Sept. 4, 1928.

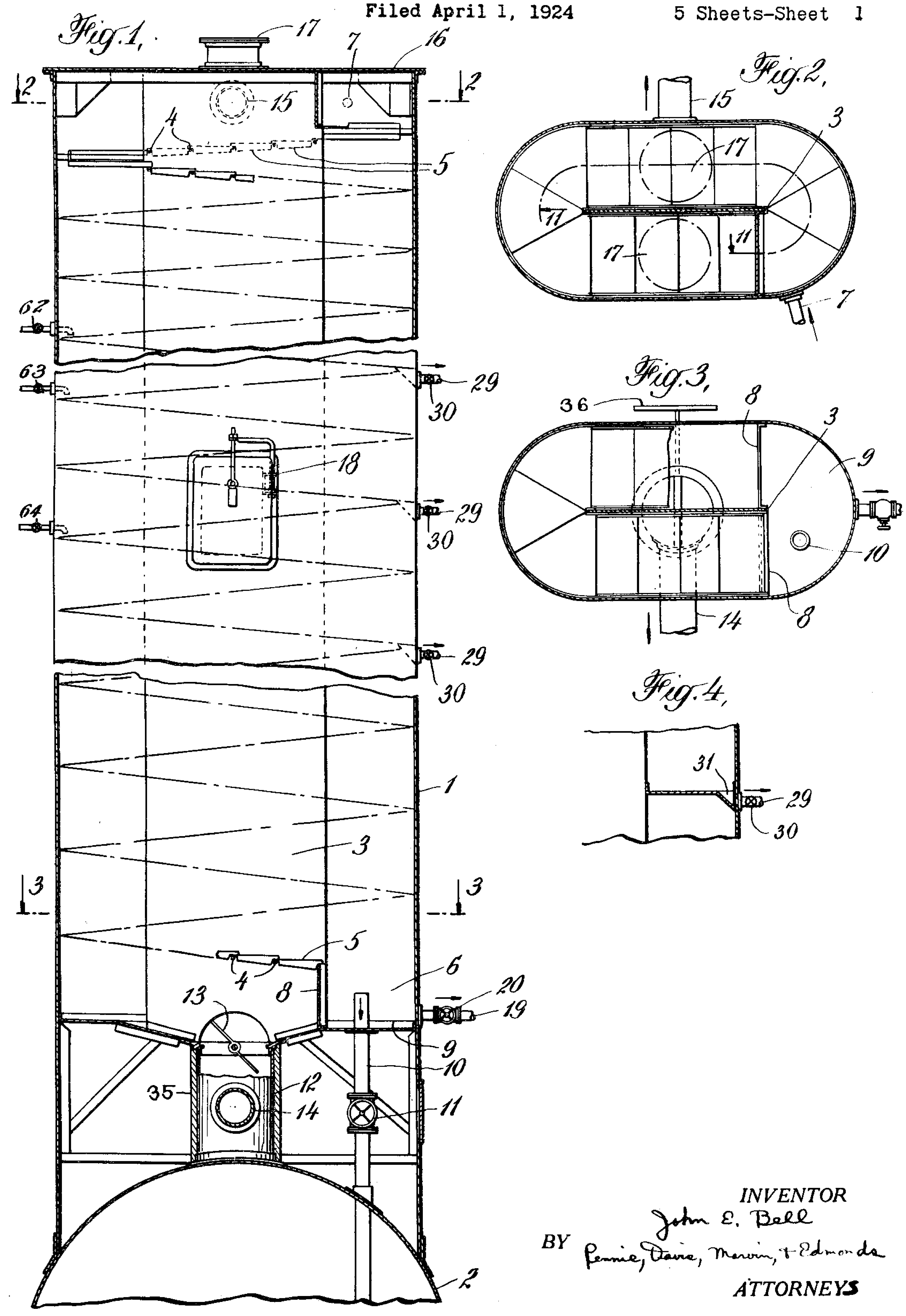
1,683,151

J. E. BELL

METHOD AND APPARATUS FOR DISTILLING PETROLEUM OILS

Filed April 1, 1924

5 Sheets-Sheet 1



INVENTOR

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Sept. 4, 1928. **1,683,151**

