3 Sheets—Sheet 1.

J. W. CULMER.

Apparatus for Separating Hydrocarbon Oils.

No. 217,995. Patented July 29, 1879.

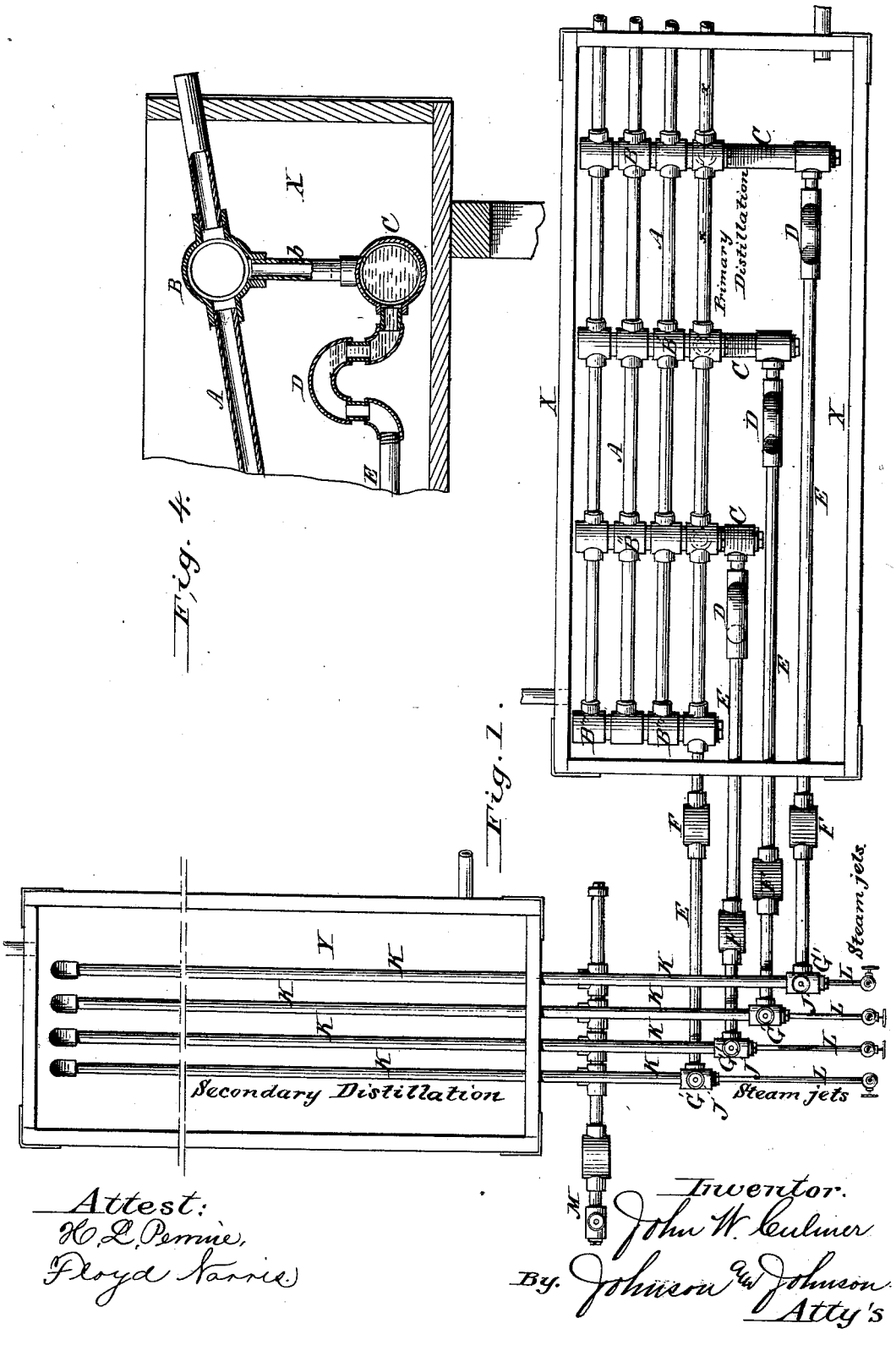

Fig. 4.

Fig. 1.

