of the apparatus, following the process of this invention, the vapor mixture from a vaporizer or distillation zone is introduced, through the opening 4, into the condensing zone of the cylinder, where the mixture passes vertically downward, the condensable constituent being condensed as it impinges upon the cooling tubes, the condensate and uncondensed vapor remaining in contact with each other, the condensate being sub-cooled as it continues downward over the cooling tubes, and the uncondensed vapor and condensate continuing downward into the lower portion or condensate receiving zone of the cylinder. Here the baffle plate 35 affects the vapor and condensate in their course of travel so that the condensate is divided from the vapor by dropping downward into the bottom of the receiver, while the said uncondensed vapor changes its direction of travel, making a complete 180° turn, flowing upwardly on the under side of the baffle plate, and passes out of the cylinder through the port 34. The condensate is separately withdrawn from the receiver through the port 33.

It will be apparent that the liquid level of the condensate must be maintained at a point above the outlet port 33 and below the lower edge of the baffle plate 35, providing a space between the liquid and the lower edge of the baffle through which the uncondensed vapor may pass, any suitable form of regulator as aforementioned being utilized in this connection. By the aforedescribed unique construction of the condenser, the flow of the condensate and the vapor through the condensing zone is so regulated that the said condensate and vapor are in uninterrupted contact with each other during the entire passage through said zone. The disposition of the baffle plate, with relation to the diameter of the shell, is such that the flow of vapor will be regulated at a predetermined rate in the receiving part of the condenser, by reason of its limiting the space through which the vapor and condensate must pass, thereby effecting a substantially complete separation of the condensate from the uncondensed vapor.

It will be noted that in the operation of this apparatus there is no change in the direction of flow of the mixture from the time the same is introduced at the top of the cylinder, until it reaches the lower portion thereof, at which time both its volume and the density have been materially reduced by virtue of the condensation of heavy hydrocarbons which has taken place in the upper portion of the cylinder. An advantage is thereby achieved of having a minimum amount of turbulence and a minimum loss of pressure due to frictional resistance to flow past the cooling surfaces. Further, a substantial equilibrium is maintained between the hydrocarbons remaining in the vapor state and the portion which is condensed, this being due to the facts that the condensate as formed, remains in contact with the vapor as it drips downward over the tubes, and a close approach to counter-current flow of the vapor and condensed liquid on the one hand against the cooling medium on the other hand is maintained.

It will be understood that the condensate when taken off through the port 33, may be further treated in the usual manners well known in the art, and the uncondensed vapor taken off from the port 34 will be passed in the usual manner to succeeding units of the distilling system for such further treatment as may be desired, such as further condensing the remaining vapors. The further treatment of the uncondensed vapor before the same leaves the condensing unit will be hereinafter described with reference to the modified form of the apparatus illustrated in Fig. 6.

The apparatus may be used in the manner aforedescribed, employing a partial vacuum within the cylinder by means of a suitable pump or other vacuum producing means such as a jet (not shown), for drawing the uncondensed vapors through the port 34, or the apparatus may be employed for use where other processes not requiring a vacuum, are followed.

It will also be understood that the apparatus is applicable for condensing any mixture of vapors having different boiling points, and where it is desired to condense one or more of the constituents and remove the same from the other constituents.

Referring particularly to Fig. 6, there is here illustrated a modified form of this invention, wherein the mixture from the vaporizer or distillation zone is introduced into the condenser through a horizontal duct 38, which passes through the wall of the cylindrical shell 1*a*, the duct 38 taking the place of the opening 4, in the aforedescribed construction. Baffle plates 31*a* are secured to the inner sides of the cylindrical shell and form vertical walls adjacent the sides of the tube units, in the same manner as described with reference to the baffles 31 illustrated in Fig. 3. In this instance, however, an enclosing baffle 39, is provided at the upper ends of the baffles 31*a*, above the inlet duct 38 forming a cover, for the space between the verti-

cal baffles, the duct 38 opening into this space and the baffles serving to direct the mixture entering the condenser from the duct, down over the cooling units 46 and 46*a* which are disposed and constructed in the same manner as the cooling units 6 and 6*a* of Fig. 1. The lower ends 40 of the baffles 31*a* are inclined inwardly at the top of the receiving zone 3*a*, terminating in the upper part of the zone. The segmental spaces between the sides of the cylinder and the baffles 31*a* are left in communication with the condensate receiving zone, to permit the upward passage of the uncondensed vapor, their path in this part of the condenser being indicated by arrows in Fig. 6. In this construction, a condenser unit for the aforesaid uncondensed vapor is provided at the upper end of the cylindrical shell. This condenser is of substantially the same construction as the cooling units illustrated in Figs. 1, 2 and 3. It is however, mounted vertically on the upper end of the shell 1*a*, with its floating head 14*a* extending down into the shell. The condenser is provided with an outer cylindrical shell 41 which completely surrounds the cooling tubes 7*a* and the floating head, and extends downwardly into the shell 1*a*, a cover 42 being secured at its lower end. A flange 5*a* is provided on the end of the shell 1*a* and a flanged ring 5*b* is mounted around the shell 41, the flanges being secured together to hold the vertical condensing unit in position. In the upper part of that portion of the shell 41 which is extended into the shell 1*a*, openings 43 are formed, to permit the passage therethrough of the said uncondensed vapor which has passed upward through the segmental spaces at the sides of the cooling units into the upper portion of the shell 1*a*. An outlet port 34*a*, is provided in the upper part of the shell 41, to which a duct 48 is connected. The duct 48 communicates with a pumping unit (not shown) of any suitable construction, by means of which the uncondensed vapor is drawn off from the vertical condenser and a partial vacuum is effected within the condenser.

