H. FRASCH.

APPARATUS FOR USE IN OBTAINING PETROLEUM PRODUCTS.

APPLICATION FILED OCT. 4, 1902. RENEWED JAN. 18, 1910.

951,729.

Patented Mar. 8, 1910.

5 SHEETS—SHEET 1.

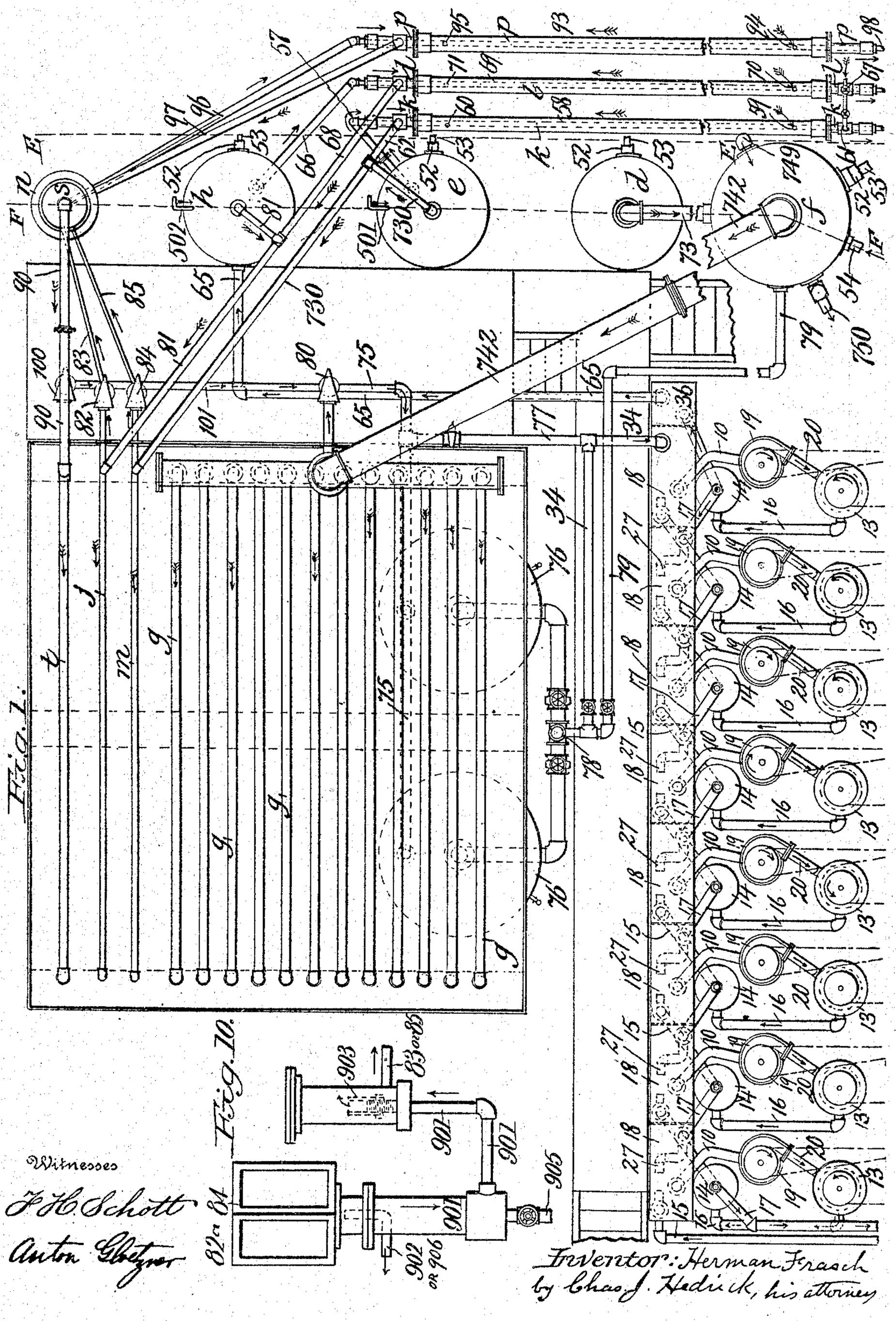

Fig. 1.

Fig. 10.

Witnesses

F. H. Schott

Anton Gbetzner

Inventor: Herman Frasch

by Chas. J. Hedrick, his attorney

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5 SHEETS—SHEET 2.

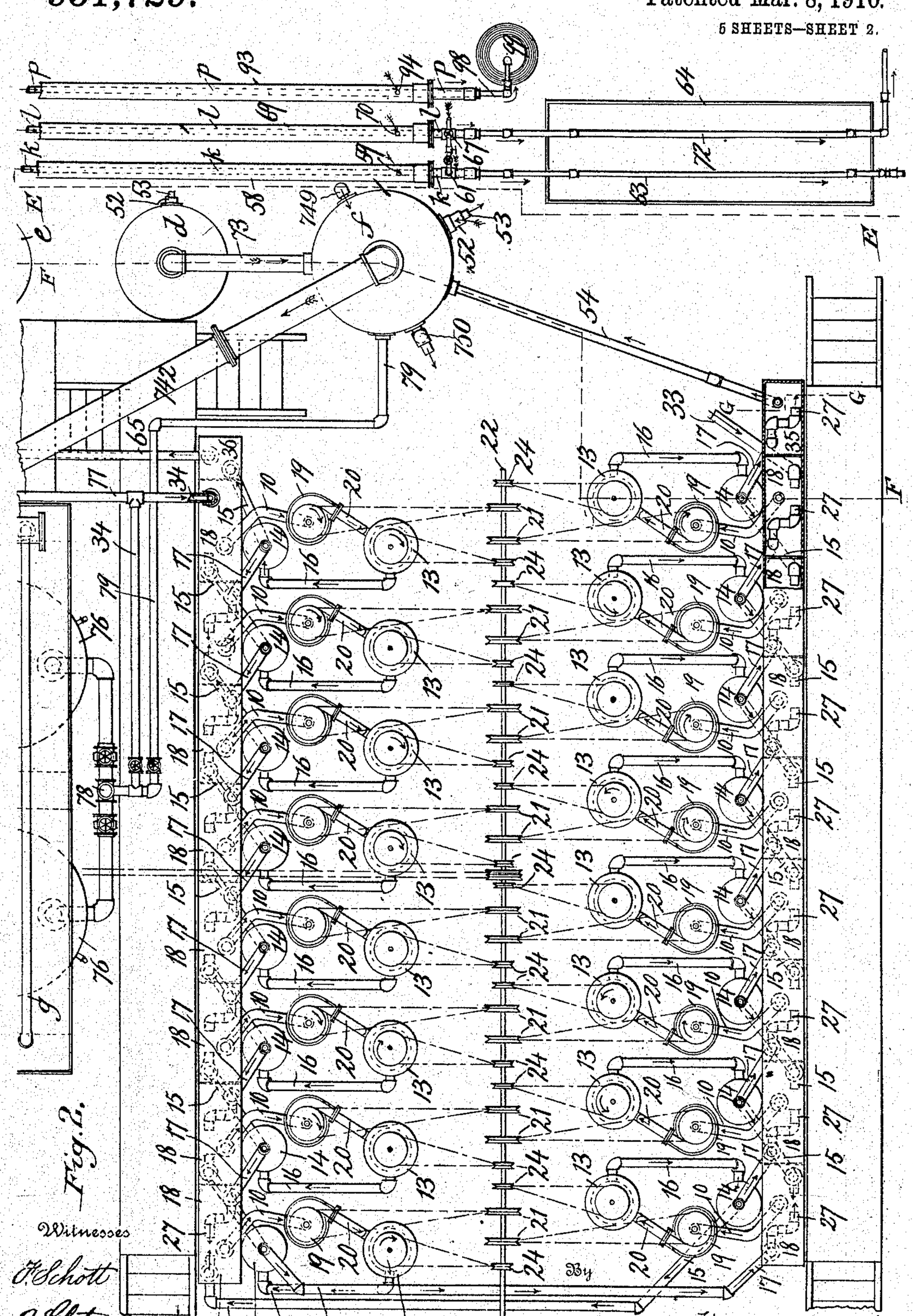

Fig. 2.