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METHOD AND APPARATUS FOR DISTILLING PETROLEUM OILS

Filed April 1, 1924 5 Sheets-Sheet 2

Fig. 5,

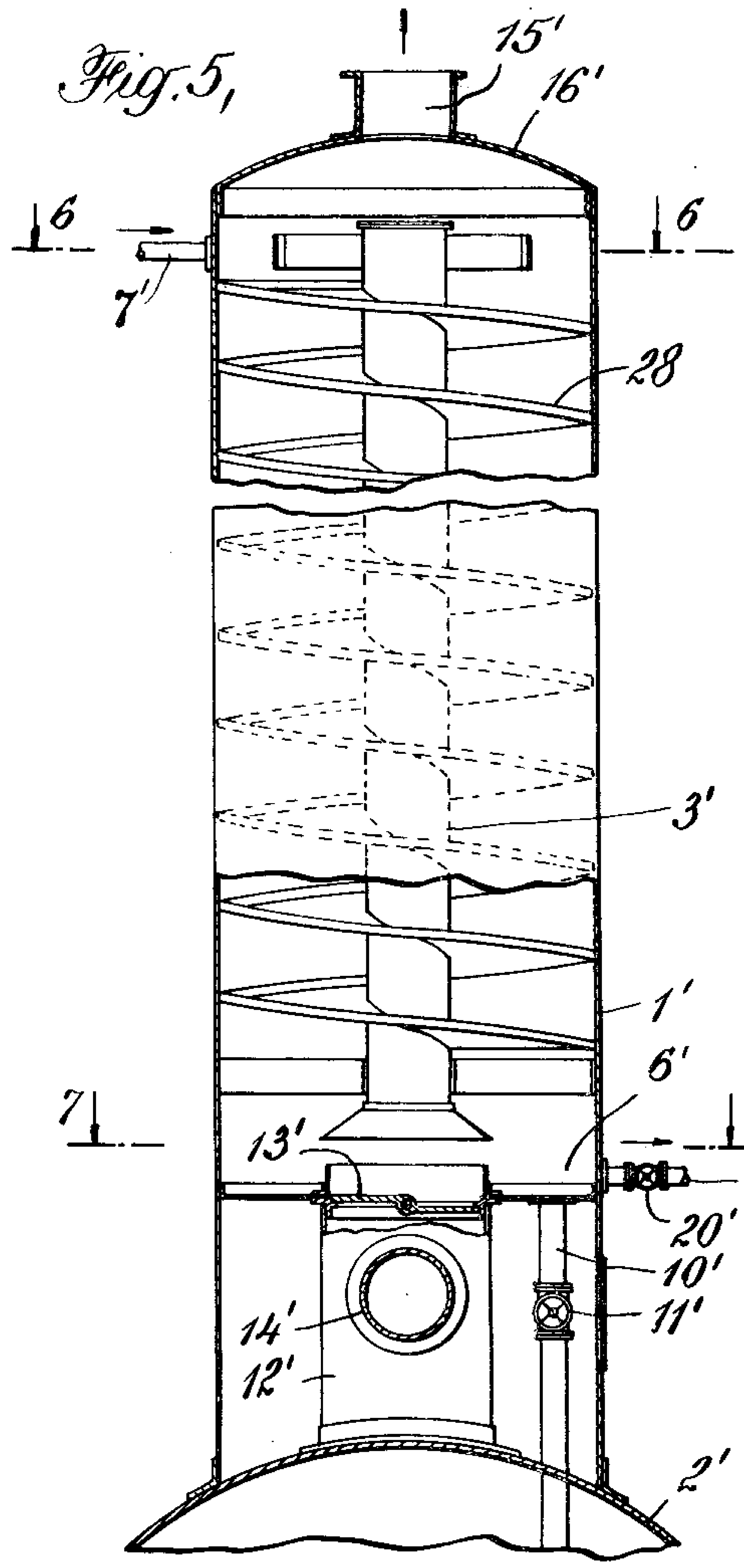


Fig. 6,

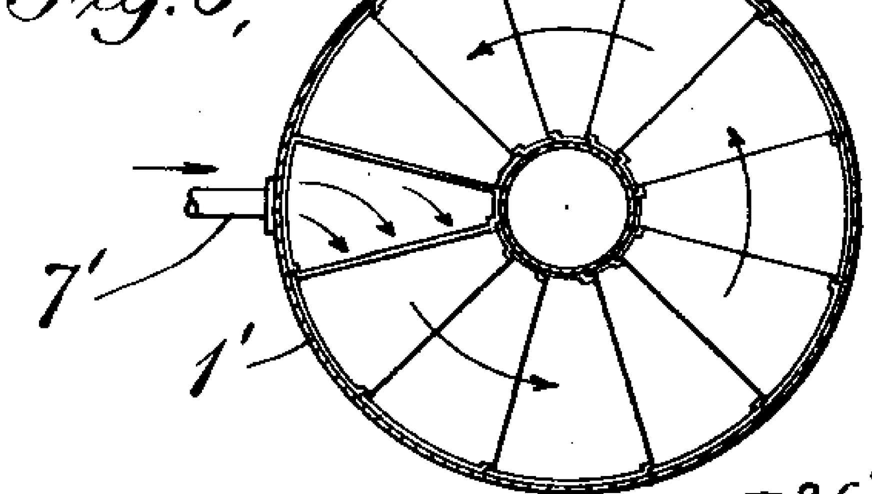


Fig. 7,

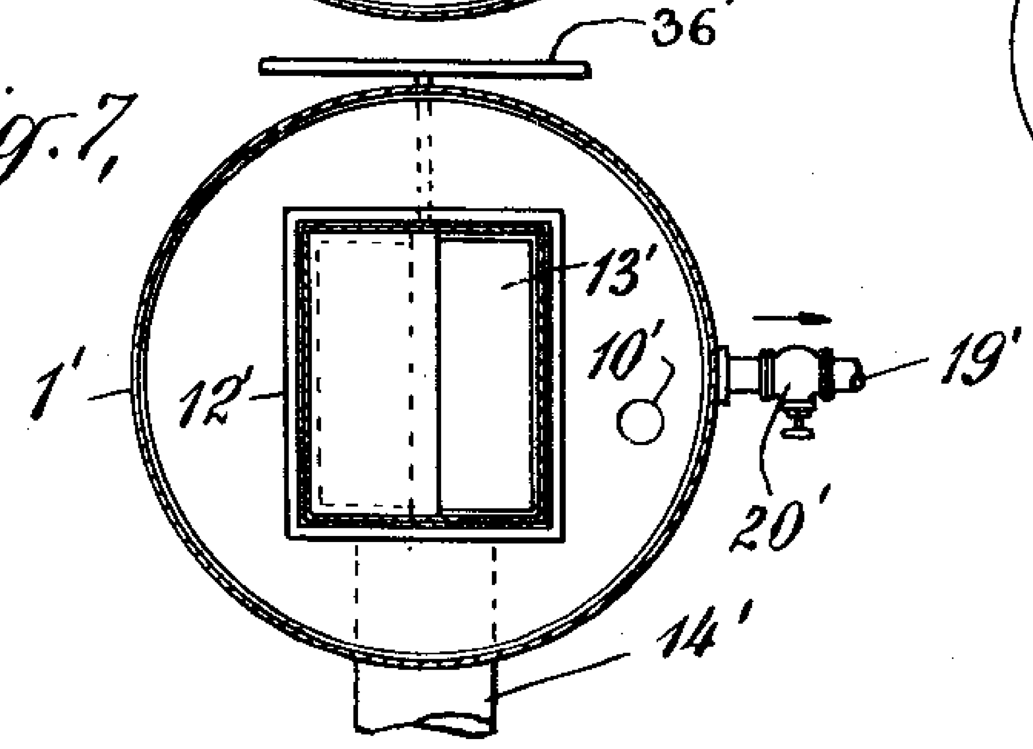


Fig. 8,

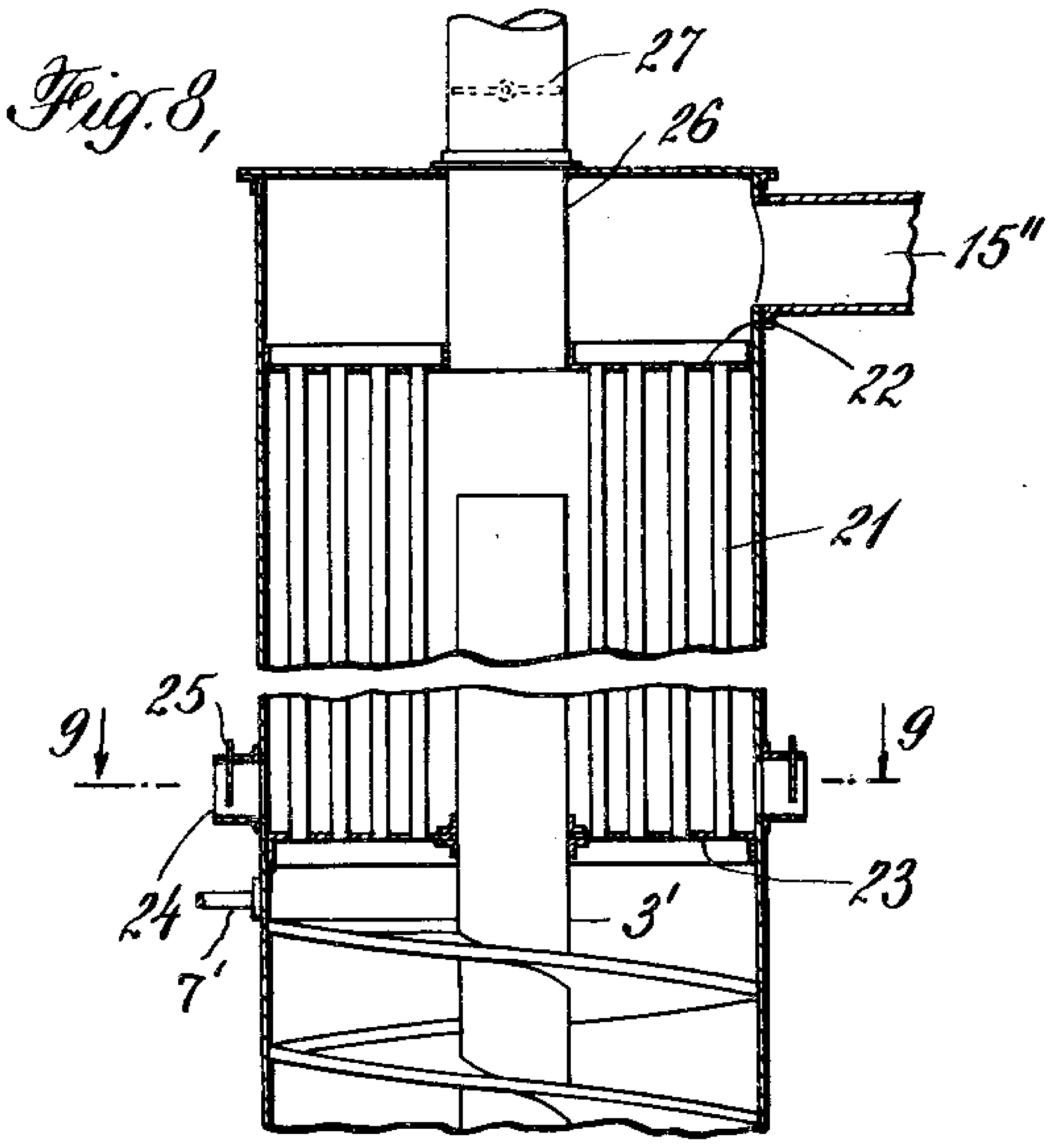
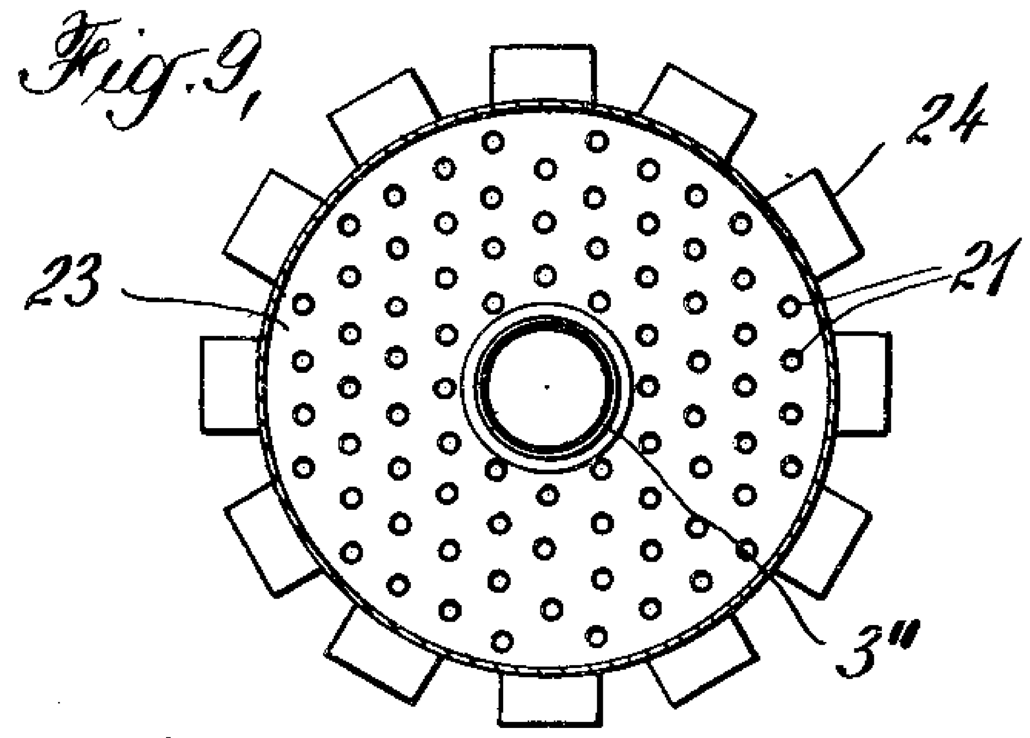
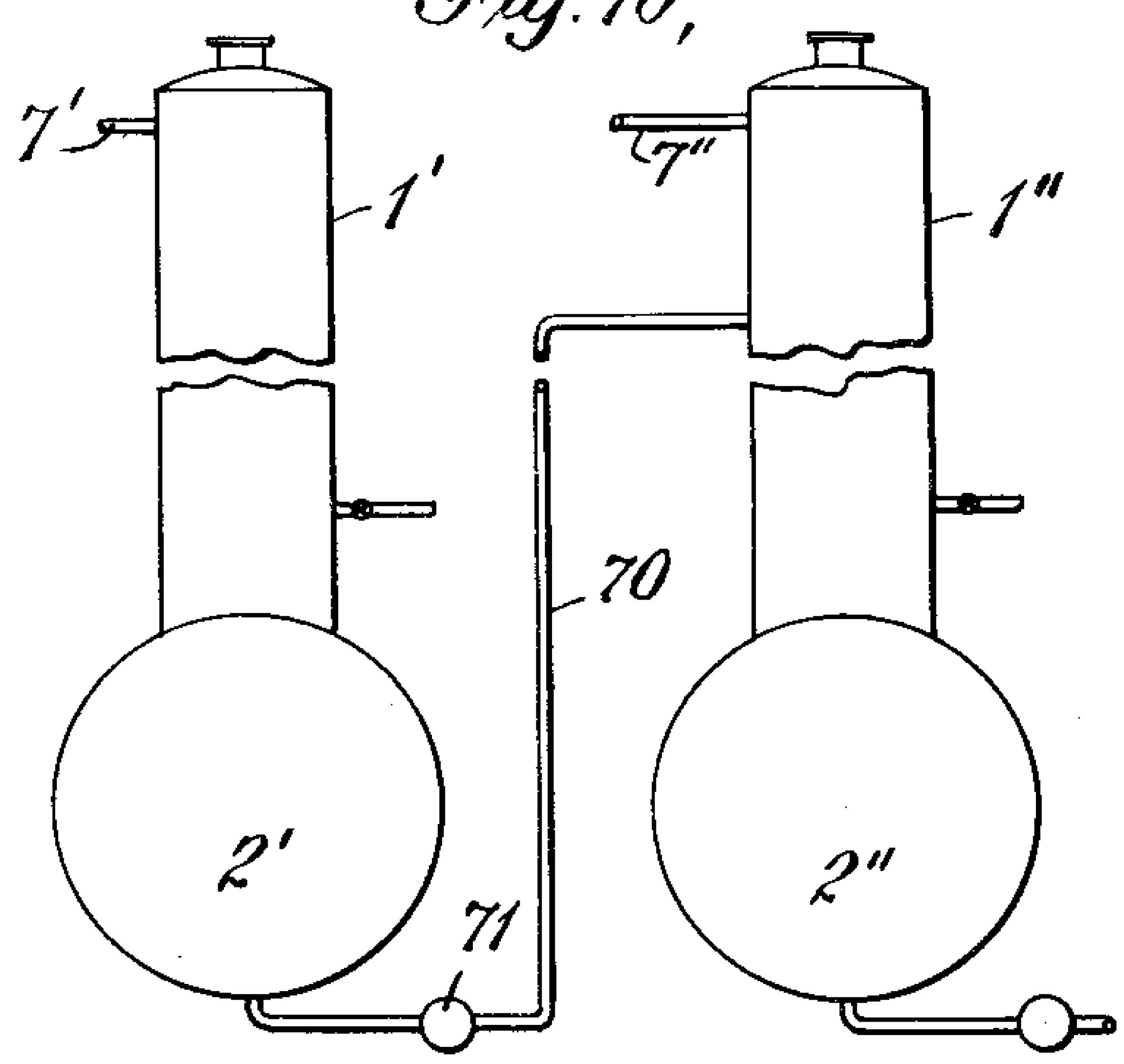