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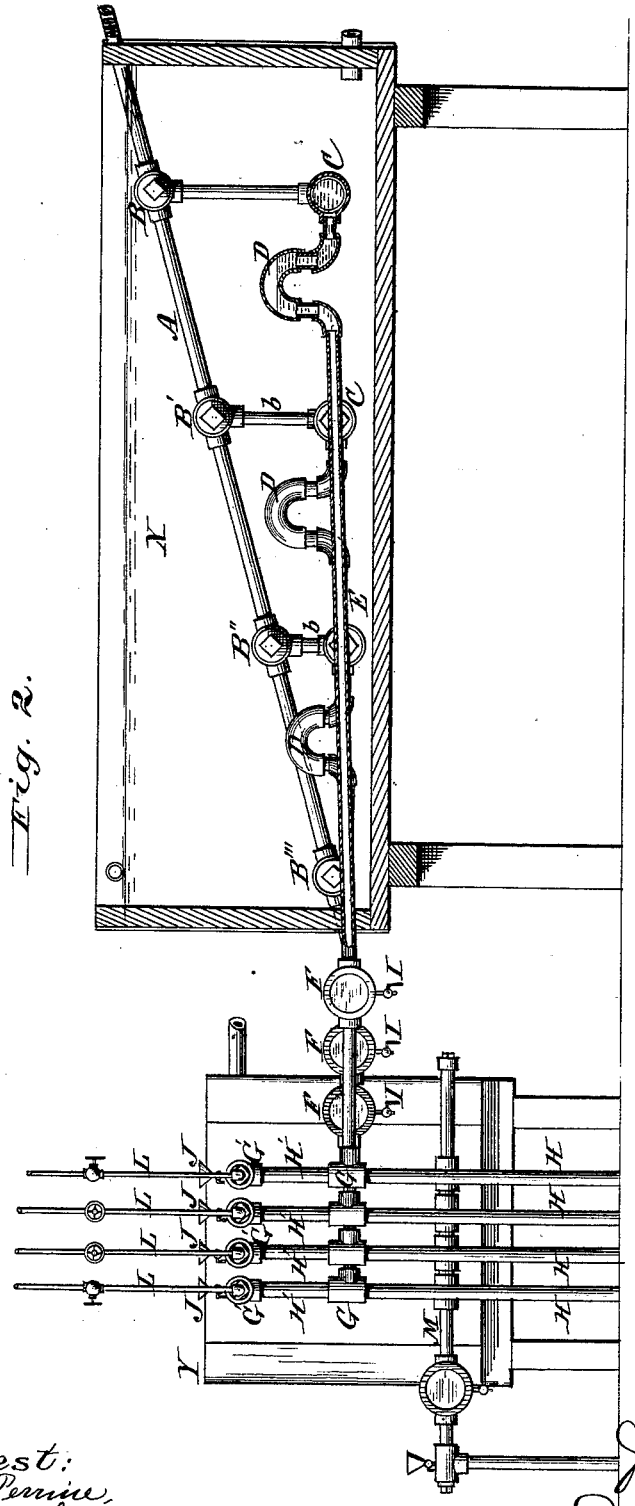

Fig. 2.