Witnesses
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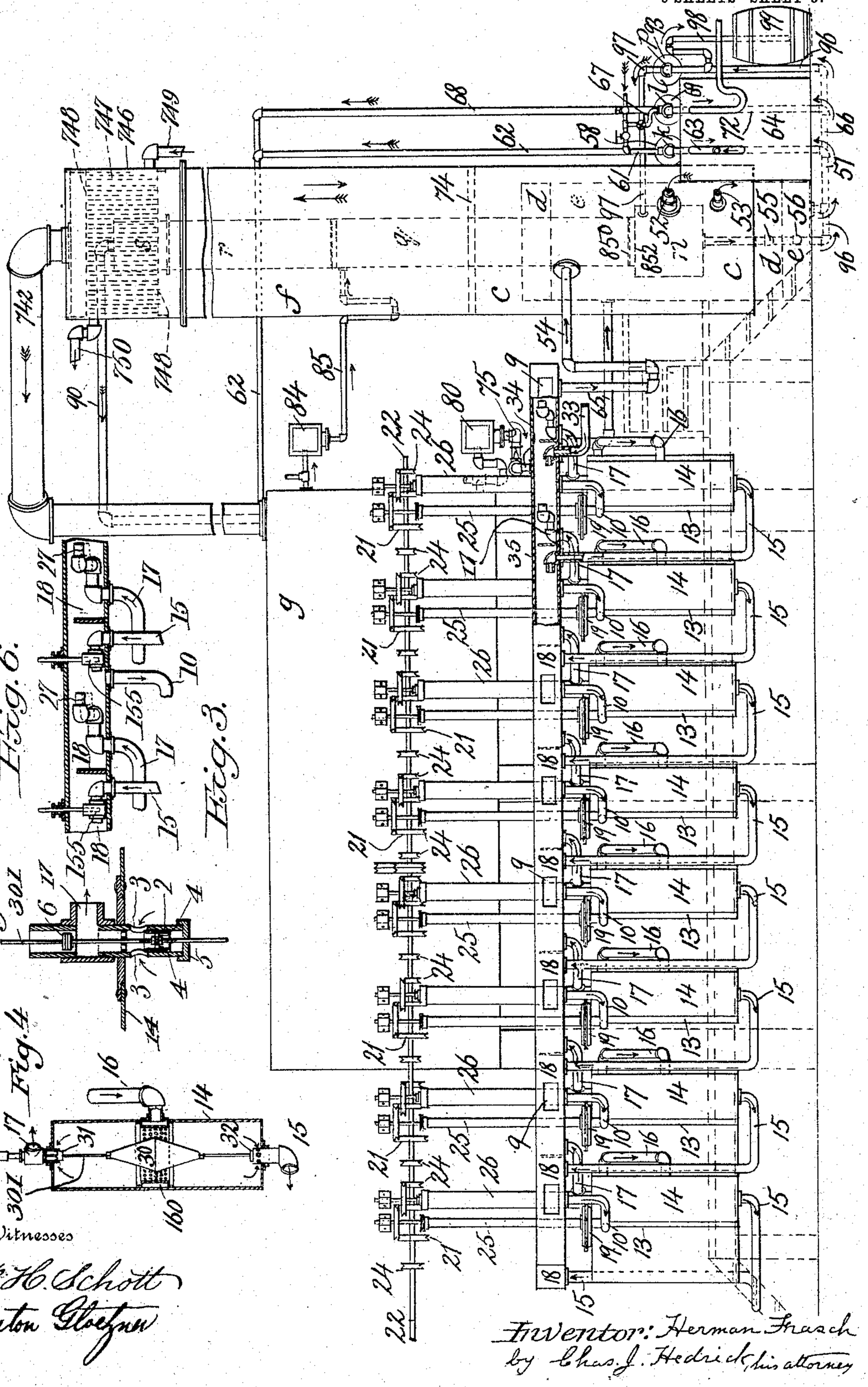

Fig. 3.

Fig. 6.

Fig. 5.

Fig. 4.

Witnesses

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by Chas. J. Hedrick, his attorney

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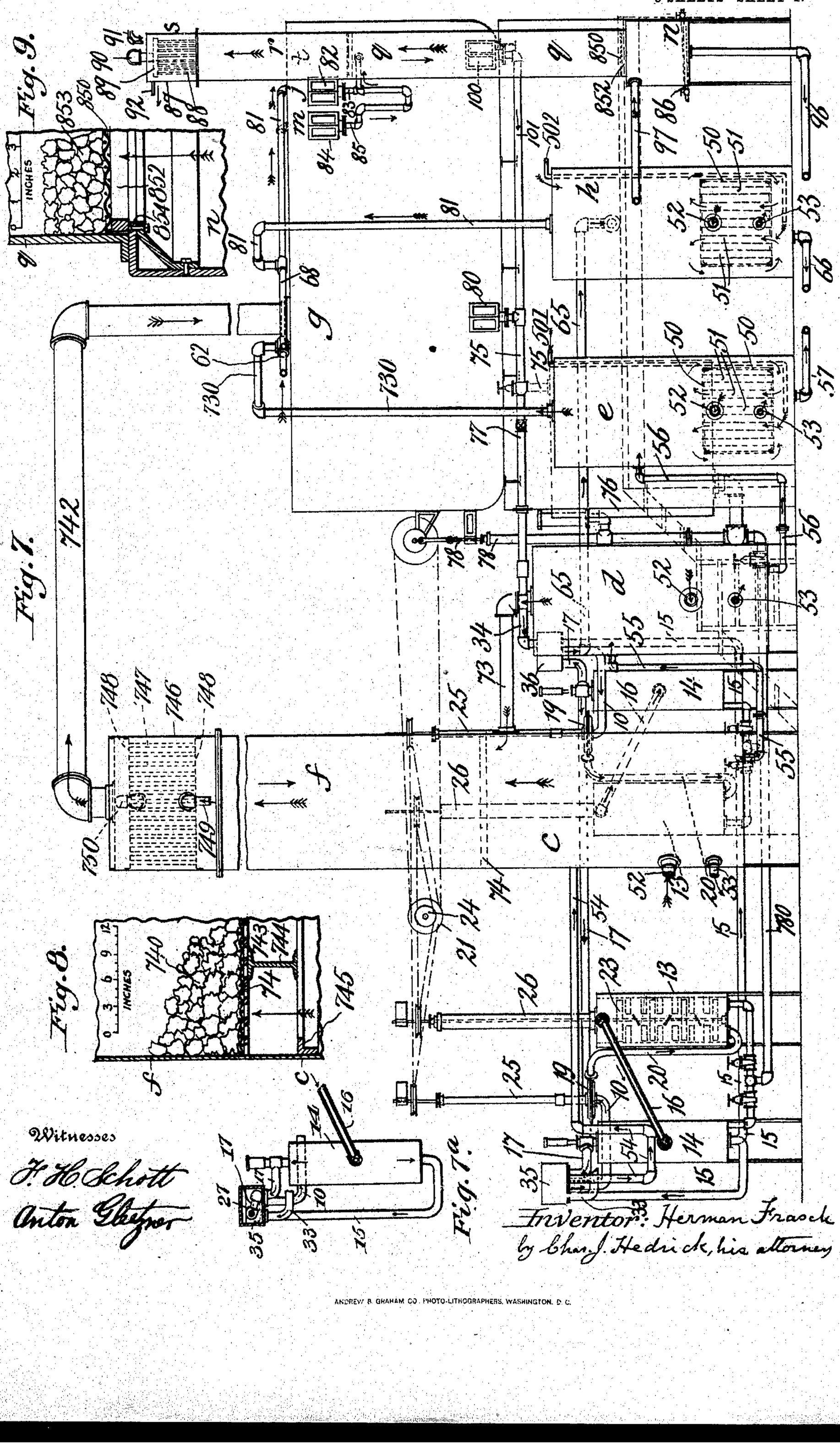
5 SHEETS—SHEET 4.



Witnesses

F. H. Schott

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5 SHEETS—SHEET 5.

Fig. 11.

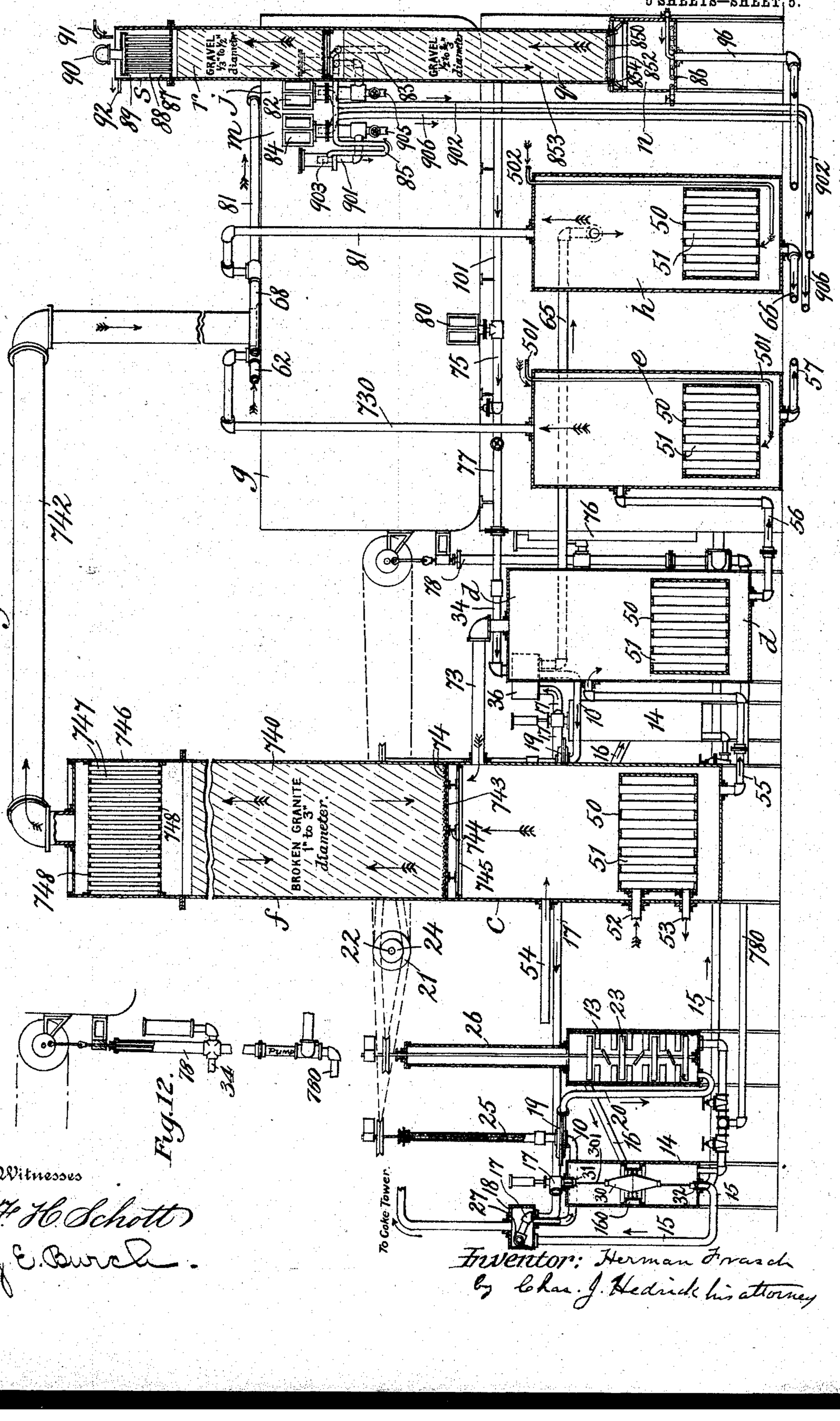

Fig. 12.