Fig. 9,



15' Fig. 10,



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METHOD AND APPARATUS FOR DISTILLING PETROLEUM OILS

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Fig. 11

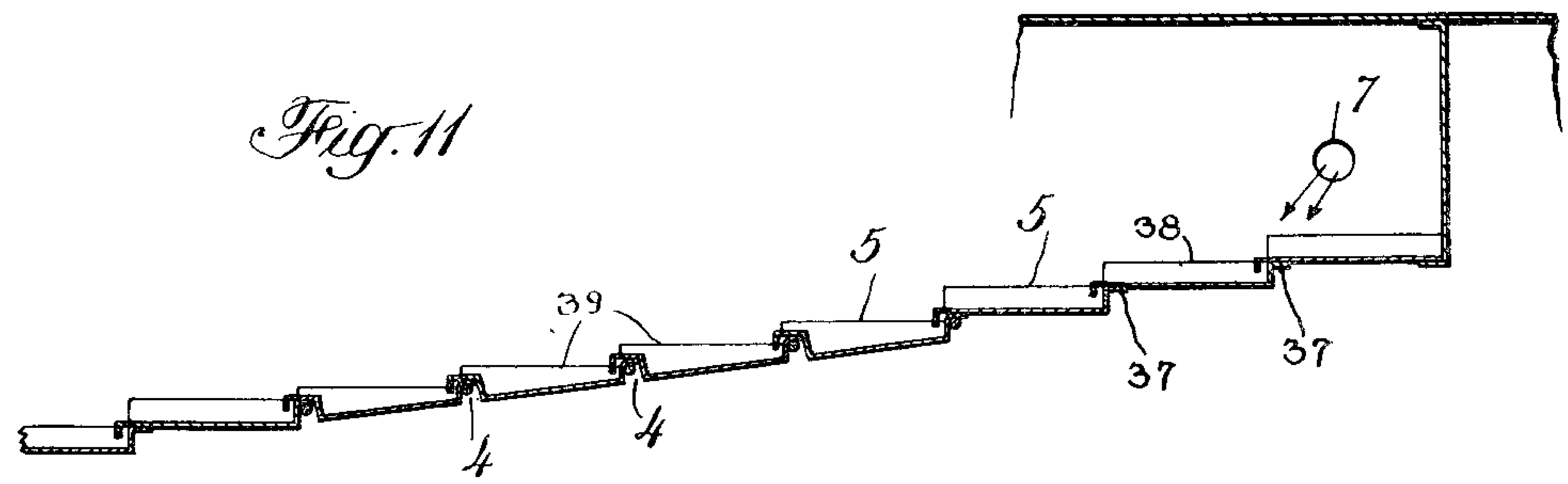


Fig. 12

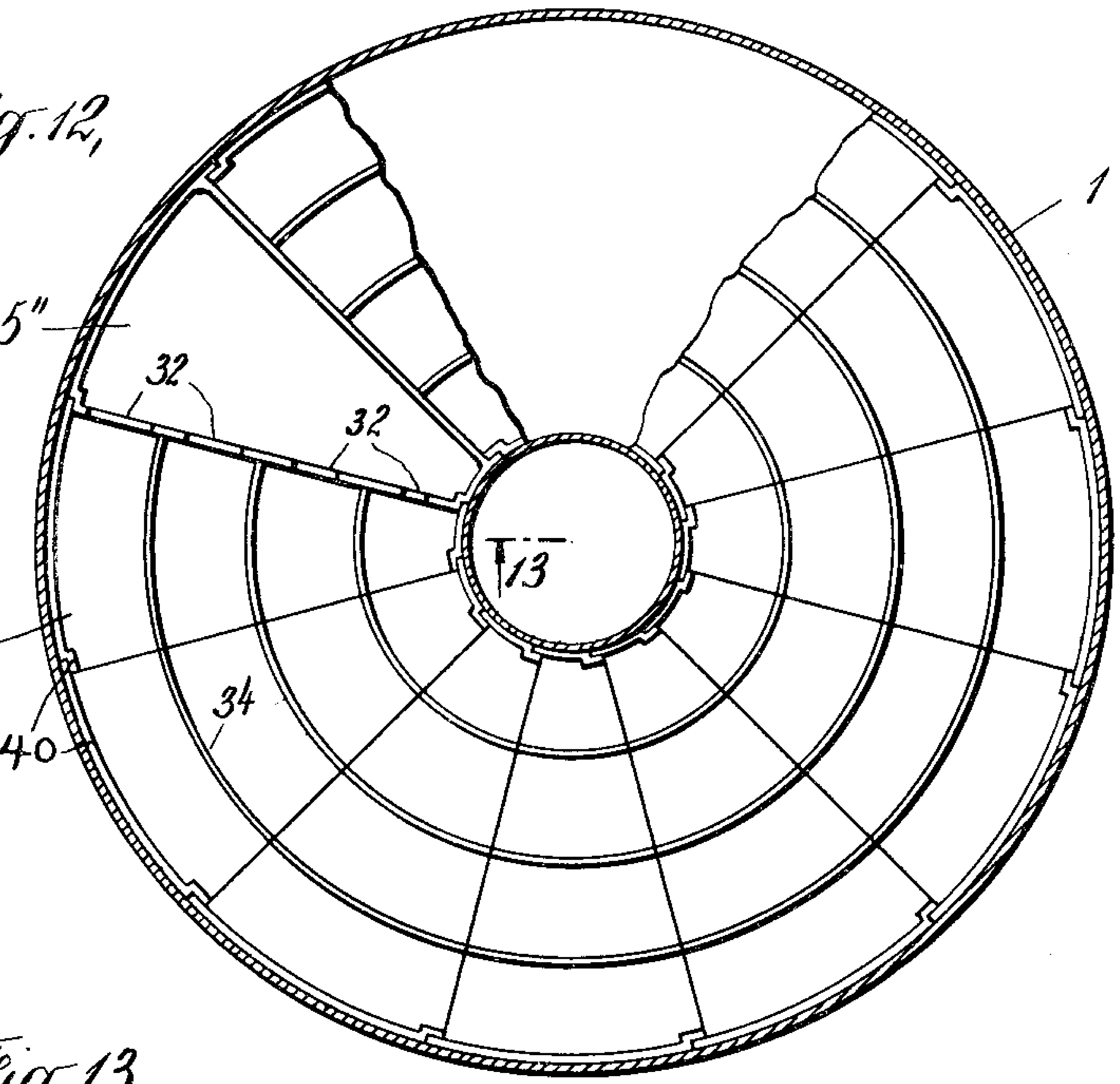