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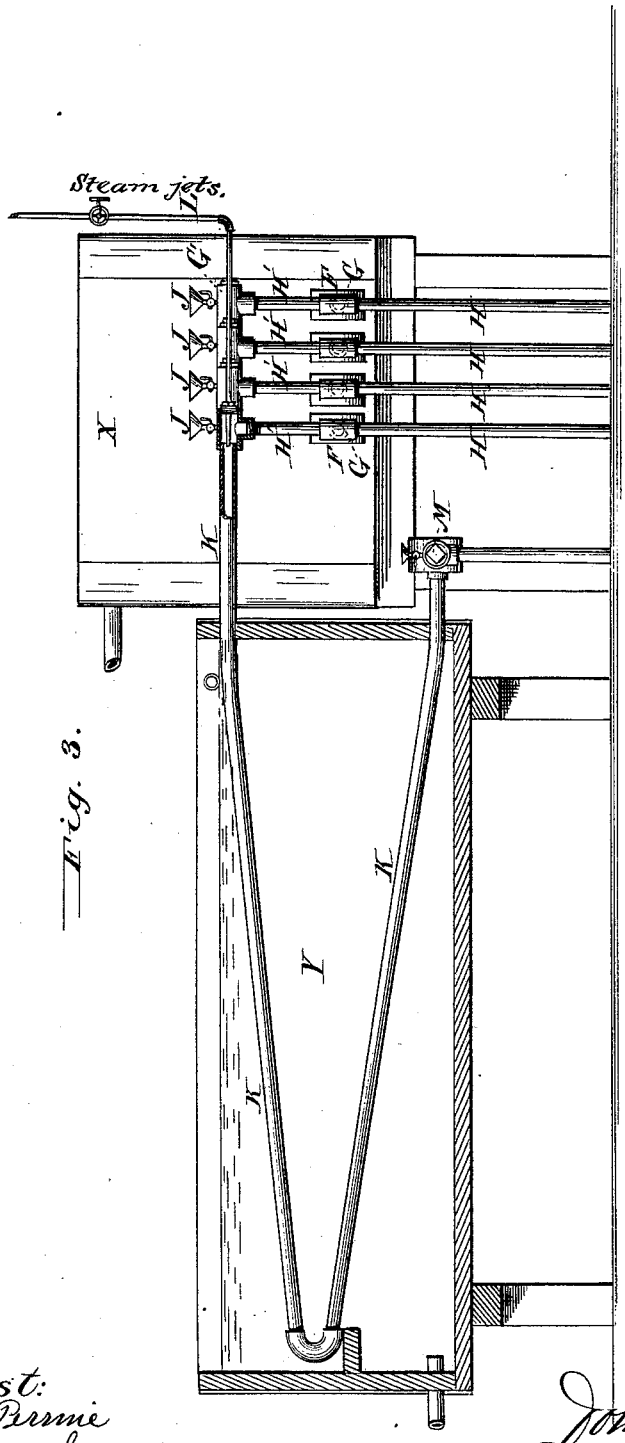

Fig. 3.

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UNITED STATES PATENT OFFICE.

JOHN W. CULMER, OF PITTSBURG, ASSIGNOR OF ONE-HALF HIS RIGHT TO WILLIAM J. BRUNDRED, OF OIL CITY, PENNSYLVANIA.

IMPROVEMENT IN APPARATUS FOR SEPARATING HYDROCARBON OILS.

Specification forming part of Letters Patent No. **217,995**, dated July 29, 1879; application filed June 5, 1879.

To all whom it may concern:

Be it known that I, JOHN W. CULMER, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Apparatus for Separating Hydrocarbons, which I denominate a "Separator-Condenser," of which the following is a full, clear, and exact description.

In the distillation of petroleum, as at present conducted, the petroleum is first vaporized by direct application of heat to the still in which it is confined, and the hydrocarbons pass out as vapor for condensation in a worm inclosed within a water-tank. These worms are either single or multiple in their form of construction, and the hydrocarbons are received at the end of the worm in the liquid forms resulting from their condensation. The lightest of these hydrocarbons are never condensed, in commercial practice, but pass off at the gas traps or pipes; and uncondensed hydrocarbons and fixed gases are passing off through these pipes during the entire time of distillation.

The first of the condensation, and, practically, the first liquid series of hydrocarbons, are the lighter of the benzine series, and are turned into their proper tank or receptacle for subsequent treatment as gasoline. This forms the first separation, its limit being determined by the gravity of the liquid at the tail pipes or terminal of the worm. When the hydrometer indicates a gravity for this liquid determined by the still-man, the products of condensation are turned into another tank as heavy benzine, this portion of the hydrocarbons being limited within certain degrees of gravity in a similar arbitrary fashion, and forming the second separation.

When the gravity is reached at which it is wished to turn into illuminating-oil, the products are shifted into still another channel, being the third separation, and at this stage it is customary to turn steam into the worm, the steam-connection being made either into the uptake or goose-neck at the still or at some point in the worm.

The distillate is kept running until it becomes low in gravity and dark in color, when the fires are lowered, the result being a distillate of lighter gravity and color, but carrying with it a large percentage of fixed gas, and, consequently, of a low fire-test. When this becomes too dark or too fiery for admission to the illuminating-oil it is turned off either to a tank for its special reception or to combine with the benzine of the second separation, this turning in being practically a fourth separation, and this embraces all the final run of the still.

There may be other separations made during the running of the illuminating-distillate, portions of it being cut out for "water-white" oil or for oils of high fire-test; but in no case can there be fewer than the four separations described.