Witnesses

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J. E. Burch.

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UNITED STATES PATENT OFFICE.

HERMAN FRASCH, OF NEW YORK, N. Y., ASSIGNOR TO STANDARD OIL COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

APPARATUS FOR USE IN OBTAINING PETROLEUM PRODUCTS.

951,729. Specification of Letters Patent. Patented Mar. 8, 1910.

Application filed October 4, 1902, Serial No. 125,967. Renewed January 18, 1910. Serial No. 538,731.

To all whom it may concern:

Be it known that I, HERMAN FRASCH, a citizen of the United States, residing at New York, Manhattan borough, county of New York, in the State of New York, have invented certain new and useful Improvements in Apparatus for Use in Obtaining Petroleum Products; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates more particularly to apparatus for use in the obtainment of burning oil (kerosene) from crude petroleum of the nature of that obtained from the wells near the town of Beaumont, in the county of Jefferson, and State of Texas. This petroleum and its distillates of like nature are herein termed Beaumont oil (or Beaumont petroleum) for convenience of reference, such designation being intended to include petroleum and petroleum distillates of the same or substantially similar character wherever found or however obtained.

On subjecting Beaumont oil to the procedure customarily used for obtaining burning oil (kerosene) from the petroleum of the Pennsylvania oil fields, that is to say, on separating the burning oil fraction from the rest of the Beaumont oil, by one or more distillations with or without cracking, and treating the so obtained burning oil distillate with sulfuric acid (followed by washing with water and then with solution of alkali), the resulting product will be safe, colorless and of a mobility to climb a lamp wick (although much denser than Pennsylvania burning oil), but it will smoke when burned in ordinary petroleum (kerosene) lamps for illuminating purposes, especially if the flame be turned low. The raw distillate shows the same smoky flame. I have discovered that this burning oil fraction of Beaumont petroleum does not consist wholly of smoky hydrocarbons, but is composed also (in part) of non-smoking hydrocarbons, and that the smoky and non-smoking hydrocarbons which volatilize together in distillation, and which consequently make a smoky distillate, can, by the differential solvent action of an appropriate menstruum, such as methyl alcohol or ethyl alcohol, be separated from each other sufficiently for the obtainment of a non-smoking oil as the direct result of the operation.

The apparatus of the present invention includes means which can advantageously be employed in effecting such separation and which in their best form consist of series of mixing vessels, pumps and settling and decanting vessels with appropriate pipe connections and auxiliary appliances.

The solvent action of methyl alcohol or ethyl alcohol is greater on the smoky than on the non-smoking hydrocarbons; but it is evident that a menstruum with the reverse differential action might serve to separate the two kinds of hydrocarbons; and it is believed that the apparatus of the present invention could advantageously be employed with such a menstruum, if it should be found expedient to use it.

In effecting the separation from each other of the hydrocarbons, the bulk at least of the menstruum will be accompanied by the oil which is composed of (or is richer in) the hydrocarbons soluble or more soluble in said menstruum; but more or less of the menstruum is apt also to be found in the oil which is composed of (or is richer in) insoluble or less soluble hydrocarbons; and ordinarily at least the menstruum would be separated from both oils. By such separation the oils are obtained in a more nearly pure state; and the valuable menstruum is recovered. Wherever it is possible so to do, it is considered best to effect such recovery by the aid of distillation (evaporation and condensation); and with methyl alcohol or ethyl alcohol or other volatile menstruum of low boiling point, this is possible, because, as I have discovered, the smoky hydrocarbons of Beaumont petroleum (or those at least which cause the most objection) are so high in boiling point as not necessarily to volatilize with methyl alcohol or ethyl alcohol. If the oil to be operated upon should contain hydrocarbons which would necessarily volatilize with the methyl alcohol or ethyl alcohol, they can be distilled off preliminarily, to be subjected by themselves, if need be, to a differentially solvent menstruum, in apparatus of the present invention, with recovery of said menstruum in any appropriate way, or to be used without such subjection, when already sufficiently free from smoky constituents.

The apparatus of the present invention

includes means which can advantageously be employed in recovering methyl alcohol or ethyl alcohol or other low boiling menstruum from the smoky and non-smoking oils that result from its separative action and which in their best form consist of (1) stills wherein the menstruum is expelled from the oil associated with the bulk of the same at first by dry heat without admission of steam and afterward by the aid of free steam and from the other oil by the aid of free steam, and (2) rectifiers wherein the menstruum vapors are freed from concomitant oily and aqueous vapors, together with (3) appropriate pipe connections and auxiliary appliances.

The apparatus in whole or in part, with or without modification, might also be found useful in relations other than the separation of smoky and non-smoking hydrocarbons from each other; and it should be understood that every new part, improvement or combination to be found in the complete apparatus, or any portion thereof, is intended to be secured for all the uses to which it may be adapted with or without modification.

The following description, in connection with the accompanying drawing, explains what is considered the best form of the apparatus, it being understood that modifications, omissions and additions can be made indefinitely within the limits of the invention so long as the substance of any one or more of the hereinafter written claims is taken.

Figures 1 and 2 are each a partial plan of an oil-washing apparatus or plant for the continuous subjection of the petroleum to the menstruum for separating the smoky from the non-smoking hydrocarbons of said petroleum and for the continuous separation for re-use of the menstruum from the products obtained by its use, a complete plan of the apparatus being obtained by taking the two figures together, with omission from one or other of the figures of those parts which appear on both; in Fig. 1 certain intermediate portions are broken away in order to get the figure on the sheet; Fig. 3 is a front elevation of the same apparatus, looking from the bottom toward the top of Fig. 2; Fig. 4 is a view in vertical section of one of the settling and decanting vessels forming part of said apparatus; Fig. 5 is a detail view on a larger scale of a form of valve considered more advantageous than that shown in Fig. 4; Fig. 6 is a detail view of a valve arrangement which may be used instead of or in addition to that of Fig. 4 or Fig. 5. Fig. 7 is a side elevation, partly in section, of the apparatus or plant of Figs. 1, 2 and 3, looking to the left from the line E E of Figs. 1 and 2; Fig. 7ª is a detached view in vertical section and elevation of that portion of the apparatus which is shown at the extreme left of Fig. 7, the section being taken on line G G of Fig. 2 and looking to the left; Figs. 8 and 9 are detail views of parts of rectifying columns belonging to the apparatus; Fig. 10 (Sheet 1) is a view in elevation of a device for skimming oil from the aqueous methyl alcohol of condensation; Fig. 11 is a sectional elevation on line F F of Figs. 1 and 2 looking to the left, so much of the vapor pipe 730 as lies to the right of said line being shown in elevation and the skimmers for separating oil from the aqueous alcohol (not represented in Figs. 1–9) being shown in places; and Fig. 12 is a detached view in elevation partly broken away of a pump for moving the methyl alcohol when it is required to be pumped.

In Figs. 3 and 5 one of the rectifying columns and its vapor pipe are shown partly broken away, in order to get the figures on their respective sheets.

Before describing the oil washing apparatus or plant, explanation will first be given of the manner of distilling Beaumont petroleum in order to obtain that portion of its burning oil fraction which is more especially intended to be washed in said apparatus. The stills and receivers to be used in such distillation are not shown. They may be of any known or suitable description and are not part of the apparatus constituting the present invention.

The crude Beaumont petroleum is preferably distilled in such manner as to obtain cracked oil. This is effected, as is well known, by a slow distillation. As a general proposition, about 30 per cent. can be run off before cracking commences, and 52 per cent. afterward, thus making in all about 820 barrels of first distillate from 1,000 barrels of crude. This first distillate is then distilled for separation of the burning oil fraction from heavier fractions, the vapors being passed through a rectifying column, such as the column *f* hereinafter described, for example. It is considered most convenient to collect any naphtha with the lighter end of the burning oil fraction, as the amount of naphtha should not be great. During the first part of this distillation, the distillate is conducted to the first burning oil receiver, in which the lighter end of the burning oil fraction collects, until the temperature of about 350° F., more or less, is indicated at the top of the rectifying column. When this temperature shall be reached, practically all of the hydrocarbons will have come over which would be apt to cause trouble in the separation of methyl alcohol. This is considered the most advantageous menstruum to be used, and the description, therefore, assumes it to be employed. The amount of this lighter end of

the burning oil fraction may be about 7 per cent. of the crude oil (that is, 70 barrels of said lighter end from the 820 barrels of cracked oil obtained from 1,000 barrels of crude). With Beaumont oil, as I have found it, this lighter end does not have to be subjected to the hydrocarbon menstruum, but is obtained directly as a non-smoking oil. It is most advantageous to employ it for admixture with the heavier portion of the burning oil as hereinafter described.

After the lighter end of the burning oil shall have been preliminarily separated by the distillation described, the delivery of distillate from the condenser is changed to the second burning oil receiver. The distillation is thus continued preferably until all the burning oil fraction is off. The amount collected in the second burning oil receiver may be about 48 per cent. of the crude (that is, 480 barrels of the heavier portion of the burning oil fraction from the 820 barrels of cracked oil, which were obtained from 1,000 barrels of crude oil). Of course, these figures and other like figures are approximate and descriptive only, not definitive of the invention. When the burning oil fraction, or as much of it as it may be desired to collect, has come over, the fires are put out and the residuum withdrawn from the still to be burned as fuel or otherwise disposed of. It can be distilled for product heavier than burning oil, if desired.

The distillate of the second burning oil receiver, being the heavier portion of the burning oil fraction, is then subjected to the menstruum, to wit, methyl alcohol, for separating the smoky and the non-smoking hydrocarbons therein from each other.

Another mode of proceeding would be to distil the crude oil with cracking as before in order to obtain a first distillate, then to re-distil this latter for separation of the burning oil fraction from the heavier fractions thereof, the whole burning oil distillate (equal to about 55 per cent. of the crude oil) being collected in one receiver, and lastly to separate from this burning oil distillate the lighter end (amounting to about 7 per cent. of the crude) by a steam still provided with a rectifying column. The residue, 48 per cent. of the burning oil distillate (which should be subjected to dry heat to remove any water from condensation of steam therein) is subjected to the differentially solvent menstruum.