Fig. 13

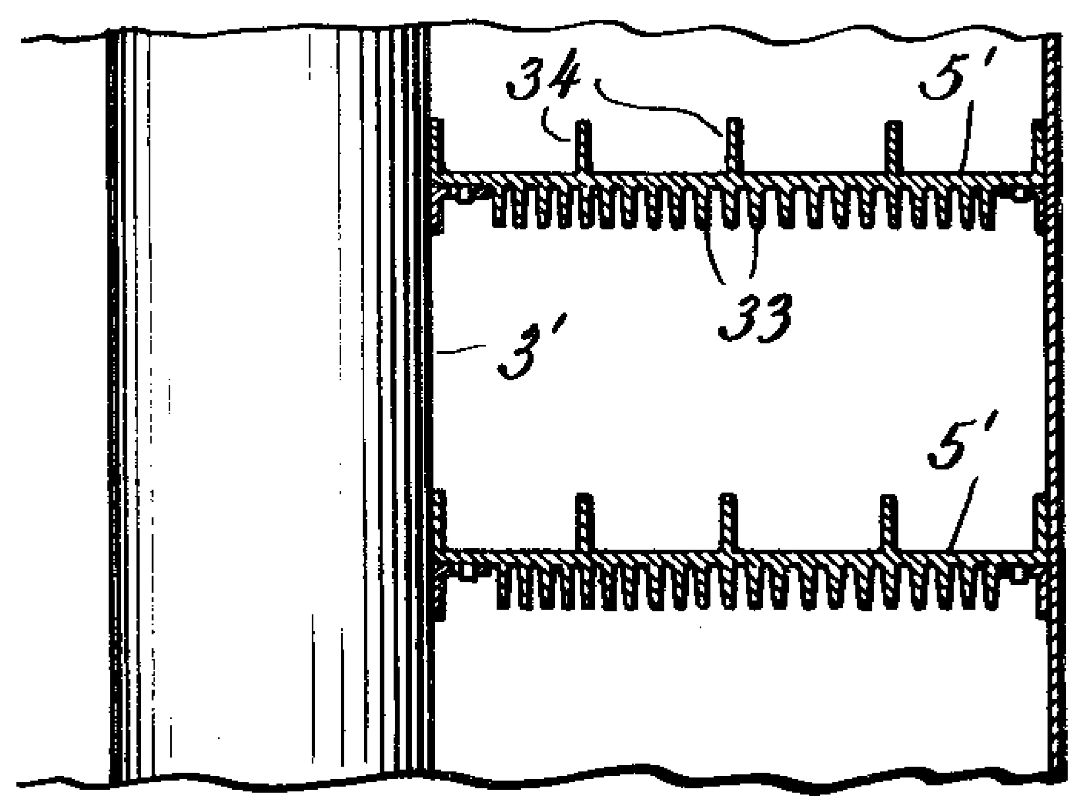
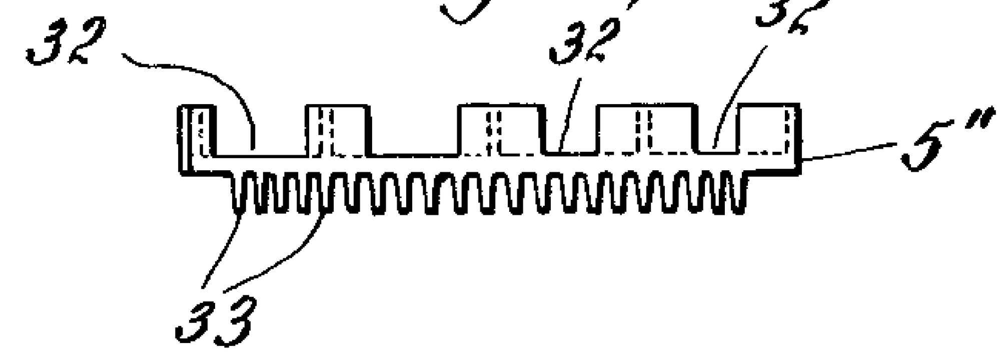


Fig. 14



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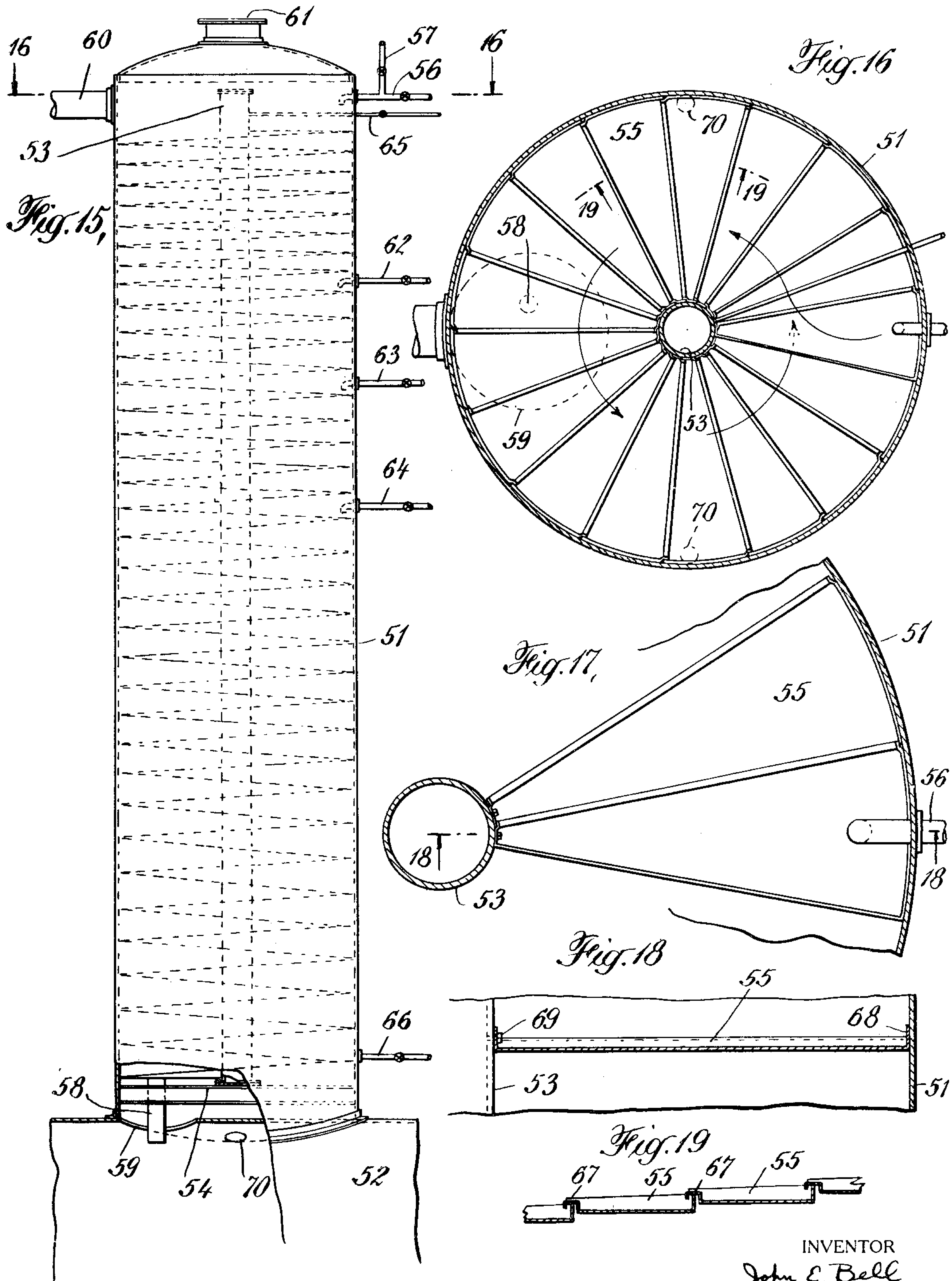

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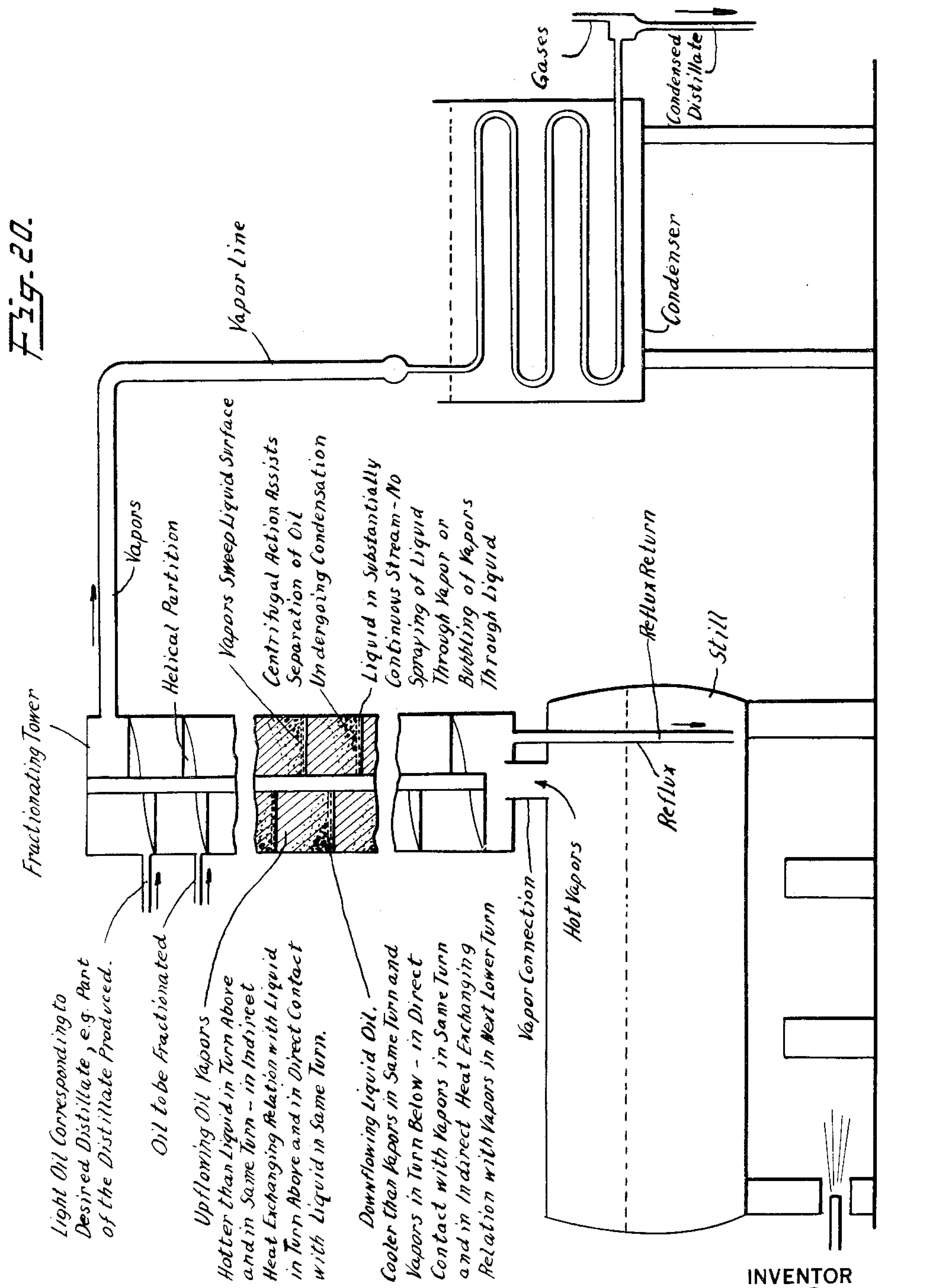

