G. M. SAYBOLT.

OBTAINING NAPHTHA FROM NATURAL GAS.

APPLICATION FILED SEPT. 1, 1906.

989,927.

Patented Apr. 18, 1911.

2 SHEETS—SHEET 1.

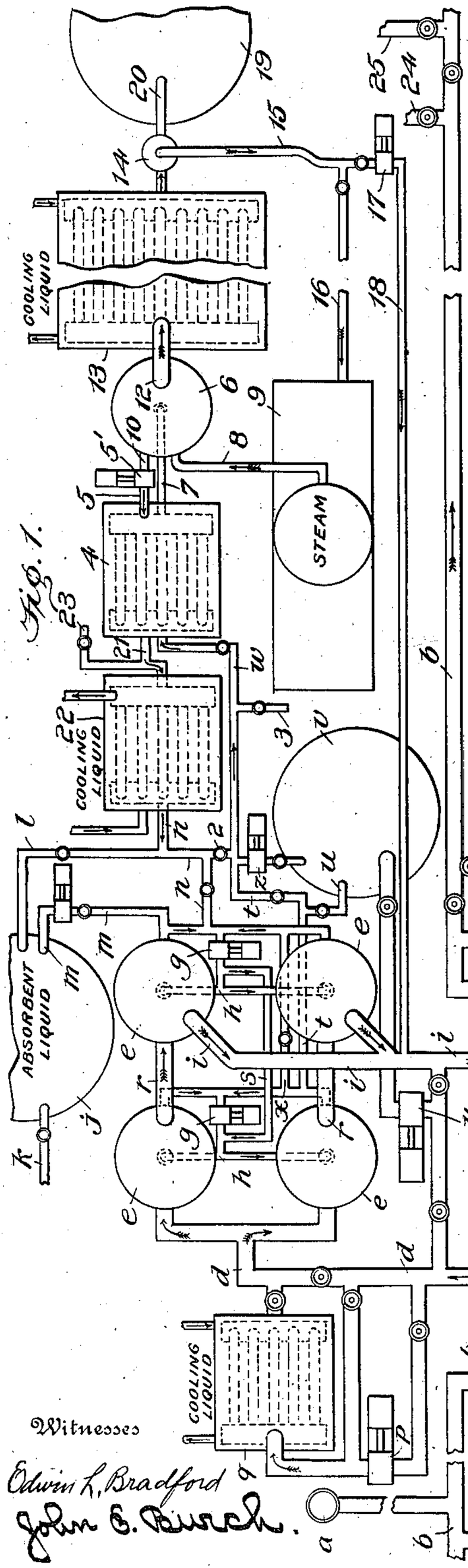

Fig. 1.

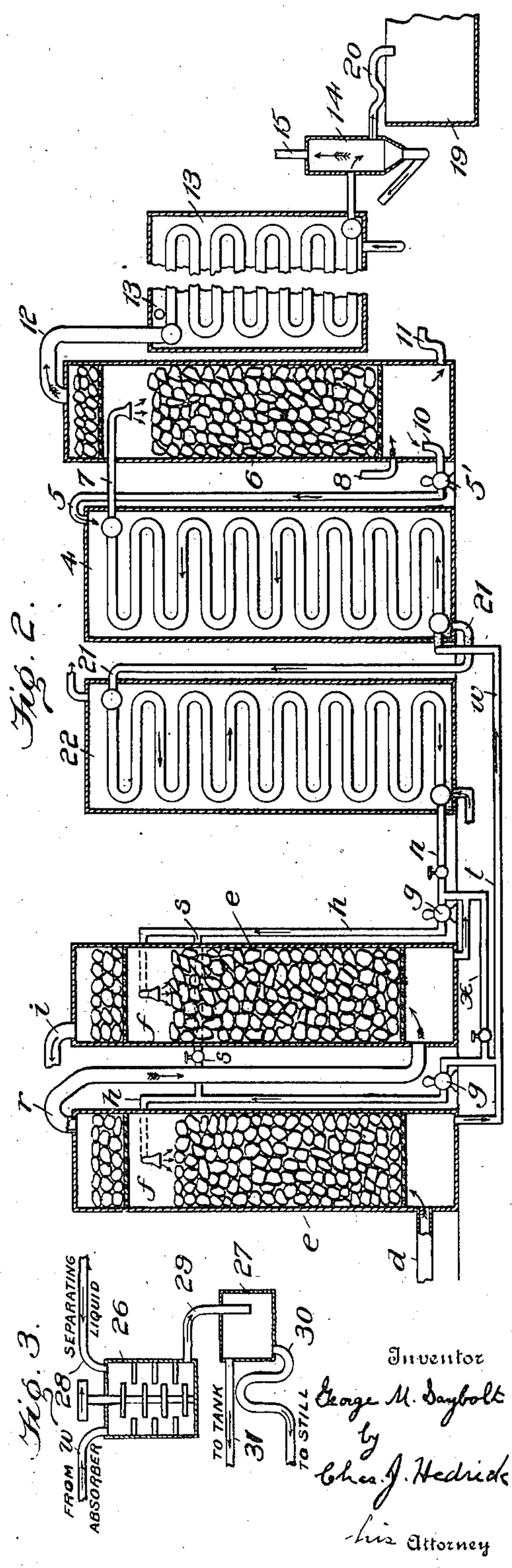

Fig. 2.

Fig. 3.

Witnesses

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2 SHEETS—SHEET 2.

Fig. 7.