To obtain the best economic results under this system, the object being merchantable illuminating-oil, the distillate mentioned as the third separation is treated by any approved method, and when bleached and deodorized is the sole product from the first distillation. The benzine of the second separation and the black oil of the fourth separation are either placed together in a still and redistilled under direct heat, in which case their distillate is again subjected to all these named separations, or they are placed in a steam-still, and the lighter hydrocarbons being vaporized by the action of live steam are carried off and condensed as gasoline, leaving within the still the heavier hydrocarbons with a higher fire-test, to be drawn off and treated substantially in the same manner as the illuminating-oil of the first distillation.

In any case, to separate the safe burning-oils from the dangerous volatile hydrocarbons at the one extreme, and those carrying a high percentage of color at the other extreme, requires a double distillation of at least a portion of the product, and this must be conducive to bad economic results, since it is well established that each new distillation results in a new production of the benzine series and of the tar or color series of hydrocarbons as a result of the application of heat.

The vaporizing of the petroleum brings into the worm at all stages of the process hydrocarbons of differing combinations in a mechanical union only. These have different points of condensation, but during the earlier por-

tion of the run are allowed to run off with the benzine—that series being in excess at that stage.

During the running of the third and fourth separations a percentage of the benzine series is condensed and commingled with them, and in the treatment of the illuminating-oil this percentage of benzine is sometimes so great as to necessitate the steaming of the oil to rid it of the benzine. It is furthermore to recover from the benzine those hydrocarbons of the valuable olefine series and such of the benzine series as may be isomeric with them, and to rid the black oil from its high percentage of the benzine series, that a second distillation by direct heat or application of steam is necessary.

In the passage of the hydrocarbons through the worm they take up and carry with them a percentage of the vapor, and prevent its condensation, which causes a loss, in addition to those fixed gases or hydrocarbons which are not condensable at any temperature attainable practically, and are consequently allowed to escape as gas, carrying with them much valuable vapor, which might be condensed under more favorable conditions.

The use of steam in the worm causes, by its condensation, a larger volume of liquid to flow through the pipes, and necessarily a larger volume of these refractory hydrocarbons are carried off uncondensed through their admixture with the liquid in motion.

The flow of the liquid products of condensation in the pipes to some extent retards the condensation of the vapor, preventing its contact with the cooled surface of the pipes, the liquid product being a poor conductor, and occupying space which should, as much as possible, be devoted solely to vapor. A better result is obtained in a more complete condensation of the hydrocarbons by extending the length of the worm, and exposing them more thoroughly and for a greater time to the low temperature of the water-tank; but this result is counterbalanced in the discoloration of the distillate, which seems to be due to its longer passage through the iron pipes, and which requires a higher percentage of acid in its color treatment.

In the use of steam in the worm with the illuminating distillate there are several conditions common to refining under which the water of condensation becomes so thoroughly commingled with the hydrocarbons as to be difficult of after separation, and to cause the product to be finished finally at the expense of a portion of its brilliancy and burning qualities. Still, the fact that the injected steam accelerates the flow of the burning oils and maintains that flow more nearly at an equable temperature is held to counterbalance this, although under the most favorable circumstances the separation of the oil from the water requires the expenditure of time. The exposure of the distillate to the air for any length of time is injurious to its color.

In the secondary distillation of the "ends," when performed in steam-stills, the distillate, so called, being that portion remaining within the stills after the gasoline has been distilled over, is subjected to the same injury, but in a greater degree, than the illuminating-oil from the first distillation. Aside from this, however, the hydrocarbons of the light series of about 60° Baumé are mixed with those of the heavy series of about 45° Baumé, and are agitated and mingled by the action of the live steam. When this agitation is over there is left a product having, apparently, a fair gravity and fire-test. This appearance is due to the fact that the two series are held in mechanical union by the molecular form produced by the action of the steam, and to some extent by their saturation with the water from its condensation. It frequently occurs that this oil, after standing some days, becomes again separated into hydrocarbons of differing gravities; that in the upper part of a vessel is found too volatile for safety, while that in the bottom is too heavy to flow up the wick of an ordinary lamp. Such oil is useless, and it would seem that a perfect redistribution of the carbon is not attainable by such means.