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Patented Sept. 4, 1928. **1,683,151**

UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR DISTILLING PETROLEUM OILS.

Application filed April 1, 1924. Serial No. 703,338.

This invention relates to improvements in the fractional distillation of petroleum oils and distillates and includes an improved method of distillation as well as an improved apparatus.

In the fractional distillation of petroleum oils, as heretofore proposed, the vapors from a still have been passed upwardly through fractionating towers and there brought in contact with liquid fed into the tower and flowing downwardly therethrough, with cascading or spraying of the liquid in its passage downwardly through the tower or with bubbling of the gases through the liquid. In such towers, the so-called washing effect of liquid sheets or sprays, or the same effect obtained by forcing the vapors to bubble through the liquid, has been emphasized as the controlling feature in fractionation. Such spraying of the liquid, however, tends to leave some of the liquid in the form of fine drops, the surface tension of which will prevent their evaporation, and they will tend to be mechanically entrained and carried out of the tower with the vapors. The cascading of the liquid and causing the gases to pass through it or bubble through it also interposes unnecessary friction loss and tends to choke the tower.

In the method and apparatus of the present invention, such spraying or cascading of the liquid through the vapors is avoided, as well as the bubbling of the vapors through the liquid, and the vapors from the still are provided with a clear and substantially unobstructed passage through the tower while they are nevertheless brought into intimate contact with the liquid flowing down through the tower, and the operation of the distillation is so carried out that close fractionation is made possible.

According to the present invention, the still is provided with a tower through which a helical passage extends and the feed is introduced at or near the top of the tower and passes down over the turns of the helix while the vapors from the still pass upwardly in a reverse direction, the heavier reflux and the unvaporized portion of the feed entering the still from the tower, and the lighter vapors, from the still and from the feed, escaping from the top of the tower as the desired fraction. In this construction and operation the flow of the vapors upwardly through the tower is free and unobstructive while the vapors are nevertheless brought into direct contact with the liquid flowing down through the tower and are also brought into indirect heat interchange with the liquid through the helical surfaces separating the turns of the passage within the tower. Effective heat interchange and refluxing of the oil is thus brought about, making possible close fractionation of the oil.

The present invention is of more or less general application in the fractional distillation of petroleum oils and makes possible the obtaining of exceptionally close cuts of the oil distilled, as well as the obtaining of a greatly increased capacity or rate of distillation and fractionation.

The invention is of special application for the rerunning of benzine, for the recovery of gasoline; but it is also of value for the rerunning of gas-oil for the separation of gasoline or other like fraction therefrom, as well as for the distillation of crude petroleum or other petroleum fractions or distillates where the obtaining of close cuts is desired.

The oil fed to the helical tower may be cold fresh oil, or may be oil which has been preheated, for example, by a previous distillation or fractionation. It may be introduced at the top of the helical tower or, in some cases, more advantageously at a distance somewhat below the top so as to provide an upper zone of the tower above the point where the feed is introduced.

The oil fed into the still flows down over the helical surfaces of the tower and is heated by direct contact with the vapors passing upwardly through the tower and by indirect contact with the vapors at a higher temperature in the next lower turn of the helix. The vapors entering the bottom of the tower from the still are cooled both by direct contact with the down flowing liquid and by indirect heat exchange with the liquid at a lower temperature flowing downwardly in the next higher turn of the helix. The heavier vapors are thus cooled and condensed while the lighter constituents of the feed are vaporized effective refluxing being thus brought about.

In the carrying out of the distillation, according to the present invention, the temperature of the oil in the still will in general be somewhat higher than the temperature of the oil flowing from the bottom of the reflux tower into the still. In practice, however, the distillation can be regulated so that the temperature of the reflux entering the still approximates that of the oil in the still, and so that practically all of the overhead distillate from the tower is distilled in the tower itself from the fresh feed introduced therethrough.

The invention provides moreover for the passing of the vapors at high velocity over the liquid surfaces so as to sweep the liquid surfaces and promote the heat transfer between the liquid and vapors; and the invention provides for obtaining such high velocity of the vapors with a minimum of friction loss and with a maximum surface of liquid subjected to the action of the gases moving at high velocity thereover.

The invention further provides for maintaining a uniform distribution of the liquid and a substantially uniform flow of the liquid over the surfaces of the tower. More particularly, the invention provides a tower of helical construction with helical surfaces made up of a series of pans or trays, each acting as a distributor to obtain uniformity of flow over the successive pans, and each pan serving to hold a thin layer of the liquid, thus somewhat prolonging the time of downward flow of the liquid through the tower and giving an increased opportunity for the refluxing action.

The invention also provides an improved method of fractional distillation in which the feed of oil may be preheated and introduced at an intermediate point or at intermediate points of the tower, and with introduction of a lighter oil or distillate at the top of the tower. By operating in this way the capacity of the tower can be greatly increased, and a sharper fractionation can also be obtained. The preheating of the feed may advantageously be accomplished by heat interchange with the vapors escaping from the tower. This method of operation is advantageous for example in the rerunning of benzine, e. g., the mixture of pressure distillate and straight run distillate which is to be rerun for gasoline after refining with sulphuric acid or other refining treatment.

The invention will be further described in connection with the accompanying drawings illustrating, in a somewhat conventional and diagrammatic manner, certain embodiments of the apparatus of the invention adapted for the practice of the process of the invention; but it is intended and will be understood that the invention is illustrated thereby but is not limited thereto.

In the accompanying drawings Fig. 1 shows one embodiment of the invention, partly in section and partly in elevation, and with parts broken away, the drawing being partly conventional and diagrammatic.

Figs. 2 and 3 are horizontal sectional views on the lines 2—2 and 3—3 respectively of Fig. 1.

Fig. 4 is a partial sectional view of part of the tower of Fig. 1.

Fig. 5 is a view similar to that of Fig. 1 showing a modified construction.

Figs. 6 and 7 are horizontal sectional views on the lines 6—6 and 7—7 respectively of Fig. 5.

Fig. 8 is a partial sectional view of a modification of the top of the tower of Fig. 5.

Fig. 9 is a horizontal sectional view taken on the line 9—9 of Fig. 8.

Fig. 10 is a diagrammatic view showing two stills arranged in series.

Fig. 11 is an enlarged view showing a preferred construction of the overlapping pans of the tower of Fig. 1.

Fig. 12 is a horizontal sectional view showing a modified construction of the tower.

Fig. 13 is a detail view in vertical section showing a further modified construction.

Fig. 14 shows a modified form of distributing pan for use in the tower.

Fig. 15 is a view similar to that of Fig. 1 showing a further modification.

Fig. 16 is a sectional view on line 16—16 of Fig. 15.

Fig. 17 is an enlarged detail of part of the tower shown in Fig. 16.

Fig. 18 is a sectional view taken on the line 18—18 of Fig. 17.

Fig. 19 is a sectional view taken on the line 19—19 of Fig. 16.

Fig. 20 is a schematic and diagrammatic representation in the nature of a flow-sheet illustrating pictorially the operation of the apparatus and the carrying out of the process of the invention.

The tower illustrated in Figs. 1 to 4 is of oval or oblong cross section. It has a shell 1, mounted upon and supported by the shell of the still 2. A central plate 3 is arranged to separate the two sides of the tower from each other.

In the construction illustrated, rods 4 extend from the sides of the tower to the central division plate 3, these rods being so arranged and positioned that a plurality of overlapping pans 5 may be supported thereon in such a way as to form, together with the pans at the ends of the division plate, a generally helical partition dividing the tower into a continuous vapor passage generally helical in arrangement. In the construction illustrated, the feed oil, or lighter oil as the case may be enters through the pipe 7 to the uppermost tray or portion of the tower and flows down over the successive pans. Additional oil inlets 62, 63 and 64, each provided with a regulating valve, are arranged at intermediate points. A reservoir 6 at the bottom of the tower receives the oil flowing from the last pan 5, this reservoir being separated from the vapor space by the division plate 8. From the reservoir 6, the oil overflows through the pipe 10, back into the still 2. A valve 11 permits cutting off or regulating the flow of oil through the pipe 10. The reservoir 6 is separated from the space below it by bottom plate 9, thus providing a space between the bottom of the reflux tower and the top of the still. A pipe 19 with regulating valve 20 therein permits drawing off of part or all of the liquid from the reservoir 6 where this is desired.