When the vapor passes into the interior of the shell 41 it impinges upon the cooling pipes 7*a* and is condensed, the condensate falling into the enclosed lower part of the shell 41. The vertical cooling unit is provided with an inlet and an outlet port, 26*a* and 27*a*, respectively, for the introduction and discharge of cooling fluid, and is constructed, as aforesaid, substantially the same as the cooling units illustrated in Figs. 1, 2 and 3. In this unit, as illustrated, only the upper head cover is divided into compartments so that there will be only one cycle of circulation of the cooling medium through the tubes. In practice, however, this unit as well as the other cooling units may be constructed so as to effect as many cycles of circulation of the cooling medium as may be desirable.

At the lower end of the cylindrical shell 41 an opening 44 is provided and a duct 45 is disposed at said opening. The duct 45 passes through the side of the shell 1*a*, and is connected to an upstanding leg 47 at the outside of the shell.

In so directing the said uncondensed vapor to the upper part of the cylinder 1*a*, and there providing the vertical condensing unit for the same, it is necessary to provide means to overcome the vacuum, which exists inside the condenser, in order to draw off condensate through the opening 44. The leg 47 passes downwardly at the side of the cylinder 1*a*, and terminates in a sump or well (not shown), the opening 44 being of sufficient height above the level of the sump so that the vacuum which exists in the condenser will be overcome by gravity, and the condensate will flow from the shell 41 to the sump. Where circumstances will not permit the leg and sump arrangement, any suitable pumping means may be employed for drawing off the condensate through the port 44.

By this construction the particular advantage is attained of providing the original mixture condensing means and further condensing means for the uncondensed vapor in a single compact unit, eliminating the various supports and connections heretofore necessary, where such units were separately constructed.

It will be understood that while there has been hereinbefore described a specific form of condenser, disposed at the upper end of the shell, 1*a*, any type of condenser may be employed at this location without departing from the spirit of this invention and, in fact, all of the various types of condensing means known in the art, are contemplated for use as the same may prove efficient or desirable.

It will be apparent that in the operation of the modified form of the apparatus, the mixture is introduced through the duct 38 at right angles to the shell 1*a*, it is deflected by the baffles 39 and 31*a* downward over the cooling units 46 and 46*a* to the lower part of the shell, the condensate dropping down into the bottom of the condensate receiving zone 3*a* and the uncondensed vapor making a 180° change in direction and flowing upward through the segmental spaces formed between the baffles 31*a* and the shell 1*a*. This vapor then passes through openings 43 into the shell 41 where it impinges against cooling tubes 7*a*, being condensed thereby, and the condensate is drawn off through the opening 44, the duct 45 and the leg 47. The oil condensate is separately drawn off from the condensate receiving zone 3*a* in the same manner as described with reference to the embodiment illustrated in Figs. 1 to 5.

Included among the many and various advantages achieved by the present invention, are the following:

The apparatus provides a single shell which embodies and takes the place of a plurality of separate condensers of the usual conventional design; the structure is self-supporting and requires no structural steel or braces; the cooling units are not only readily, separately removable, but may be interchangeable; all large diameter shell joints which have previously been necessary in similar structures have been eliminated and a minimum number of outside connections are employed, thus reducing the proportion of leakage and maintenance difficulty in keeping tight joints; the necessity of a separate condensate receiver with additional connections between the same and the condenser units have been eliminated; by the tube arrangement their entire surface is brought into effective contact with the vapor; and the regulation of the velocity of the vapor is made possible by the provision for varying the horizontal and vertical spacing of the tubes; by the modified form of the apparatus there is provided means for condensing a mixture from a vaporized or distillation zone constructed similarly to the first described embodiment of the invention and further means for redirecting the uncondensed vapors to another part of the condensing unit and there separately condensing the same; broadly, the method and apparatus is characterized by a maximum economy and efficiency as to the cost of manufacture and maintenance of the apparatus, and the operation of the same.

It will be understood that many and various changes in the form and details of construction of the various features of the structures described may be made without departing from the spirit of the invention, and that any and all such modifications as fall within the scope of the appended claims are contemplated as a part of said invention.

The invention claimed and desired to be secured by Letters Patent is:

1. An apparatus for condensing hydrocarbon vapor and the like comprising a vertical substantially cylindrical shell having an inlet opening at the top of same; a removable cooling unit transversely disposed in the upper portion of said shell comprising a plurality of spaced horizontal tubes arranged in a rectangular bundle; and a baffle plate disposed at the side of said unit within the shell adapted to direct the flow of vapor over said tubes, said shell having an outlet opening in its lower portion below said cooling unit.

2. An apparatus for condensing hydrocarbon vapor and the like comprising a vertical substantially cylindrical shell, said shell having an inlet opening in its upper portion; a cooling unit transversely disposed within the upper portion of the shell, the lower portion of said shell embodying a condensate receiving zone; a baffle plate disposed within said receiving zone, said shell having an outlet port for liquid in the receiving zone below the baffle plate and near the bottom of the zone and an outlet port for vapor in the receiving zone below and adjacent the baffle plate; and a liquid level regulator for said receiving zone.

3. An apparatus for condensing hydrocarbon vapor comprising in combination a vertical substantially cylindrical shell, a plurality of rectangular tube bundles removably positioned in the upper part of said shell, said tube bundles being provided with headers, means for connecting said headers in series whereby a cooling medium is adapted to flow through said tube bundles in succession, the lower part of said shell having a closed bottom and being free of tubes whereby it is adapted to form a condensate receiving receptacle, and an outlet for the condensate in said lower shell portion.

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