The lighter end could be removed from the first distillate by steam stilling (instead of by a fire still) or from the burning oil distillate by fire still (instead of by steam stilling), a rectifying column being preferably used in any case, in order to keep back hydrocarbons which might make the lighter end too smoky to use without special treatment, and which with ordinary distillation (without rectification) would be more apt to be carried over.

For subjecting the heavier portion of the burning oil fraction to the hydrocarbon-separating menstruum, use may be made of the oil-washing apparatus now to be described. This apparatus is shown in Figs. 1–7[a] and Fig. 11. It contains a series of mixing vessels 13, and a series of settling and decanting vessels 14 interconnected in such a manner as that the heavier liquid from the bottom of each settling and decanting vessel 14 is mixed in one of the vessels 13 with the lighter liquid from the top of another vessel 14 (farther along in the series) and that the mixture of the two liquids is delivered by a pipe 16 into a third vessel 14 for settling and decantation. Of the pipes 15 (see Figs. 4, 7 and 11) one leads from the bottom of each vessel 14; a pipe 16 connects the top of each mixing vessel 13 with the middle of each vessel 14; and a pipe 17 leads from the top of each vessel 14.

As shown the pipes 15 and 17 which connect with the same mixing vessel 13 do not open directly into the latter, but (see Figs. 2, 3, 7 and 11) into a supply chamber 18 from which the two liquids are taken through pipe 10 by the centrifugal pump 19 and by it delivered into the proper mixing vessel 13 through a pipe 20. The centrifugal pumps 19 (or other pumps) could, of course, be variously arranged and operated; but, as shown, they are located outside of the mixing vessels 13 and are driven by belts from pulleys 21 on the shaft 22; and the stirrers 23 (Fig. 7) in the mixing vessels 13 are driven by belts from pulleys 24 on the same shaft.

On top of each centrifugal pump is shown a sleeve 25 having at the top a stuffing box through which the pump shaft passes. This sleeve furnishes a space into which liquid inside the pump can rise under the influence of gravity or other force, and is intended to be so long that the pressure of the column of liquid will balance pressures tending in use to raise the liquid level therein. Thus the stuffing box is kept away from the liquids which pass through the pump and evaporation is checked or arrested. The pump 78 (Figs. 7, 11 and 12), hereinafter referred to, has a similarly arranged stuffing box as shown. With the same object there is shown a sleeve 26 on top of each mixing vessel 13, the stirrer shaft passing through the stuffing box at the top of the corresponding sleeve 26, which stuffing box is at a higher level than the supply chamber 18.

Each of the pipes 17 is provided with an adjustable discharge section 27. The adjustment might otherwise be made, but, as shown, the elbow or the nipple between the end section 27 and the rest of the pipe 17

can be turned axially by reason of the threaded connections, so that the discharge section 27 can be raised and lowered at will. In the wall of each supply chamber 18, as also in the wall of each of the chambers 35 and 36, is a glass pane 9 for allowing observation of the interior.

In each settling and decanting vessel 14 is a submerged float 30 (Figs. 4 and 11) carrying a valve 31 on its stem 301 at the top of vessel 14 for closing the inlet to pipe 17 when the float rises and a valve 32 below for closing the inlet to pipe 15 when the float falls. The float is so adjusted that in normal working both valves are open. Should, for any reason, the lighter component in the mixture of liquids supplied by pipe 16 to any settling and decanting vessel 14 run off by the pipe 17 more slowly than it is supplied by said pipe 16, the accumulation of said lighter component will allow the float 30 to descend and close the inlet to pipe 15 so that more of the mixture will run off through the pipe 17 until the normal working is reëstablished. On the other hand, if the heavier component accumulates in any settling and decanting vessel 14, the float rises and closes the inlet of the pipe 17 so that more of the mixture will run off by the pipe 15 until the equilibrium shall be established. The mixture of liquids is supplied by pipe 16 to an annular chamber 160, the inner wall of which is perforated with numerous small holes and serves to distribute the liquids uniformly around the interior of the vessel 14.

In Fig. 5 the valve 2 is placed between the outlets 3 and the middle of the vessel so that the current does not tend to close the same. The body of the valve has holes 4 so that the liquid may pass into and out of the space between the valve 2 and the cap 5. At 6 are weights by which the proper depression of the float 30 may be secured. This float could have other proper shape, instead of the double conical form shown.

In Fig. 6 the end of the pipe 15 is provided with a simple gate valve 155 having a stem which passes through a stuffing box on the cover of the supply chamber 18. By adjusting the position of this valve the outflow by the pipe 15 can be controlled; while the raising and lowering of the end 27 controls the outflow by the pipe 17.

The operation of washing the before mentioned distillate from the second burning oil receiver with, say, methyl alcohol, which is a menstruum lighter than the oil to be washed, is as follows: The said oil enters the apparatus by the pipe 33 at one end of the same, namely, at the lower right hand corner of Fig. 2 as shown; while the methyl alcohol enters by the pipe 34 at the other end of the apparatus, namely, at the upper right hand corner of Fig. 2. It would be difficult, if not impossible, to trace the travel of the two liquids simultaneously; and it seems best first to follow the course of the oil. The pipe 33 discharges the oil into the supply chamber 18 which is the first in the series as regards the oil and is shown next to the chamber 35. From this chamber 18 the oil is drawn through pipe 10 into the first centrifugal pump 19, which discharges it through pipe 20 into the bottom (Figs. 7 and 11) of the first mixing vessel 13; whence it passes by pipe 16 (Figs. 3, 4 and 7) to the middle of the first settling and decanting vessel 14. From the bottom of this vessel it passes by the corresponding pipe 15 (Figs. 2, 3, 4 and 6) into the second supply chamber 18. Thence it passes through second pipe 10, second centrifugal pump 19, second pump 20, second mixing vessel 13, second pipe 16, second decanting and settling vessel 14, and second pipe 15 into the third supply chamber 18. From this third supply chamber 18 it passes by way of the third centrifugal pump 19, third mixing vessel 13, and third decanting and settling vessel 14 to the fourth supply chamber 18; and so it passes along from each supply chamber 18 to the next in order, traversing in its passage the centrifugal pump, the mixing vessel, and the decanting and settling vessel corresponding with each supply chamber; until from the last decanting and settling vessel 14 (at the upper right hand corner of Fig. 2) it enters the chamber 36 through the last pipe 15, and is discharged from chamber 36 by the pipe 65. The methyl alcohol from pipe 34 enters what is the last of the supply chambers 18, as viewed in reference to the course of the oil, namely, the supply chamber 18 next to chamber 36 at the upper right hand corner of Fig. 2. It passes thence by pipe 10 to the centrifugal pump 19 traversed last in order by the oil. This centrifugal pump delivers the methyl alcohol through the pipe 20 into the corresponding mixing vessel 13; from which it is discharged through pipe 16 into the last of the settling and decanting vessels 14. From the top of this vessel the methyl alcohol passes by pipe 17 into the next supply chamber 18 to the left. From this chamber it passes by pipe 10 to the corresponding centrifugal pump 19, thence by pipe 20 to the corresponding mixing vessel 13, thence by pipe 16 to the corresponding decanting and settling vessel 14, and thence by pipe 17 from the top of this vessel 14 to the supply chamber 18 next farther to the left. In like manner the methyl alcohol passes from each supply chamber 18 to that which next precedes it in the course of the oil traversing in its passage the centrifugal pump, the mixing vessel and the settling and decanting vessel corresponding with each supply chamber; until from the first decanting and set-

tling vessel 14 (at the lower right hand corner of Fig. 2) it enters the chamber 35 through the pipe 17 and is thence discharged by pipe 54. It will thus be seen that from each supply chamber 18 oil and methyl alcohol pass together through each pipe 10, each centrifugal pump 19, each outlet pipe 20, each mixing vessel 13, and its discharge pipe 16 to the middle of the corresponding decanting and settling vessel 14; but in each decanting and settling vessel the courses of the oil and the methyl alcohol diverge. The oil sinks and passes from the bottom of the vessel 14 (Fig. 4) by pipe 15 to the next succeeding supply chamber 18; while the methyl alcohol rises and passes from the top of the vessel 14 (Fig. 4) by pipe 17 to the supply chamber 18 next preceding in the course of the oil. The oil, having been delivered by the pipe 33 into the first supply chamber 18, meets therein the alcohol which is delivered into the same supply chamber by pipe 17 from the second in the series of settling and decanting vessels 14. This methyl alcohol is highly charged with hydrocarbons which it has dissolved on its way to said first supply chamber 18 from its first introduction by the pipe 34. This highly charged methyl alcohol and the newly introduced oil are taken by the first of the series of centrifugal pumps 19 and delivered by the pipe 20 into the first of the series of mixing vessels 13.