To construct a new or to reorganize an old condenser which will effect the needed separations of the hydrocarbon series independently of any arbitrary rules regarding gravity, and which will separate the gasoline from the illuminating-distillate without redistillation, and which will produce illuminating-distillate without necessary exposure to steam or air at any point, and which will carry on these separations continuously, the separation of the products of condensation being effected within a flow-pipe or worm intercepted with interval separators, exposing its full conducting cooling-surface to the vapor, and giving the needed separations of the hydrocarbons in a way to give the fullest condensation at every point in the course of the vapor, are the objects of my invention.

In the accompanying drawings, Figure 1 represents a separator-condenser for hydrocarbons embracing my invention; Fig. 2 a vertical part section and part elevation of the same; Fig. 3, the secondary condenser in section, showing its connection with the tail pipes of the primary condenser; and Fig. 4, an enlarged section of one of the vapor-pipes, its separator cross-pipes, and tail-pipe trap-connection.

I construct my condensing-worm with the general form now in use of two or more parallel iron pipes, A, leading from the still to a point at the end of the water-box at the greatest distance from the still, and I give these pipes a continuous inclination downward from the point at which they enter the top of the tank X to the point at which they leave its bottom. At a point determined upon between these termini I bisect the vapor-pipes A with separator cross-pipes B, of a diameter sufficiently large to allow all the fluid hydrocar-

bons produced by their condensation between the still and the cross-pipe B to flow within the pipe B and below the level of the vapor-pipes A, which enter it upon the one side and leave it upon the other.

I connect the separator-pipes B, by means of a depending pipe, *b*, with a receiver, C, and the fluid products descending to and accumulating in the receiver C are carried off through a tail-pipe, E, which connects with the receiver C by means of a swan's-neck connection, D, the object of this form of connection being that only liquid or condensed hydrocarbons may flow through the tail-pipe E, which I incline to such an extent as to insure the outflow and that all vapor may be forced to pass through the vapor-pipes A for condensation.

The bisecting pipes of the worm I prefer to make of short couplings, one for each vapor-pipe, and connect these couplings by short intermediate sections, as shown in Fig. 1, because such construction affords a ready and convenient means of forming the cross-pipes and joining them with the pipes A, and by which means two or more straight worm-pipes are connected in a manner to allow the cross-pipes as well as the pipes A to be comparatively free from liquid products, and thereby afford a greater surface for condensation. These cross-pipes receive the liquid from the pipes A, and form part of a straight pipe-worm, and serve in connection therewith to effect the fractional separation of the products of condensation, while the receivers C, proper for such products, are connected with these cross-pipes and form traps, by means of the upward bends D in the tail-pipes E, which connect separately each separate receiver, so that the latter are always kept filled with the distillate, leaving the worm comparatively free from the products of condensation, and forming traps which prevent the vapor following the liquid and the overflow of the distillate into the worm, and for this purpose the receivers should be about equal in diameter to the cross separator-pipes.

It is by means of these bisecting coupling-pipes that I am enabled to use a series of straight vapor-pipes, and obtain the fullest condensing capacity, with an effective fractional separation from the worm.

The trap-receivers C, their connecting tail-pipes E, and their worm connecting-pipes *b* are arranged within the condensing-tank, and the arrangement shown of the receivers C allows the tail-pipes E to be placed at one side of the vapor-pipes, thus rendering the construction compact, and giving easy access to all the joints of the coupled parts, as shown in Fig. 1.

The pipe *b*, of which there is one to each cross-pipe, connects with one of the couplings of said cross-pipe, which renders such connection much easier and cheaper than if such connection were made by piercing the vapor-pipe, and gives the advantage of using short sections of piping for the worm, which, in point of expense, is a matter of much moment in such apparatus. So, in like manner, the tail-pipe upward bends D are of couplings high enough only to keep the receivers filled with the distillate, as traps, while the bends themselves are at no time filled with the outflowing distillate, but simply serve as overflow-bends, and prevent the distillate from rising in the pipes *b* above the lowest point in said bends, as shown in Figs. 2 and 4, so that the upper portion of the bends D and the upper portions of the pipes *b* are utilized as vapor-condensing parts in the liquid-conduits below the worm; but this advantage could not be obtained were it not for the trap-receivers C in connection with the worm.

In the connection of the tail-pipes E with the secondary pipes K, it is important that the steam-jet pipes L should be so placed within the secondary pipes as to cross the connection of these two pipes above the level of the flow of the distillate from tail-pipes, so as to effect the purpose stated without interfering with the continuous downward flow of the distillate, and without such disposition and relation of the steam-jets with the secondary condenser they would fail of their purpose.