A vapor connection 12 leads from the still to the bottom of the helical vapor passage in the tower, this connection being shown as protected by insulation 35. Similar insulation (not shown) may be used on the tower as a whole. The vapor connection 12 has a valve 13 arranged at its upper end to shut off the tower from the still and has a separate pipe connection 14 by which the vapors may be by-passed directly to a condenser without entering the tower. The vapor outlet from the tower is indicated at 15.

Access may be had to the tower for inspection, repair and other purposes by means of manholes 17 at the top of the tower or manholes 18 on the sides of the tower. The upper header of the tower, as a whole, is indicated at 16.

A preferred form of construction of the individual trays forming the helix of the tower is shown in Fig. 11. The pans 5 may be stamped out of sheet metal and supported upon the rods 4. The pans forming the turns of the convolutions at the ends of the plate 3 are suitably secured together and to the shell and plate 3 for example by riveting. The various pans or plates forming the helix are shallow so that they do not hold any considerable amount of liquid and they are so arranged as to insure a substantially uniform distribution of the liquid over the width of the successive pans.

In Fig. 11 the pans 38 at the turn of the tower are shown as overlapping at 37 and can be secured to each other, for example, by riveting.

In the modified constructions of Figs. 5 to 14 similar parts are indicated by the same reference numerals as in Figs. 1 to 3 but with primes appended thereto.

The towers shown in Figs. 5 to 10 and in Figs. 12 and 13 are cylindrical instead of oblong in cross-section. The helical partition dividing the tower into a helical passage or vapor space and providing a helical path for the downflowing liquid may be made up of a single continuous sheet of metal, with distributing means such as baffles or ripples spaced apart to insure uniform distribution of the down-flowing liquid, or it may be made up of a series of plates or trays. A continuous helical dividing plate is illustrated conventionally at 28 in Fig. 5, with the distributing means omitted, but this division member may be made of a series of individual members as indicated in Figs. 6 and 12.

In Figs. 8 and 9 an air condenser is shown as arranged at the upper end of the helical tower, the vapors from the upper turn of the helix passing upwardly through the tubes 21, extending between headers 23 and 22, and the uncondensed vapors escaping through the outlet pipe 15″. A series of air inlets 24 are provided each with a regulating damper 25 and a central air outlet 26 is provided with valve or damper 27 therein. By means of the dampers or valves 25 and 27 the amount of air circulating through this added air reflux tower can be regulated.

In Fig. 10 two stills 2′ and 2″ are shown as arranged in series, each having a tower of the helical construction illustrated in Fig. 5, the feed for the second tower being the oil from the first still, this oil being pumped from the still 2′ to a point somewhat below the top of the second tower through the pipe 70 by means of pump 71. The towers also have connections 7′ and 7″ for the introduction of stock to the top of the tower.

In order to insure a uniform or approximately uniform distribution of the liquid over the width of the helical path, distributing plates or baffles may be provided. An initial distributor plate is shown in Fig. 12 having openings 32 of progressively increasing size from the center outward. The helical surfaces themselves may also have division members dividing the helical surface into a series of generally concentric surfaces. Division plates 34 are shown in Fig. 12 for this purpose.

In order further to promote the heat interchange between the vapors and liquid, the trays or helical surfaces may be provided with corrugations or ribs, thus increasing the effective surfaces of the bottom of the pans exposed to the vapors. Such ribs are shown in Figs. 13 and 14. The individual trays 5 and 5′ may be cast with these projections and then assembled for example as illustrated in Fig. 12.

In Figs. 15—19, a cylindrical helical tower is shown, of a somewhat modified construction. This tower has its outer cylindrical shell 51 mounted upon and supported by the shell 52 of the still. A central pipe 53 is supported by the I-beam 54, while the individual trays 55 are secured to and supported by the central pipe 53 at their inner ends, for example, by bolt 69, as illustrated in Figs. 17 and 18, and these trays or pans are supported by the shell 51 at their outer ends, for example, by welding the outside end 68 to the shell as illustrated in Fig. 18.

The feed line 56 is provided for introducing the feed oil or a lighter oil as the case may be into the top pan of the tower while a branch line 57 is provided for introducing water when it is desired to flush out the tower, and remove the oil therefrom. From the lower tray of the tower an outlet or overflow pipe 58 leads back to the still. The vapors from the still enter the bottom of the tower through the opening 59, while a vapor outlet 60 is provided at the top of the tower. A top man-hole 61 permits access to the top of the tower. Three additional oil inlets 62, 63 and 64, each provided with a regulating valve, are arranged at intermediate points in the tower.

A steam line 65 is connected with the central pipe 53 and permits driving out of vapors from the central pipe when the still is shut down and the tower is to be opened. This central pipe is loosely closed at its upper and lower ends and may be provided with perforations at its lower end to facilitate draining of condensates therefrom. One or more holes 70 in the still shell permit drainage back to the still of liquid collecting at the low points in the space at the bottom of the tower. A pipe 66 connects with a steam supply for steaming out the tower when required.

The pans or trays illustrated in Figs. 15—19 are similar to those of Fig. 11 but are of substantially uniform size throughout the tower. Each of these pans or trays, as illustrated in Fig. 19, has a turned-down overflow lip 67, somewhat above the bottom of the pan so as to keep a thin layer of liquid in the pan, and arranged for delivering the liquid overflow into the next lower pan. With the helical surface made up of a series of such pans or trays, there will be a series of thin bodies or layers of liquid in the pans, which liquid will overflow from one pan to the next, and thus provide a substantially continuous and uniformly distributed flowing layer of oil over the helical surface of the partition extending through the tower. The oil overflowing from one pan to the next will assist in breaking up and agitating the liquid, while the maintenance of small individual bodies of the liquid in the form of thin layers provides a large exposed surface for contact with the vapors but nevertheless retards the free downward flow of the liquid and prolongs the time of such flow, as compared with similar helical surfaces having smooth helical surfaces which present no impediments to the free downward flow of liquid.

With a still 10 feet in diameter by 40 feet long the helical tower may have a diameter of 8 feet and a height of around 35 feet, and in the case of a fire still such a tower will preferably be located on the opposite end of the still shell from the end where the still is fired.

In the tower illustrated in Fig. 15, the turns of the helix are spaced apart a somewhat greater distance at the bottom of the tower than at the top. For example, the lower nine revolutions of pans may be spaced apart about 13¼ inches, the next 9 complete revolutions of pans may be spaced apart about 11¾ inches, the next 10 revolutions about 9⅞ inches and the top 7 revolutions about 8 inches, giving cross-sectional vapor areas decreasing progressively from about 3.5 square feet at the bottom of the tower, to about 2 square feet at the top of the tower. Such a tower can advantageously be operated with an average flow of vapors from the top of the tower in excess of 5,000 lbs. per square foot of cross-sectional area of the vapor space, and as much as 6,000 to 8,000 pounds or more of vapors per square foot of vapor space may escape from the tower per hour; or a total of around 15,000 lbs. of vapor or more may be taken out of the top of the tower per hour in the case of a tower of the size and construction illustrated.

In the operation of the apparatus described, the feed for the still is pumped in at or near the top of the tower and flows down over the plates of the helical partition extending through the tower and into the still. The temperature of the still bottom is raised until the vapors leaving the top of the tower have the necessary temperature to give the desired end point in the distillate. With crude feed and a gasoline cut with a 450° F. end point, the temperature of the liquid in the still would be around 580–600° F. and the temperature of the vapors leaving the top of the tower about 350° F. The relatively high temperature of the still bottom is necessary to drive off all the light vapors that can be cut into 450° F. end point distillates.

Instead of introducing cold feed, the feed to the tower can be heated, and, if this is done, the temperature of the still bottom necessary to obtain a corresponding distillate would be less than it would be with cold feed, and, as a consequence, some of the lighter constituents that might go into the 450° F. end point distillate might remain in the still. With cold feed, however, an increased temperature of the still itself insures the driving off of substantially all of the light vapors that can be cut into 450° F. end point vapors. By providing for the further cooling of the tower, for example by means of an air condenser at its upper end as illustrated in Fig. 8, an increased temperture of the oil in the still can be maintained to insure the driving out of all of the low-boiling vapors which might otherwise remain in the oil in the still. In this case, however, added heat would have to be supplied to the oil in the still to replace that lost by the air cooling, this added heat corresponding to the increase in temperature of the oil in the still.

In the operation of the apparatus, however, it is not necessary either to preheat the feed or to use additional cooling, for the operation of the apparatus has shown that a greater percentage of gasoline yield can be obtained from a crude charge, without preheating of the feed, than is indicated by the ordinary methods of fractionation used in the laboratory. Certain added advantages can however, be obtained when preheated feed is used. The present invention, for example, enables more gasoline to be cut from the crude oil charge than the amount which laboratory analysis indicates. Thus, in one case where the laboratory tests indicated that there was 35% of a 450° F. end point cut in the crude, a yield of 39% was recovered by the apparatus and method of the present invention.

The amount of vapors that can be passed through the tower of the present invention depends in part upon the area between the convolutions of the helix, that is, the cross sectional area of the helical passage for the vapors. At the bottom of the tower the volume of the vapors is greater than at the top, since they are are at a higher temperature and must carry the heat for evaporating the light portion of the feed and for heating the remaining portion of the feed to the temperature at which the reflux leaves the tower. Some of the hot vapors entering the bottom of the tower are moreover condensed and returned as liquid, although this is somewhat offset by the vapors set free from the feed. With equal areas between the convolutions of the helix the friction loss would be greater at the bottom of the tower than at the top. This can be overcome by spacing he convolutions at a greater distance apart at the bottom of the tower than at the top, as illustrated in Figs. 1 and 15.