The methyl alcohol and oil are mixed in the centrifugal pump and again in the mixing vessel 13, the thorough mixture of the two liquids giving the methyl alcohol a better opportunity to dissolve smoky hydrocarbons out of the oil. Its capacity for this being not quite saturated, it exchanges some of its non-smoking hydrocarbons for a portion of the smoky hydrocarbons of the newly introduced oil, and the alcohol becomes more highly charged than when it escaped from the second of the series of settling and decanting vessels 14. The mixture of the so-charged alcohol and the once washed oil is discharged from the first vessel 13 by the pipe 20 into the middle of the first settling and decanting vessel 14, when, under the action of gravity, a separation into two layers takes place. The alcohol with its dissolved hydrocarbons being the lighter rises to the top of the vessel and passes by pipe 17 to the chamber 35, while the heavier once washed oil settles to the bottom and is carried by the pipe 15 to the second of the supply chambers 18. In this chamber 18 the once washed oil meets the charged alcohol from the third vessel 14; and from it the oil and alcohol are delivered by the second pump 19 to the second mixing vessel 13. Here the oil is washed again; and thereby yields a second portion of the smoky hydrocarbons to the alcohol. The two are delivered by the pipe 20 to the second settling and decanting vessel 14, where separation by gravity takes place, the charged alcohol passing by pipe 17 to the first supply chamber 18, as above mentioned, and the twice washed oil by pipe 15 to the third supply chamber 18. In this third supply chamber the twice washed oil meets the charged alcohol from the fourth vessel 14; and from it the said oil and alcohol pass to the third mixing vessel 13, where the oil is subjected a third time to the solvent action of the alcohol and deprived of a third portion of its smoky hydrocarbons, the separation of the thrice washed oil from the alcohol being effected in the third vessel 14. Thus the oil continues its flow from supply chamber 18 through pump 19 and mixing vessel 13 to settling and decanting vessel 14, meeting in the successive supply chambers alcohol less and less highly charged with smoky hydrocarbons until in the last supply chamber 18 it meets the fresh alcohol from pipe 34 and, after being washed with it, passes to the chamber 36. The methyl alcohol also dissolves more or less of the non-smoking hydrocarbons, especially when it is first applied to the oil; but these are largely exchanged for smoky hydrocarbons in the subsequent mixings and settlings. The methyl alcohol should be nearly anhydrous and of a density equal to or lighter than 44° B., and may have a boiling point between 146° F. and 150° F. By this systematic washing of the oil, introduced by pipe 33 (and consisting of the heavier portion of the burning oil fraction of Beaumont or analogous petroleum) with the methyl alcohol, introduced by the pipe 34, two products are obtained, each composed of an oil and methyl alcohol. The oils are of two kinds, namely, an oil sufficiently free from smoky hydrocarbons to be burned in the common flat flame petroleum (kerosene) lamps, and an oil containing a proportion of said smoky hydrocarbons materially greater than existed in the unwashed oil. The composition of these two oils will depend somewhat (1) upon the particular points at which the cuts were made in separating the oil subjected to the washing operation; (2) upon the quality of the methyl alcohol employed, and (3) upon the ratio of the amount of methyl alcohol employed to the amount of oil washed therewith. The longer the distillation is continued and the distillate collected in the second burning oil receiver, the heavier, of course, will be the oil in said receiver; and, as already explained, the point at which such collection is stopped can be varied at the will of the operator. Practically crude wood alcohol, or the 97 per cent. methyl alcohol of commerce, can be used effectively as the hydrocarbon separating menstruum when dehydrated by distilling and rectify-

ing in column *q r s* (Figs. 7, 9 and 11) hereinafter described.

What is considered the best ratio of oil to alcohol in washing is about six volumes of nearly anhydrous methyl alcohol introduced at 34 to one volume of oil introduced at 33. The general principle recommended to be followed is to use as little methyl alcohol as will yield a satisfactory non-smoking oil. If more methyl alcohol should be used, there would be an unnecessary amount of the non-smoking hydrocarbons carried into the smoky oil (of chamber 35); but, of course, the invention would still be employed, the only difference being in the comparative profit of the employment. If too little methyl alcohol should be used, the burning oil product (of chamber 36) can be further washed or subjected to any treatment which would yield non-smoking oil. For washing the oil composed of the 48 per cent. cut, after removal of a 7 per cent. cut of lighter burning oil, as above described (which 48 per cent. cut is believed to be as advantageous as any, if not the most advantageous), the ratio of six volumes of nearly anhydrous methyl alcohol to one volume of said oil is considered as useful as any, if not the most useful ratio for making the usual grade of burning oil (kerosene). Good results have been obtained by so distilling the Beaumont crude oil as to obtain 82 per cent. of cracked oil distillate, then in redistilling this cracked oil collecting separately (1) a first burning oil cut equal to 7 per cent. of the crude and (2) a second burning oil cut equal to 35 per cent. of the crude, and then washing this second cut with four times its volume of nearly anhydrous methyl alcohol; but the yield of non-smoking burning oil was less than in making a second burning oil cut equal to 48 per cent. of the crude and washing with six times the volume of methyl alcohol and the oil itself was but little, if any, better.

By the washing with methyl alcohol a useful separation of the smoky from the non-smoking hydrocarbons is effected; but both of the so obtained oils are mixed with methyl alcohol, which it is desirable to separate and recover as closely as possible for re-use, for one reason because without a large recovery, the cost of the methyl alcohol might (and at present prices would) be larger than the value of the products obtained; and the more methyl alcohol recovered, other things being equal, the more economical the working.

The methyl-alcohol-separating apparatus consists, first, of a series of two stills *c d* (Figs. 1, 7 and 11) with a rectifying column *f*, dephlegmator 746 and condenser *g* common to the two stills, for recovering the bulk of the methyl alcohol from the smoky oil (of chamber 35) with which the methyl alcohol has charged itself in the washing operation; second, of a series of two stills *e* and *k* with condenser *m* (common to both) for recovering the rest of the methyl alcohol from the smoky oil; third, of a series of two stills *h l* with condenser *j* (common to both) for recovering the methyl alcohol from the non-smoking oil (of chamber 36), and, fourth, of a series of two stills *n p* with column *q r s* and condenser *t* for redistilling the distillates from the condensers *m j* of stills *e h k l*. As shown, the condenser *m* serves for both the still *e* and the still *k;* as does the condenser *j* for the two stills *h l;* but other arrangements of condensing means could be adopted. It is considered simpler to use one condenser when no separation of distillate is desired. The distillate from all four stills consists of aqueous methyl alcohol with whatever hydrocarbons may have passed over therewith; but the hydrocarbons from stills *e k* would be of the smoky kind; and those from stills *h l* would be of the non-smoking kind. It is preferred to recover the two kinds of hydrocarbons separately, as hereinafter explained; and, in order to enable this to be accomplished, separate condensers *m* and *j*, respectively, are shown; but it is not considered desirable to condense the vapors from still *e* separately from those of still *k*, or the vapors from still *h* separately from those of still *l;* in view of the fact that only the same kinds of vapors pass over from the still *k* as from the still *e* and from the still *l* as from the still *h*.

The aqueous methyl alcohol condensed from the vapors of all four stills is further distilled in the lower part *q* of column *q r s* and in stills *n p*. The feathered arrows show the direction of the streams of vapor (methyl alcohol vapor, oil vapor or steam); the unfeathered arrows the directions of the streams of liquid (methyl alcohol, oil or water).

The stills *c d e* have each a tight steam belt or steam coil. As shown (see Figs. 7 and 11) there is a steam belt consisting of a drum 50 with tubes 51 open at both ends and extending through the heads of the drum, in which the tubes are secured so that the liquid in distillation can circulate through the tubes. The steam is admitted into the drum around the tubes by the pipe 52; and the water of condensation is withdrawn by the pipe 53. The steam inlet and water of condensation outlet are marked 52 and 53 for all the stills *c d e*. Exhaust steam is preferably used in the stills *c* and *d* and live steam in the still *e*. The stills *c d* are heated solely by dry heat; but the still *e* has also a steam pipe 501, which delivers free steam into the lower part of still *e*. The methyl alcohol and the oil, which it has dis-

solved, pass from chamber 35 by the pipe 54 to the still *c*, wherein a large part of the methyl alcohol is vaporized by the heat of the exhaust steam in the heating belt. The oil and unvaporized methyl alcohol pass by pipe 55 from still *c* to still *d*, where the methyl alcohol is further vaporized by exhaust steam in the heating belt of the still. The oil and the remaining methyl alcohol then pass by pipe 56 to the still *e*, where the rest of the methyl alcohol, except traces, is removed by live steam in the heating belt aided by the free steam from the pipe 501, which free steam prevents any water from settling at the bottom of still *e*. The smoky oil, still holding traces of methyl alcohol, passes by the pipe 57 to the still *k*. This still consists of a long tube *k* inclosed for the greater part of its length by a jacketing tube 58, which is closed at the ends and provided with a steam inlet 59 at one end on top and an exhaust 60 at the opposite end underneath. The tube *k* is provided at its oil outlet end with a steam inlet pipe 61 and at its oil inlet end with a vapor escape pipe 62. The pipe 61 conducts free steam (it may be exhaust steam or live steam, saturated or more or less superheated steam, but most advantageously dry live steam at, say, about sixty to eighty pounds pressure, more or less) into the tube *k* which is partly filled with oil; and this steam escapes through the vapor pipe 62 with the vapors of methyl alcohol which it has aided in liberating from the smoky oil in said tube *k*. The oil passes to and through a cooler, consisting, as shown, of a pipe 63 (Fig. 3) immersed in water in the box 64, and thence to a storage tank, not shown. It can then be used for any desired purpose, as fuel, for example; or as material for making or enriching illuminating gas, or otherwise. It can also be run again through the washing apparatus and a non-smoking or a less smoky oil obtained therefrom.

The still *h* is heated mainly by dry heat, preferably by a close steam belt 50—51, Fig. 7, supplied with live steam by pipe 52, the water of condensation escaping by pipe 53. It also has a small steam pipe 502 by which free steam is introduced near the bottom to prevent water settling. The non-smoking oil passes from the chamber 36 by the pipe 65 into the still *h;* and having in this latter been deprived of its methyl alcohol (except traces) by the vaporization which is caused by the heat of the live steam in the heating belt and by the free steam from pipe 502, the said oil passes by the pipe 66 to the still *l* for recovering the remaining traces of the methyl alcohol therefrom. This still as shown is a duplicate of the still *k* and consists of a long tube *l* with steam inlet pipe 67 and vapor outlet pipe 68 and a jacketing tube 69 with steam inlet 70 and condensed water outlet 71. The non-smoking oil partly fills the tube *l* and the steam from the inlet 67 passes over it to escape with the methyl alcohol vapors by the pipe 68. The oil passes through a cooling pipe 72 (Figs. 2 and 3) to a storage tank. The non-smoking oil is then mixed with the lighter burning oil hydrocarbons before referred to, and the mixture is treated with sulfuric acid (followed by washing with water and then with solution of alkali) after the manner well understood by those skilled in the manufacture of burning oil from petroleum (or the oils are treated separately and then mixed), a refined burning oil (kerosene) being thus obtained which can be burned in lamps, including the common flat flame petroleum (kerosene) lamps. If such burning oil should not be of the desired fire test, it can be brought to test by steaming the same, as well understood by those skilled in the art. The smoky oil is used for fuel, or is used for making or enriching illuminating gas or is used as may be desired.