At the terminus of the pipe E it passes through the wall of the water-tank X, and at a convenient point outside the water-tank and within the still-house I connect it with a distillate-tank by means of the fitting G and the depending pipe H. Between the fitting G and the wall of the water-tank X, I insert the X-connection F, being a four-way fitting provided with glass disks, through which to observe the color and progress of the distillate, and I attach to the lower side of this fitting F the pet-cock I, through which I draw off from time to time samples of the distillate to note its gravity and quality. Upon the top of the T-fitting G, or upon a higher fitting, G′, of an extension, H′, of the depending pipe H, I place the funnel-cock J, for the purpose of pouring back the samples after examination.

In one side of the top-cock fitting I insert a pipe, K, and through the other side of such fitting I insert the steam-pipe L, passing it within the entrance of the pipe K, as in Fig. 3, that it may form a central steam-jet within a circumscribing vapor-pipe, for a purpose to be presently stated. The pipe K is passed into a second water-tank, Y, and, returning with a continuous inclination downward, is connected to the tail-pipe M, through which the products of the condensation of all the injected vapor pass as gasoline.

At other points between the cross-pipe B and the terminus of the worm I introduce the cross separator-pipes B′ B″ B‴, if so many are required; or, if necessary, I may construct a worm with more than that number of separator cross-pipes. In any case, each of these is constructed and arranged substantially as is B, the details being the same in each case, the vapor-pipe K, from the tail-pipe of each separator, passing into the water-tank Y and

returning to connect with the tail-pipe M, forming a secondary or auxiliary condenser solely for the recovery of the gasoline.

Where I apply my improvement to a condenser having a single continuous vapor-pipe, the method of connection between the vapor and tail pipes only differs in the lesser number of connections required and their proportional enlargement.

In operation, the flow of vapor and its condensation is the same as with the ordinary condenser until the cross-pipe B is reached. At this point all the condensed hydrocarbons are trapped off into the receiver C, and the pipes A, between the cross-pipes B and B′, are left free for the condensation of the vapor flowing through them. The liquid hydrocarbons from the receiver C flow out through the swan's-neck D, which is curved upward to such an extent as to maintain a column of liquid interposed between the receiver C and the outflow or tail pipe E, but not to such an extent as to cause an overflow of these liquid products from the cross-pipes B into the condenser or vapor pipes A.

At B′ are received the condensed products between B and B′, consisting of hydrocarbons of a character different from those received at the cross-pipe B, so also at B″ and B‴; and in each case the pipes are left, to a great extent, free from liquid products, and present a greater surface for condensation of the vapor, while the liquid already condensed has much less opportunity to take up and carry off uncondensed vapor, or to become mixed with hydrocarbons of a totally differing character and requiring subsequent separation.

At the point where the tail-pipes E pass into the still-house the distillate may be examined through the glass disks of the fittings F. I prefer to keep all passages closed, to prevent access of the air to the distillate, as well as to keep the still-house free from the dangerous vapor or gases.

At the outflow of the distillate to its appropriate tank through the fitting G any vapor or uncondensed hydrocarbon which may have followed it through the tail-pipe, or which may have been generated during its passage, is forced off by the steam-jet from the pipe L, and, passing through the vapor-pipe K within the water-tank Y, is condensed into gasoline, and carried to its appropriate tank or receptacle through the tail-pipe M, which, with the exception of the steam-jet connection L, is fitted in every respect in a manner similar to the distillate-pipes E. The steam-pipes L are connected to the boiler or other steam-generator in any approved way.

The tail-pipes E may connect with separate tanks, or they may be connected together, to the end that, if desired, the flow may be made from all into any one receiving-tank, or from two or more into one receiving-tank. For convenience I prefer to terminate the tail-pipes E with vertical branch pipes H, leading down below the level of the ground, the vertical pipe forming a support for the vapor-pipe K and steam-pipe L. This is not essential, however, as the distillate may be led to the tanks by any form of pipe or conduit, so long as the steam-pipe connection is made above the level of the flow of the liquid product from the tail-pipe E, so as to obtain the effect of the steam-jet as an ejector of the vapor without interference with the continuous flow of the liquid hydrocarbons.

In practice I prefer to use my condenser at such a temperature that the lightest of hydrocarbons shall not be condensed in the passage through the water-tank X, but shall remain as vapor, to be steamed off through the worm or pipes K K and recovered as gasoline without further trouble, and to this end the water-tank Y is kept as cool as possible.