In distillation of petroleum at ordinary temperature, a back pressure of more than about three pounds on the ordinary shell stills is objectionable. With the towers of the present invention, however, the escape of vapors is through an unobstructed helical conduit where the frictional resistance is substantially the only resistance to free escape. Accordingly, a relatively large volume of vapors can pass through the tower without causing objectionable back pressure.

It will be evident that the number of convolutions of the helix can be varied with corresponding variation in the length of travel of the vapors and of refluxing action. By using a sufficiently long helical passage and providing sufficient surface in the pans the temperature of the reflux where it leaves the tower and enters the still can be brought up to a temperature approximating that of the oil in the still, for example, within 20 or 30 degrees. If the reflux was actually at the temperature of the oil in the still, and if the still temperature was sufficiently high to insure that there was no 450° F. end point constituents in the liquid oil in the still, all of the vapors that passed out of the top of the tower would be distilled in the tower itself and none of the vapors leaving the still would pass completely through the tower. Under such conditions, the volume of the vapors passing out of the still and refluxed back would be just sufficient to make the latent heat of condensation at the temperature of the reflux equal to the heat required to vaporize the overhead distillate at the temperature at which it leaves the tower and to heat the remaining portion of the feed up to the temperature of the reflux. While these conditions are difficult of attainment in practice, they may nevertheless be approximated in the apparatus and according to the process of the present invention. That is, the process of the present invention can be so carried out and regulated, with feed of oil to the top of the reflux tower, that the temperature of the reflux entering the still approximates more or less closely the temperature of the oil in the still while practically all of the vapors coming off as overhead distillate are distilled from the feed during its passage through the reflux tower and practically all of the vapors entering the tower from the still are refluxed back to the still.

In referring to the obtaining of a gasoline cut of 450° F. end point from crude oil I have referred to the first distillation of crude oil in a continuous still. That is, the oil fed to the top or to a point somewhat below the top of the tower would be the crude oil, and the hot oil from the still would be withdrawn in proper proportion to maintain the desired level in the still.

The invention is also applicable to the other stills of a continuous battery, in which case the oil from the first still would be pumped to the tower of the second still, and so on. The oil from the first still may be pumped to a point below the top of the tower on the second still, for example, a point about midway in the height of the tower, and a part of the condensed distillate from the tower, or a fraction of similar character, may be introduced into the top of the tower. Such an arrangement of stills is shown conventionally in Fig. 10. With such a battery of stills each provided with a tower of helical construction the oil can be progressively fractionated and successive fractions obtained from the successive stills. The bottom temperature of each still would then be carried sufficiently high to give the desired cut from the top of the tower of that particular still. By operating a continuous battery of stills in this way, a series of exceptionally close cuts can be obtained.

Where, however, as under present market conditions, it may be desirable to obtain only a 450° F. end point stock for gasoline and a reduced crude residue, the bottom temperature of the still is carried at about 580° F. Ordinarily the residue from such a still would not be further fractionated, as the bottom temperature of the second still would have to be higher than that of the first, preferably around 650–675° F., and at these temperatures the oil begins to crack. Furthermore, inasmuch as substantially the complete gasoline content of the crude can be removed in a single cut, the reduced crude remaining then becomes a satisfactory charging stock for pressure stills so that there is no further need of frictionation. Where, however, instead of a single closely regulated cut a series of low-boiling fractions is desired, a series of stills and towers can advantageously be used as a continuous battery with pumping of the oil from the bottom of one still into the tower of the next hotter still.

Instead of fractionating crude oil, other petroleum fractions or distillates can be similarly fractionated. Gas oil, for example, can be advantageously stripped of its 450° F. end point fraction and an additional amount of gasoline stock thus obtained, while leaving the gas oil in a more valuable condition for charging to the pressure stills. As a further example, a gas oil cut can be separated from reduced crude.

The invention is also of special value in connection with the re-running of benzine, e. g., admixed pressure distillate and straight run benzine, after refining with acid for the separation of gasoline therefrom, enabling a substantially complete and sharp separation to be obtained. In the re-running of such lighter fractions it will be evident that the temperature and rate of feed, as well as the temperature of the still itself, will be regulated to give an overhead distillate of the desired composition.

It is characteristic of the present invention that the provision of a substantially unobstructed passage for the vapors where they are nevertheless brought into intimate contact and heat-interchanging relation with the liquid fed into the tower enables a greatly increased rate of distillation to take place as compared with ordinary fractionating towers. The vapors will pass through the tower at a relatively rapid rate and with a correspondingly high velocity. Such a high velocity is desirable, for it greatly increases the effectiveness of the heat transfer between the vapors and the liquid and tends to sweep the surfaces free from stagnant vapors as well as giving a centrifugal separation of the particles that may be carried along mechanically.

With increase in velocity of the vapors, however, there is an increased tendency for liquid to be carried over mechanically with the vapors. In order to avoid this and nevertheless maintain a high velocity of the vapors, I provide for introducing the feed at a point somewhat below the top of the tower instead of into the tower at its upper end. For example, in a still having a diameter of about 14 feet and a length of about 40 feet, the oblong or elliptical helical tower, such as shown in Figs. 1—3, may have a height of about 30 feet and cross sectional dimensions of about 6 x 12 feet and, in such a tower, the feed may be introduced about five feet down from the top of the tower through suitable openings (not shown). With a still and tower of this size, gas oil from coke stills can be re-run for gasoline with a rate of feed to the tower of about 125 to 150 barrels per hour and with the recovery of 20 to 25% of light distillate. It will be evident that, where the feed is introduced below the top of the tower, the distance from the top at which the feed is so introduced may be varied. For the fractionation of very hot oil the feed may for example be introduced a third of the way down from the top of the tower.

In order to obtain a still further and sharper fractionation, some of the overhead distillate may be returned to the top of the tower. This low-boiling condensate will be re-evaporated and will exert a cooling effect which will serve to condense and return the higher-boiling constituents. By introducing the feed at a distance down from the top of the tower, and by introducing a regulated amount of the overhead distillate at the top of the tower, an increased sharpness of fractionation can be obtained, as well as an increased velocity of the vapors through the tower. The rate of distillation can accordingly be increased while the increased tendency to carry the heavier oil mechanically with the vapors is overcome by the cooling effect incident to the introduction of additional overhead distillate at the top of the tower. If the overhead distillate itself is carried along mechanically with the escaping vapors, this is unobjectionable.

In Fig. 15 three inlets are shown below the top of the reflux tower and the feed may be introduced through one or another of these inlets. This feed may be preheated, for example, by heat interchange with the vapors escaping from the top of the tower; and light distillate may be introduced at the top of the tower. Preheated benzine can advantageously be introduced at such an intermediate point and gasoline distillate introduced at the top of the tower. The gasoline introduced at the top will be re-vaporized and driven off, together with the gasoline from the feed, but in re-evaporating, it will serve to cool the heavier vapors and condense them and the resulting liquid will then flow down through the tower and assist in cooling the still heavier vapors lower down in the tower. By introducing gasoline at the top of the tower in this way, and by introducing pre-heated benzine at an intermediate point, an increased yield of gasoline can be recovered from the benzine, and the rate of distillation can also be materially increased. Where, for example, a yield of about 65% of gasoline would be obtained without preheating of the feed or introduction of gasoline at the top of the tower, a yield of 73% was obtained by introducing gasoline at the top of the tower, and introducing the benzine about 10 feet down from the top of the tower. It will be evident, however, that the yield will vary with the character of the benzine or other oil which is subjected to distillation. The increased yield of gasoline is also obtained with a sharper cut, e. g., at 450° F. end point.

With introduction of a light distillate into the top of the tower it also becomes possible to take out a heavier distillate of definite boiling point from intermediate levels of the tower, for example, from outlets 29 arranged at intermediate points as illustrated in Figs. 1 and 4. Pockets 31 may thus be provided for collecting the liquid at such an intermediate point and the liquid may be drawn out through one or another of the pipes 29 by opening the regulating valve 30.

In the operation of the towers, for example, for the continuous fractionation of gasoline from crude oil, the upper portion of the tower can be considered as primarily a heater. The feed is cold and is heated by the vapors in contact with it. At first there will be a complete condensation of the vapors due to the fact that the feed is cold. As soon, however, as the feed becomes heated, it will start to give off light vapors which will mingle with those coming from the still, reducing their specific gravity. The vapors from the still flowing upwardly through the tower will in turn be condensed to a greater or less extent, the heavier constituents returning as liquid to the still and the lighter constituents remaining in the vapor form. The condensate from the vapors will be heavier than the vapors themselves and this tends to reduce the specific gravity of the remaining vapors. The interchange of heat effected in this way, with driving off of the lighter vapors from the feed stock and condensation of the heavier portions of the vapors from the still, is carried on throughout the tower and ends only when the reflux or feed enters the still or when the reflux entering the still is at the same temperature and consequently of the same constitution as the liquid in the still.

The liquid in the tower is heated, first, by contact with the vapors and, second, by the heat that passes through the trays or pans. That is, the heating is in part effected by direct heat exchange of the vapors with the liquid and in part by indirect contact through the metal of the trays or pans over which the liquid is flowing and under which the vapors are passing. The amount of heat absorbed in these two ways depends on the surfaces exposed. With the same temperature difference there is a similar amount of heat absorbed from the vapors by the bottom surfaces of the pan per square foot of surface as there is per square foot of liquid surface directly exposed to the vapors, assuming that the upper surfaces of the pans are completely covered with the liquid. The present invention takes advantage of both of these methods of heating and provides practically a maximum area of surface of heat transfer. In apparatus in which a spray or falling sheet of liquid is exposed to vapors, there is a minimum of effective surface of the liquid exposed for absorbing heat from the vapors, whereas in the present invention there is a maximum of surface of contact for heat interchange, inasmuch as the pans or baffles are constructed so as to be completely covered by the liquid on the upper side and completely swept by the gases on both sides. The cascading or spraying of the liquid is avoided so that there is also avoided any appreciable tendency for the gases to pick up and carry along mechanically liquid which is introduced therein by cascading or spraying.