The vapors of methyl alcohol from the still *d* pass into the rectifying column *f* by the vapor pipe 73; and those from the still *c* ascend into said column. This column has a perforated partition 74, it may be of any desired form, and is provided with a filling 740 (Figs. 8 and 11) of (most advantageously) broken granite of from an inch to three inches diameter. As shown in Figs. 8 and 11, there is a disk 74 of wire cloth resting upon a perforated plate 743 which in turn rests upon I beams 744 supported at the ends by the ring 745 fastened to the walls of the column. As the vapors of methyl alcohol rise through the column *f*, they meet a descending volume of liquid which is constantly losing by evaporation and replenishing by condensation, so that oil which may have been carried with the methyl alcohol vapors finds its way back to the still *c*, while the methyl alcohol vapors pass to the dephlegmator 746, wherein they are further separated from oil vapors before they pass by pipe 742 to the condenser *g*. The dephlegmator 746 consists of a number of upright vapor tubes 747, set between heads 748 and surrounded by water introduced by the pipe 749 and escaping by the pipe 750. The water supply to the dephlegmator may be regulated so as to have a temperature of about 120° F. more or less at the outlet 750.

In the condenser *g* the methyl alcohol vapors are condensed; and the condensed methyl alcohol passes by the pipe 75 to the methyl alcohol storage tanks 76 or (proper cocks being closed) by the pipe 75, by-pass 77 and pipe 34 to the last supply chamber 18 hereinbefore referred to. From the storage tanks 76 it can be delivered by the pump 78 through pipe 34 to said supply chamber.

The same pump 78 will serve for exhausting the contents of vessels 13 and 14 through pipe 780 (Fig. 7) and for delivering the same through pipe 79 (Figs. 2 and 3) into the still *c* (the valve in pipe 34 being closed and that in pipe 79 being opened for this purpose). Between the condenser *g* and the pipe 75 is a box 80 with glass sides and movable slide so that the flow of the liquid can be observed and a test sample taken, if desired.

The methyl alcohol vapors and steam from the still *e* pass by the pipe 730 to the condenser *m* by which they are reduced to the liquid state. The methyl alcohol vapors and steam from still *k* pass by pipe 62 into pipe 730 and then to condenser *m*. From the condenser *m* the dilute methyl alcohol passes through box 84 and pipe 85 to the distilling and rectifying column *q r s*.

The mixture of steam and methyl alcohol vapors from the still *h* is delivered by the pipe 81 into the condenser *j* which receives also the steam and methyl alcohol vapors delivered from the still *l* into pipe 81 by the pipe 68. From condenser *j* the liquid of condensation flows into box 82 and thence by pipe 83 into the column *q r s*.

Between each of the boxes 82 and 84 and the column *q r s* it is desirable to employ a continuous settling and decanting apparatus in order to remove from the dilute methyl alcohol any oil which may accompany the same. Such an apparatus is shown separately in Fig. 10 (Sheet 1). The liquid from the box fills the inverted siphon 901; any oil in suspension rises and overflows by the pipe 902 or 906, while the dilute methyl alcohol flows over the top of the adjustable pipe section 903 and is introduced by the pipe 83 or 85 into the column *q r s*.

The oil may be conducted by pipe 902 or 906 to the inlet end of one of the stills *k l*. The oil from condenser *m* would be led to the still *k* and that from condenser *j* to the still *l*.

In Fig. 11 a continuous settling and decanting apparatus is shown in combination with each of the boxes 82 and 84. The oily part of the liquid from box 82 is carried away by the pipe 902 (to be further distilled in still *l* for recovery of any methyl alcohol present therein); while the aqueous methyl alcohol passes by the pipe 83 into the column *q r s*. The oily part of the liquid from box 84 is carried away by the pipe 906 (to be further distilled in still *k*), while the aqueous methyl alcohol is discharged by the pipe 85 into the column *q r s*. Each settling and decanting apparatus has a draw-off 905 through which it and the corresponding box and condenser can be emptied.

The column *q r s* (Figs. 7 and 11) has at its bottom a perforated partition shown (see Fig. 9) as a disk of wire cloth 850 resting on a grating 852, upheld by the annular ledges 854, and is provided with a filling of gravel 853 which will pass through a sieve of wire cloth with three meshes to two linear inches and not through one with two meshes to the linear inch. It surmounts the still *n* which is a plain box provided with a close steam coil 86. Its lower section *q* serves as a distilling column as well as a rectifier. The section *r* serves for rectification in connection with the section *q*. It has a perforated partition at its base and is provided with a filling of gravel which is best a little finer than in the column *q*, say, gravel which will pass through a sieve of two meshes to the linear inch and not through one of three meshes to the linear inch. The dephlegmator *s* could be formed by a water jacket surrounding a section of column filled with the gravel; or it might be of any ordinary or suitable form; but as shown it consists of a water box 87 inclosing a number of vertical pipes 88, open at both ends and secured at the bottom in the sheet which closes the top of column *r* and at the top in the manifold 89 from which the vapor pipe 90 leads to condenser *t*, (Fig. 1).

The box 87 has a water inlet 91 and overflow 92 which may be so regulated that the water in the box has a temperature of about 120° F., more or less, at the overflow.

The still *p* consists of a long tube inclosed in a larger jacketing tube 93, which has a steam inlet 94 on top at one end and a water of condensation outlet 95 underneath at the other end. The still or tube *p* is connected by liquid pipe 96 with the bottom of the still *n* and by the vapor pipe 97 with the top of said still *n* or base of column *q r s*. The liquid outlet 98 of the still *p* is shown as leading to a barrel 99, which may have a sewer connection. This liquid will be mainly water; it may contain a little oil; and this can be recovered by settling and decantation, if desired; but under proper working it ought not to be sufficient in quantity to be worth the trouble of recovering.

The liquids from condensers *m* and *j* pass through boxes 82 and 84 and pipes 83 and 85 to the upper part of column section *q*, which they descend, flowing over the gravel 853 (Fig. 9) therein and meeting repeatedly the vapors of methyl alcohol and of water as they rise through the column. The result of their repeated meetings is that the methyl alcohol is gradually evaporated and the water vapor condensed, so that a liquid much poorer in methyl alcohol enters the still *n*. Here a further quantity may be evaporated by the heat of coil 86 (or the heat of coil 86 may be dispensed with when not necessary); and the poor liquid then flows by pipe 96 to the still *p* where the last traces of alcohol are removed, leaving the residue to be conducted off by the pipe 98.

The vapors from the still *p* pass by the pipe 97 to the still *n* and ascend the column section *q* along with whatever vapors may be generated in the still *n*. As they rise they meet the descending liquid from condensers *m* and *j* and also from the condensations which occur in the column section *q*, column section *r* and dephlegmator *s*.

The vapors of methyl alcohol and of water which leave the top of column *q* rise through the column *r* wherein they are subjected to rectification (that is to say, to repeated partial condensations with intermediate re-evaporations) by contact of the constantly descending liquid with the rising vapors, so that the methyl alcohol has been almost deprived of water when it enters the dephlegmator *s*. Here the vapors are subjected to the cooling influence of the water in the box 87 and water vapor is almost completely removed from the methyl alcohol vapors, which pass by the pipe 90 to the condenser *t*, where they are reduced to the liquid state. The so obtained liquid methyl alcohol is delivered to the box 100, from which the pipe 101 carries it into the pipe 75 and so restores it to the general circulation of the apparatus.

In order to obtain nearly anhydrous methyl alcohol in the first instance, the crude wood alcohol, or the commercial methyl alcohol of 97 per cent., can be vaporized by dry heat (steam in close coils or other) in a still and the vapors passed through column sections *q r* and the dephlegmator *s* to a condenser. The operation can best be performed intermittently, the still being filled and heated to drive off the vapors and then emptied of the residual liquid, preparatory to filling anew.

By (1) distilling crude Beaumont oil, with cracking so as to obtain a first distillate amounting to 82 per cent. of the crude oil; (2) redistilling with rectification the so obtained oil until the distillate in the first burning oil receiver (or first cut burning oil distillate) amounts to 7 per cent. of the crude oil; (3) continuing the distillation of the cracked oil, and collecting the distillate (second cut burning oil distillate) in the second burning oil receiver until it amounts to 48 per cent. of the crude oil; (4) passing the so obtained second cut burning oil distillate in one direction through the series of mixing vessels 13 and settling and decanting vessels 14 and six volumes of nearly anhydrous methyl alcohol in the opposite direction through the said series simultaneously; (5) taking the methyl alcohol from chamber 35, together with the hydrocarbons which it shall have taken to itself in passing through said series of vessels 13 and 14, and distilling the said methyl alcohol from the oil in stills *c d*, with rectification of the vapors in the column *f*; (6) running the residual oil from still *d* through the stills *e* and *k* so as to drive off the last traces of methyl alcohol by free steam; (7) taking the oil from chamber 36, together with the methyl alcohol which has been carried with the oil in its passage through the series of vessels 13 and 14, instead of traveling with the bulk of the methyl alcohol to chamber 35, and distilling the methyl alcohol from said oil in stills *h* and *l*; (8) redistilling in column section *q* and stills *n p* the liquids from condensing the vapors from stills *e h k* and *l* and consisting mainly of dilute methyl alcohol, with a little oil, and rectifying the vapors in the column sections *q* and *r* with final expulsion of water in the dephlegmator *s*, the following four final products are obtained, namely: First. As the result of operations (1) and (2) an oil equal to about 7 per cent., more or less, of the crude oil sufficiently free from smoky hydrocarbons for admixture with the heavier less volatile non-smoking oil, mentioned below, for burning oil (kerosene). Second. As a result of operation (6) and preceding operations, a highly carbonaceous oil amounting to about $23\frac{1}{3}$ per cent., more or less, of the crude oil having a viscosity not more than about 25 per cent. greater than that of water and a ratio of carbon and hydrogen in its composition of about seven parts by weight of the former to one part of the latter, distilling within the temperature limits of burning oil (kerosene), yielding on the test distillation hereinbefore explained test portions which are denser by not less than ten nor more than twenty degress Baumé than the portions from Pennsylvania burning oil in the same temperature intervals, and exhibiting the characteristics of an oil obtained by solution in a differentially solvent menstruum such as methyl alcohol or ethyl alcohol. Third. As the result of operations (1) to (4), both inclusive, in connection with operation (7), a non-smoking oil amounting to about $24\frac{2}{3}$ per cent., more or less, of the crude oil, having a sufficient mobility to be utilized for burning oil (kerosene), distilling within the temperature limits of burning oil (kerosene), yielding on the test distillation hereinbefore explained test portions having densities respectively greater than those of the portions from Pennsylvania burning oil for the same temperature intervals, and exhibiting the characteristics of an oil which has been subjected to a differentially solvent menstruum such as methyl alcohol or ethyl alcohol. Fourth. As a result of operations (5) to (8), both inclusive, nearly anhydrous methyl alcohol recovered for re-use from the hydrocarbons which are in solution therein as the result of operation (4).