For convenience in operating upon petroleum of a refractory character or carrying a high percentage of the light hydrocarbons, I may insert two or more secondary vapor-pipes, K, with steam-jets L, in each or any one of my outflow-pipes.

I obtain by the use of this condenser valuable separations of the hydrocarbon series, which cannot be obtained otherwise with any approach to uniformity. I may use the product from each of my cross-pipes separately, or I may combine any two or more of them, as there is so small a variation in their gravities that they may be combined at once without danger of after separation.

I obtain my distillate in better condition for treatment, more free from discoloration and from fixed gas and uncondensed hydrocarbons, and separated from the lighter benzine series without redistillation of any portion of the products. I obtain my products in their proper tanks or receptacles without exposure to the air, and I keep my still-house free from dangerous inflammable gas. I obtain a better yield of merchantable products, since I am not subject to the loss from redistillation, and at a lower cost, because not subject to the outlay incident to a second handling of the oil.

I do not claim as new the arrangement of a steam-jet within a vapor-pipe, as I am aware that device has been used under various circumstances and for many purposes, although not under the conditions and for the purpose shown and described in this specification; nor do I claim as novel the application of a swan's-neck connection between an inflow and outflow pipe for the purpose of preventing the passage of gas or vapor with the flow of the liquid; and I am aware that fittings have heretofore been constructed and inserted within the outflow-pipes of a condenser through which the passage of the liquid products might be seen.

The state of the art shows that proportional condensation and fractional separation have been proposed with a worm by means of separate tail-pipes provided with traps and leading from an inclined vapor-pipe at points recurring at lower levels thereof, and in which

such trap-pipes connect with depressions on the under side of said condensing-worm to carry off the products of the vapors which are condensed, while preventing the vapor from following the outflow of such products; but such construction is necessarily confined to a single inclined condensing-pipe, and therefore not possible for comprehensive capacity with a system of straight connected vapor-pipes, as in my separator-condenser, which in such apparatus is of vital importance in a commercial sense in rendering such apparatus practically effective in carrying out such process economically.

I am also aware that in apparatus for rectifying alcohol a nest of helical pipes or spiral-coil condenser has been used with intercepting receivers arranged upon the same horizontal plane, the pipes entering at one side of said receivers and leaving them on the other side, and from which receivers discharge-pipes for the products of condensation lead vertically through the bottom of the condenser-tank to a delivering-pipe, from which lead at different points pipes connecting at different heights with the rectifying-column, the receivers being for the purpose of obtaining a more effective condensation of the spirit, and the separation of the same into various grades or qualities of wine, by dividing up and separating the vapors, so that the condensation of the watery portions will take place with less spirit mixed therewith.

I claim—

1. In a separator-condenser for hydrocarbons, the worm consisting of two or more straight pipes, A, connected at recurring lower levels by couplings forming cross-pipes B B′ B″ B‴, in combination with a trap-receiver, C, for each cross-pipe and a separate tail-pipe, E, having the upward bend D between said trap-receiver and the outflow end of said tail-pipe, all constructed for operation substantially as herein set forth.

2. In a condenser for hydrocarbons, the combination, with the tail-pipe E, of the fitting F and pet-cock I, and the fitting G′, provided with the funnel-cock J, as shown and described.

3. In a separator-condenser for hydrocarbons, the combination of the secondary condensing-pipes K and the tail-pipes E of the primary condenser, connected for operation, as herein set forth, with the steam-jet pipes L, entering the secondary pipes above said tail-pipes and crossing the outlet-connection of the latter with said secondary pipes, for the recovery of the gasoline from vapor or uncondensed hydrocarbon escaping with the distillate through the tail-pipes, or which may have been generated during the passage of said distillate, and without interference with the continuous flow of the distillate from the primary condenser.

4. A separator-condenser for hydrocarbons, consisting substantially of the primary vapor-pipes A, cross-pipes B, receiver C, trap-connection D, tail-pipes E, secondary vapor-pipes K, steam-pipes L, secondary tail-pipe M, and water-tanks X and Y, as shown and described, and for the purpose set forth.

In testimony whereof I have hereunto set my hand.

JNO. W. CULMER.

Witnesses:

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J. W. HAMILTON JOHNSON.