In the construction of the present invention the vapors have a clear passage over the pans and are continuously kept in contact with the liquid; while they have an equally close contact with the bottom of the pans and sweep over all portions of both of these exposed surfaces.

The construction is also such that the vapors can pass through the tower at a higher velocity, thus greatly increasing the effective heat transfer. The importance of a high velocity will be appreciated from the fact that with double the vapor velocity approximately half of the surface will absorb the same amount of heat. The construction and arrangement of the present invention gives substantially a maximum vapor velocity in contact with the heat absorbing surfaces and with a minimum friction loss.

It is a further advantage of the present invention that the bottom of the pans are in contact with the vapors which are a full turn further down the tower and therefore hotter than the vapors above the liquid. In this respect also the invention is distinguished from so-called pan towers or bubble towers in which the vapors in contact with the bottom of the pans pass at once through them to the top surfaces so that there is little difference in temperature. In the present invention the increased temperature difference between the hotter vapors below the pans and the cooler liquid above them makes the heat transfer more effective both in removing lighter constituents from the liquid and in condensing heavier constituents from the vapors, the heavier constituents from the vapors falling back into the pan below at a full turn further down on the tower.

With an oblong construction of tower such as illustrated in Figs. 1—3, a greater length of each flight or convolution is obtained than with a circular tower of the same area. Hence an increased temperature difference between the successive turns in the tower is obtained which further increases the effectiveness of the heat transfer between the vapor flowing upwardly and the liquid flowing downwardly. The effectiveness of the heat transfer can be further increased by increasing the effective surface of the bottoms of the pans, for example, by providing ribs or corrugations as illustrated in Figs. 13 and 14.

In order to insure a uniform or approximately uniform distribution of the liquid laterally over the surface of the pans, the pans may be given a slight inclination from the center of the tower outwardly or, if the pans are level, distributing weirs or baffles may be used with the weir openings so proportioned as to make the flow across the width of the helix proportional to the surface of the helix at that particular point; that is, the weir openings are small at the center and large at the outer circumference. Where the helical surface instead of being a continuous length of sheet steel, is made up of a series of pans, these pans in effect form a continuous helical surface and may provide overflow lips or baffles which insure that the oil passes in thin streams over the successive portions of the helix except where it backs up at the notched weirs.

It will thus be seen that the present invention provides an improved apparatus for distilling and fractionating petroleum oil and distillates with refluxng of the vapors by means of feed introduced directly into contact therewith, and that the feed so introduced acts not only by direct contact with the vapors but also by indirect contact with the vapors at a complete turn further down in the tower, thus greatly increasing the effectiveness of the heat transfer end of the fractionating and refluxing action. A greater temperature difference is thus obtained between the liquid above and the vapors below the helical surfaces than can be obtained with the ordinary baffle arrangements of reflux towers.

It will also be seen that the present invention provides an improved method of fractional distillation which enables close cuts to be obtained, for example, in the re-running of benzine and in the topping or fractionating of crude oil for the recovery of lighter fractions such as gasoline therefrom. The invention is applicable, however, for the re-running or fractionating of other distillates where a similar separation into well defined fractions is desired.

I claim:

1. In the fractional distillation of petroleum oils, introducing hot oil vapors into the lower portion of a fractionating tower and introducing the oil to be fractionated into the upper portion of the said tower, causing the liquid oil introduced into the upper portion of the tower to flow downwardly in a substantially continuous helical stream through the tower and causing the oil vapors to flow upwardly in a helical path in direct contact with the surface of the stream of liquid oil and in indirect heat exchanging relation with the stream of liquid oil at a higher point.

2. The method of fractional distillation of petroleum oil for the separation of a fraction of definite end point therefrom which comprises introducing the oil to be fractionated into the upper portion of a fractionating tower and causing it to flow downwardly therethrough in a substantially continuous stream to a still communicating with the lower end of the fractionating tower, heating the oil in the still and driving off vapors therefrom into the lower portion of the said fractionating tower and causing these hot vapors to flow upwardly in a helical path in direct contact with the surface of the stream of oil flowing downwardly through the tower and in indirect heat exchanging relation with the said stream of oil at a higher point, and maintaining the temperature of the oil in the still at a point sufficient to remove substantially all of the fraction of the desired end point.

3. In the fractional distillation of petroleum oils, introducing hot oil vapors into the lower portion of a fractionating tower and introducing the oil to be fractionated into the upper portion of the said tower at a point below the top thereof, causing the hot oil vapors introduced into the lower portion of the tower to flow upwardly in a helical path through the said tower and causing the liquid oil introduced into the upper portion of the tower to flow downwardly through the said path while maintaining the vapors in the turns of the helical path in direct contact heat exchanging relation with the liquid in the same turn and in indirect heat exchanging relation with the cooler liquid in the next higher turn, and introducing into the tower at a point above the point of introduction of the oil to be fractionated an oil lighter than the oil to be fractionated.

4. In the fractional distillation of petroleum oils, introducing hot oil vapors into the lower portion of a fractionating tower and introducing the oil to be fractionated into the upper portion of the said tower, causing the oil vapors introduced into the lower portion of the tower to flow upwardly in a helical path through the said tower and causing the liquid oil introduced into the upper portion of the said tower to flow downwardly through the said path while maintaining the vapors in the turns of the helical path in direct contact heat exchanging relation with the liquid in the same turn and in indirect heat exchanging relation with the cooler liquid in the next

higher turn, the area through which indirect heat transfer is taking place being maintained in excess of the area of direct contact between the vapors and the liquid.

5. In apparatus for the fractional distillation of petroleum oils, a fractionating tower having a vapor inlet and a liquid outlet near the lower end and a vapor outlet and a liquid inlet near the upper end, a helical partition within the tower providing a helical path between the vapor inlet and the vapor outlet and between the liquid inlet and the liquid outlet, adjacent turns of the path being in indirect heat exchanging relation through the partition, and distribution means arranged on the upper surface of said partition for promoting uniform liquid flow.

6. In apparatus for the fractional distillation of petroleum oils, a fractionating tower having a vapor inlet and a liquid outlet near the lower end and a vapor outlet and a liquid inlet near the upper end, and a helical partition within the tower providing a continuous helical path between the vapor inlet and the vapor outlet and between the liquid inlet and the liquid outlet, said partition being arranged to permit heat transfer therethrough between adjacent turns of the said helical path, and means on the lower side of the said partition for increasing the area of the surface exposed to heat transfer to in excess of that on the upper side.

7. In apparatus for the fractional distillation of petroleum oils, a fractionating tower having a vapor inlet and a liquid outlet near the lower end and a vapor outlet and a liquid inlet near the upper end, and a helical partition within the tower providing a continuous helical path between the vapor inlet and the vapor outlet and the liquid inlet and the liquid outlet and arranged to permit heat transfer therethorugh between adjacent turns of the helical path, said partition being made up of a series of pans adapted to retain pools of liquid on their upper side.

8. In apparatus for the fractional distillation of petroleum oils, a fractionating tower comprising a vertically arranged shell and a flat central plate, a helical partition being arranged between the said shell and the said central plate to provide a helical path extending through the tower and adapted to confine both vapor flow and liquid flow to the said path, a vapor inlet and a liquid outlet communicating with the said path near its lower end and a vapor outlet and a liquid inlet communicating with the said path near its upper end.

In testimony whereof I affix my signature.

JOHN E. BELL.

higher turn, the area through which indirect heat transfer is taking place being maintained in excess of the area of direct contact between the vapors and the liquid.

5. In apparatus for the fractional distillation of petroleum oils, a fractionating tower having a vapor inlet and a liquid outlet near the lower end and a vapor outlet and a liquid inlet near the upper end, a helical partition within the tower providing a helical path between the vapor inlet and the vapor outlet and between the liquid inlet and the liquid outlet, adjacent turns of the path being in indirect heat exchanging relation through the partition, and distribution means arranged on the upper surface of said partition for promoting uniform liquid flow.

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7. In apparatus for the fractional distillation of petroleum oils, a fractionating tower having a vapor inlet and a liquid outlet near the lower end and a vapor outlet and a liquid inlet near the upper end, and a helical partition within the tower providing a continuous helical path between the vapor inlet and the vapor outlet and the liquid inlet and the liquid outlet and arranged to permit heat transfer therethorugh between adjacent turns of the helical path, said partition being made up of a series of pans adapted to retain pools of liquid on their upper side.

8. In apparatus for the fractional distillation of petroleum oils, a fractionating tower comprising a vertically arranged shell and a flat central plate, a helical partition being arranged between the said shell and the said central plate to provide a helical path extending through the tower and adapted to confine both vapor flow and liquid flow to the said path, a vapor inlet and a liquid outlet communicating with the said path near its lower end and a vapor outlet and a liquid inlet communicating with the said path near its upper end.

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JOHN E. BELL.

CERTIFICATE OF CORRECTION.

Patent No. 1,683,151. Granted September 4, 1928, to

JOHN E. BELL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, line 82, for the word "prelated" read "preheated"; page 5, line 25, strike out the word "are" second occurrence, and line 37, for the word "he" read "the"; page 6, line 13, for the word "frictionation" read "fractionation"; page 7, line 60, for the word "heat exchange" read "direct contact", and line 61, for the word "contact" read "heat exchange"; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of November, A. D. 1928.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.