By mixing the non-smoking oil from operations (1) and (2) with the less volatile

non-smoking oil from (7) as above, a fifth product is obtained, namely, a non-smoking oil equal to about 31⅔ per cent., more or less, of the crude oil, having a mobility sufficient to be utilized for burning oil (kerosene), distilling within the temperature limits of burning oil (kerosene) yielding on the test distillation hereinbefore explained test samples having densities respectively greater than those of the portions from Pennsylvania burning oil in the same temperature intervals, and being further characterized by the portions distilling over below 400° F. containing on the average if not in every instance a larger percentage of hydrocarbons which are attacked readily by fuming sulfuric acid, than those distilling over therefrom between 400° F and 550° F. The so-obtained oil also exhibits (in its portions distilling over between 400° F. and 550° F. for example) the characteristics of an oil which has been subjected to a differentially solvent menstruum, such as methyl alcohol or ethyl alcohol.

The same products will be obtained by (1) distilling the crude oil with cracking, (2) redistilling this first distillate without rectification to obtain burning oil distillate containing both the more volatile and the less volatile portions, (3) distilling off the more volatile portions with rectification thereof, leaving the less volatile portions of the said burning oil distillate as a residue to be subjected to the differentially solvent menstruum, and (4 *et seq.*) proceeding afterward as above stated.

Other modes of proceeding within the invention can also be resorted to.

To finish the non-smoking oil for sale or use, it is treated with sulfuric acid and washed with water and then with solution of alkali, or, in other words, it is subjected to the well known sulfuric acid treatment. The so-refined oil will have the properties just recited as belonging to the non-smoking oil before it was subjected to treatment. The highly carbonaceous oil could be subjected also to the sulfuric acid treatment; but it will serve as a fuel or gas oil as well without.

To prevent loss of methyl alcohol by escape of the vapors thereof from the different portions of the apparatus, ventilating pipes leading to a coke tower can be provided as indicated on Fig. 11 for the supply chambers 18 at the left of the figure. In such tower the methyl alcohol would be absorbed in water, in order to be recovered therefrom by distillation.

I claim as my invention or discovery:

1. An apparatus composed of a series of stationary mixing vessels with stirrers therein, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, substantially as described.

2. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, the last mentioned pipe connections including supply chambers into each of which open pipes leading, respectively, from the top of one and the bottom of another settling and decanting vessel, substantially as described.

3. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, the last mentioned pipe connections including supply chambers into each of which open pipes leading, respectively, from the top of one and the bottom of another settling and decanting vessel, and adjustable discharge ends on one set of the last mentioned pipes, substantially as described.

4. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, and including supply chambers into each of which open pipes leading, respectively, from the top of one and the bottom of another settling and decanting vessel, and pumps for forcing the liquids through said vessels and pipe connections, substantially as described.

5. The combination with a mixing vessel, a settling and decanting vessel, and a pipe connection between them, of a pump having its stuffing box at the end of a sleeve of such height that the column of liquid therein balances the pressure tending to raise the liquid level, substantially as described.

6. The combination with a settling and decanting vessel, and a pump, of a mixing vessel having a sleeve of such height that the column of liquid therein balances the pressure tending to raise the liquid level and a stirrer whose shaft passes through the stuffing box at the top of said sleeve, and pipe connections between said vessels and pump, substantially as described.

7. The combination with a pump, of a

mixing vessel having a sleeve of such height that the column of liquid therein balances the pressure tending to raise the liquid level and a stirrer whose shaft passes through the stuffing box at the top of said sleeve, and a pipe connection between the pump and mixing vessel, substantially as described.

8. The combination with an elevated supply chamber, of a mixing vessel having a sleeve extending above the said chamber and provided at the top with a stuffing box for the stirrer shaft of said vessel, and a pipe connection between the said chamber and the said vessel, substantially as described.

9. In apparatus having a moving part in a chamber which is connected with means whereby its liquid contents is put under pressure, and in combination with such moving part, and chamber, a sleeve of such height that the liquid column therein balances the pressure in said chamber, and a stuffing box at the top of said sleeve for the passage of the device to operate said moving part, substantially as described.

10. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with a still, a condenser, and pipe connections between, respectively, the still and condenser, the still and one of the outlets of said apparatus, and the condenser and one of the inlets of said apparatus, substantially as described.

11. The combination of a mixing vessel, a settling and decanting vessel, a pipe connection between the former vessel and the middle portion of the latter, two stills, condensing means, and pipe connections between, respectively, the two stills and the condensing means, one still and one end of said settling and decanting vessel, the other still and the other end of said settling and decanting vessel, and the condensing means and the mixing vessel, this last connection serving to deliver the distillate from both stills to said mixing vessel, substantially as described.

12. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with two stills, condensing means, and pipe connections between, respectively, the two stills and the condensing means, one still and one of the outlets of said apparatus, the other still and the other outlet of said apparatus, and the condensing means and one of the inlets of said apparatus, this last connection serving to deliver the distillate from both stills to said inlet, substantially as described.

13. The combination with a settling and decanting vessel, of a still run wholly by dry heat, a still run by free steam, and pipe connections between, respectively, one end of said vessel and the liquid inlet of the first mentioned still, and the liquid outlet of the first mentioned still and the liquid inlet of the other, substantially as described.

14. The combination with a settling and decanting vessel, of a still run wholly by dry heat, a still run by free steam, a rectifier, and pipe connections between, respectively, one end of said vessel and the first mentioned still, the liquid outlet of the latter and the liquid inlet of the free steam still, and the vapor outlet of the last mentioned still and the rectifier, substantially as described.

15. The combination with a mixing vessel, a settling and decanting vessel, and a pipe connection between the former vessel and the middle portion of the latter, of a still run wholly by dry heat, a still run by free steam, a rectifying column, condensing means, and pipe connections between, respectively, one end of said settling and decanting vessel and the first mentioned still, the latter and the free steam still, the last mentioned still and the rectifier, the first mentioned still and the condensing means, the rectifier and the condensing means, and the condensing means and the mixing vessel, this last connection serving to deliver the distillate from both stills to said mixing vessel, substantially as described.

16. The combination with a settling and decanting vessel, of two stills whereof one at least is run wholly by dry heat, two stills run by free steam, and pipe connections between, respectively, one end of said vessel and one of said first mentioned stills, the other end of said vessel and the other of said first mentioned stills, one of the first mentioned stills and a free steam still, and the other of the first mentioned stills and the other free steam still, substantially as described.

17. The combination with a settling and decanting vessel, of two stills whereof one at least is run wholly by dry heat, two stills run by free steam, rectifying means, and pipe connections between, respectively, one end of said vessel and one of said first mentioned stills, the other end of said vessel and the other of said first mentioned stills, one of the first mentioned stills and a free steam still, the other of the first mentioned stills and the other free steam still, and between the free steam stills and the rectifying means, substantially as described.

18. The combination with a mixing ves-

sel, a settling and decanting vessel, and a pipe connection between the former vessel and the middle portion of the latter, of two stills whereof one at least is run wholly by dry heat, two stills run by free steam, rectifying means, condensing means, and pipe connections between, respectively, one end of said settling and decanting vessel and one of said first mentioned stills, the other end of said settling and decanting vessel and the other of said first mentioned stills, one of the first mentioned stills and a free steam still, the other first mentioned still and the other free steam still, the free steam stills and the rectifying means, a dry steam still and the condensing means, the rectifying means and the condensing means, and the latter and the mixing vessel, substantially as described.

19. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with a still run wholly by dry heat, a still run by free steam, and pipe connections between, respectively, one of the outlets of said apparatus and the dry heat still, and the liquid outlet of the latter and the liquid inlet of the free steam still, substantially as described.

20. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with a still run wholly by dry heat, a still run by free steam, rectifying means, condensing means, and pipe connections between, respectively, one of the outlets of said apparatus and the dry heat still, the liquid outlet of the dry heat still and the liquid inlet of the free steam still, the free steam still and the rectifying means, the dry heat still and the condensing means, and the rectifying and the condensing means, the connection of the dry steam still with the condensing means being independent of the rectifying means connected with the free steam still, substantially as described.

21. The combination of a still run wholly by dry heat, a still run by free steam, rectifying means, condensing means, and pipe connections between, respectively, the liquid outlet of the dry heat still and the liquid inlet of the free steam still, the free steam still and the rectifying means, the dry heat still and the condensing means, and the rectifying and the condensing means, the connection of the dry steam still with the condensing means being independent of the rectifying means connected with the free steam still, substantially as described.

22. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with a still run wholly by dry heat, a still run by free steam, rectifying means, condensing means, and pipe connections between, respectively, one of the outlets of said apparatus and the dry heat still, the liquid outlet of the dry heat still and the liquid inlet of the free steam still, the free steam still and the rectifying means, the dry heat still and the condensing means, and the rectifying and the condensing means, the connection of the dry steam still with the condensing means being independent of the rectifying means connected with the free steam still, substantially as described.

23. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with two stills whereof one at least is run wholly by dry heat, two stills run by free steam, and pipe connections between, respectively, one outlet of said apparatus and one of said first mentioned stills, the other outlet of said apparatus and the other first mentioned still, the liquid outlet of one of the first mentioned stills and the liquid inlet of a free steam still, and the liquid outlet of the other first mentioned still and the liquid inlet of the other free steam still, substantially as described.

24. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with two stills whereof one at least is run wholly by dry heat, two stills run by free steam, a condenser, and pipe connections between, respectively, one outlet of said apparatus and one of said first mentioned stills, the other outlet of said apparatus and the other first mentioned still, the liquid outlet of one of said first mentioned stills and the liquid in-

let of a free steam still, the liquid outlet of the other first mentioned still and the liquid inlet of the other free steam still, the vapor outlet of a dry heat still and the condenser, and the condenser and one of the inlets of said apparatus, substantially as described.

25. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with two stills whereof one is run wholly by dry heat, two stills run by free steam, rectifying means, condensing means, and pipe connections between, respectively, one outlet of said apparatus and one of said first mentioned stills, the other outlet of said apparatus and the other first mentioned still, the liquid outlet of one of the first mentioned stills and the liquid inlet of a free steam still, the liquid outlet of the other first mention still and the liquid inlet of the other free steam still, the vapor outlet of one of the first mentioned stills and the condensing means, the vapor outlet of the other first mentioned still and the rectifying means, the vapor outlets of the two steam stills and the rectifying means, the rectifying means and the condensing means, and the condensing means and an inlet of said apparatus, substantially as described.

26. The combination with a settling and decanting vessel, of a still run wholly by dry heat, a still run by free steam, a rectifying column containing solid material in small pieces, and pipe connections between, respectively, one end of said vessel and the dry heat still, the liquid outlet of said dry heat still and the liquid inlet of the free steam still, and the vapor outlet of the free steam still and the rectifying column, substantially as described.

27. The combination with a settling and decanting vessel, of a still run wholly by dry heat, a still run by free steam, a rectifying column containing solid material in fine pieces and provided with a water jacketed dephlegmator, and pipe connections between, respectively, one end of said vessel and the dry heat still, the liquid outlet of said dry heat still and the liquid inlet of the free steam still, and the vapor outlet of the free steam still and the rectifying column, substantially as described.

28. The combination with a settling and decanting vessel, of a still run wholly by dry heat, a still run by free steam, a rectifying column containing solid material in fine pieces, a condenser, and pipe connections between, respectively, one end of said vessel and the dry heat still, the liquid outlet of said dry heat still and the liquid inlet of the free steam still, and the vapor outlet of the free steam still and the rectifying column by way of said condenser, the condenser outlet communicating with said column at its midheight, substantially as described.

29. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, in combination with a still run wholly by dry heat, a still run by free steam, a rectifying column, a condenser, additional condensing means, and pipe connections between, respectively, one of the outlets of said apparatus and said dry heat still, the vapor outlet of the dry heat still and the additional condensing means, the liquid outlet of the dry heat still and the liquid inlet of the free steam still, the vapor outlet of the free steam still and the condenser, the condenser and the midheight of said column, the vapor outlet of said column and the additional condensing means, and the said additional condensing means and an inlet of said apparatus, substantially as described.

30. The combination with a mixing vessel, of a settling and decanting vessel, a pipe connection between the former vessel and the middle of the latter, a valved pipe connection leading from each end of said decanting and settling vessel, and a submerged float in the last mentioned vessel connected with both the top valve and the bottom valve and operating to close one outlet when it opens the other in rising or falling, substantially as described.

31. A settling and decanting vessel having an inlet at the middle and a valved outlet at each end of said vessel and also having therein a submerged float connected with both the top valve and the bottom valve and operating to close one outlet when it opens the other in rising or falling, substantially as described.

32. A settling and decanting vessel, provided with a submerged float valve therein, for controlling the outflow therefrom, in combination with two supply chambers, and pipe connections between, respectively, one end of said vessel and one supply chamber, and the other end of said vessel and the other supply chamber, one of said pipe connections having an adjustable discharge end, substantially as described.

33. The combination of a mixing vessel, a settling and decanting vessel, a pipe connection between the former vessel and the middle portion of the latter, two supply chambers, and pipe connections between, respec-

tively, one end of said vessel and one supply chamber and the other end of said vessel and the other supply chamber, substantially as described.

34. The combination of a mixing vessel, a settling and decanting vessel, a pipe connection between the former vessel and the middle portion of the latter, two supply chambers, and pipe connections between, respectively, one end of said vessel and one supply chamber and the other end of said vessel and the other supply chamber, one of said pipe connections having an adjustable discharge end, substantially as described.

35. The combination of a mixing vessel, a settling and decanting vessel, a pipe connection between the former vessel and the middle portion of the latter, a submerged float valve in said settling and decanting vessel for controlling the outflow therefrom, two supply chambers, and pipe connections between, respectively, one end of said vessel and one supply chamber and the other end of said vessel and the other supply chamber, substantially as described.

36. The combination of a mixing vessel, a settling and decanting vessel, a pipe connection between the former vessel and the middle portion of the latter, a submerged float valve in said settling and decanting vessel for controlling the outflow therefrom, two supply chambers, and pipe connections between, respectively, one end of said vessel and one supply chamber, and the other end of said vessel and the other supply chamber, one of said pipe connections having an adjustable discharge end, substantially as described.

37. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, submerged float valves in said settling and decanting vessels for controlling the outflow therefrom, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, the last mentioned pipe connections including supply chambers into each of which open pipes leading, respectively, from the top of one and the bottom of another settling and decanting vessel, substantially as described.

38. An apparatus composed of a series of mixing vessels, a series of settling and decanting vessels, pipe connections between the mixing vessels and the middle portions of corresponding settling and decanting vessels, submerged float valves in said settling and decanting vessels for controlling the outflow therefrom, and pipe connections leading from the ends of the several settling and decanting vessels to preceding and to following mixing vessels, respectively, the last mentioned pipe connections including supply chambers into each of which open pipes leading, respectively, from the top of one and the bottom of another settling and decanting vessel, and adjustable discharge ends on one set of the last mentioned pipes, substantially as described.

39. An apparatus composed of a series of supply chambers, a series of mixing vessels having sleeves with stuffing boxes thereon above the said chambers around the devices for operating the stirrers in said vessels, a series of settling and decanting vessels, means for controlling the outflow therefrom, a series of pumps having sleeves with stuffing boxes thereon above said supply chambers around the devices for operating the pumps, and pipe connections between said chambers, vessels and pumps provided with adjustable discharge ends in said chambers and so arranged that liquids from each supply chamber are mixed in a mixing vessel, are delivered into the middle portion of a settling and decanting vessel, and pass from said vessel by the top and bottom thereof, respectively, to other supply chambers, substantially as described.

40. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, substantially as described.

41. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, in combination with pumps in said pipe connections, substantially as described.

42. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, in combination with pumps and additional mixing vessels in said pipe connections, substantially as described.

43. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, said pipe connec-

tions being provided with means to vary the relative outflow from the ends of the several vessels, substantially as described.

44. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, said pipe connections being provided with adjustable discharge ends and valves to regulate the outflow from said vessels, substantially as described.

45. An apparatus composed of a series of supply chambers, a series of settling and decanting vessels, and pipe connections between said chambers and the said vessels so arranged that liquids from opposite ends of two of said vessels meet in one of said chambers and are delivered to the middle portion of a third of said vessels, in combination with a still, a pipe connection between one of said vessels and said still, a rectifying column of divided solid material receiving the vapors from said still, and a dephlegmator composed of upright tubes distributed over the top area of said column, so that the liquid of condensation falls at various points onto said solid material, substantially as described.

46. An apparatus composed of a series of supply chambers, a series of mixing vessels having sleeves with stuffing boxes thereon above the level of said chambers around the devices for operating the stirrers in said vessels, a series of settling and decanting vessels, means for controlling the outflow from said vessels, a series of pumps having sleeves with stuffing boxes thereon above the level of said supply chambers around the devices for operating the pumps, and pipe connections between said chambers, vessels and pumps provided with adjustable discharge ends in said chambers and so arranged that liquids from each supply chamber are mixed in a mixing vessel, and delivered into the middle portion of a settling and decanting vessel, and pass from said vessel by the top and bottom thereof, respectively, to other supply chambers, in combination with two stills whereof one at least is run wholly by dry heat, two stills run by free steam, a rectifying column containing solid material in fine pieces and provided at the top with a water jacketed dephlegmator, condensing means, and pipe connections between, respectively, one outlet of said apparatus and one of said first mentioned stills, the other outlet of said apparatus and the other of said first mentioned stills, the liquid outlet of one of said first mentioned stills and the liquid inlet of a free steam still, the liquid outlet of the other first mentioned still and the liquid inlet of the other free steam still, part of the said condensing means and an inlet of said apparatus, the vapor outlet of one of said first mentioned stills and so connected condensing means, the vapor outlet of said dephlegmator and so connected condensing means, another part of said condensing means and a liquid inlet at the mid-height of said rectifying column, the vapor outlet of the other first mentioned still and condensing means having the last mentioned connection, and the vapor outlets of the two free steam stills and similarly connected condensing means, substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

HERMAN FRASCH.

Witnesses:
F. W. LOTHMAN,
J. C. UPDEGROVE.