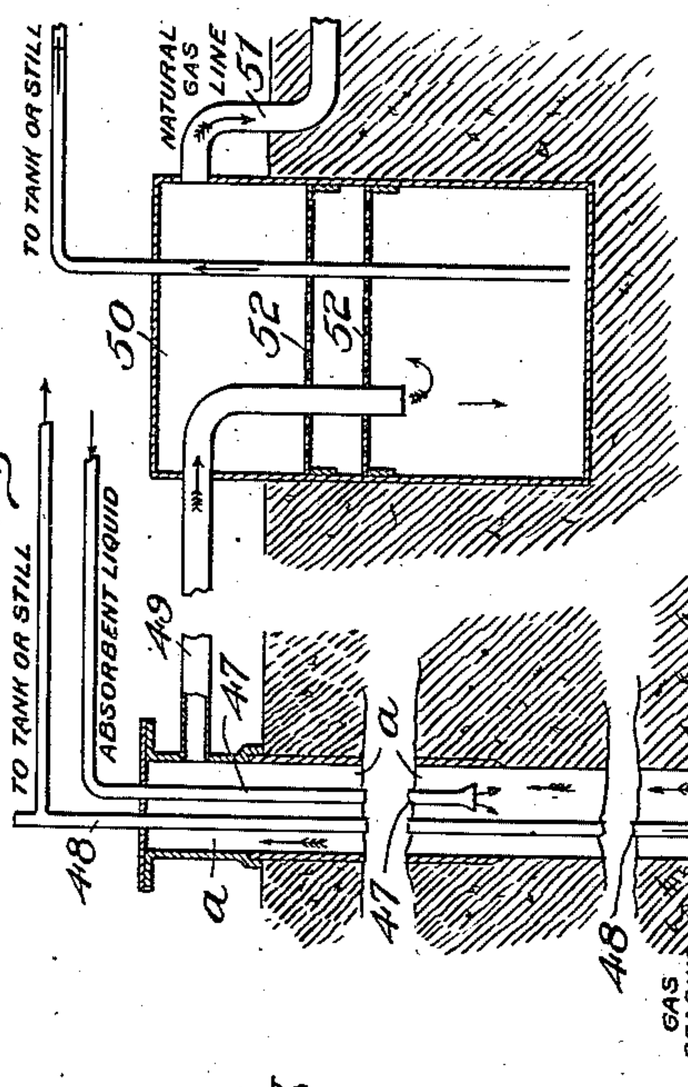


Fig. 8.

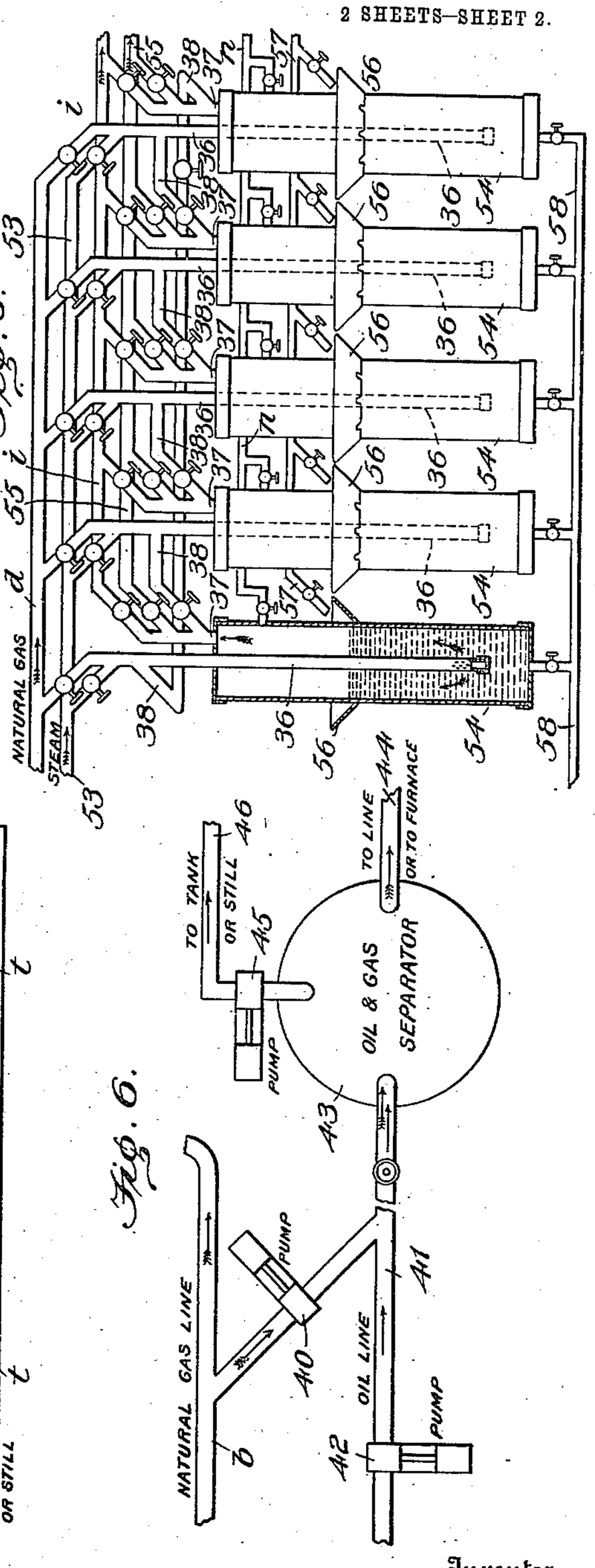


Fig. 5.

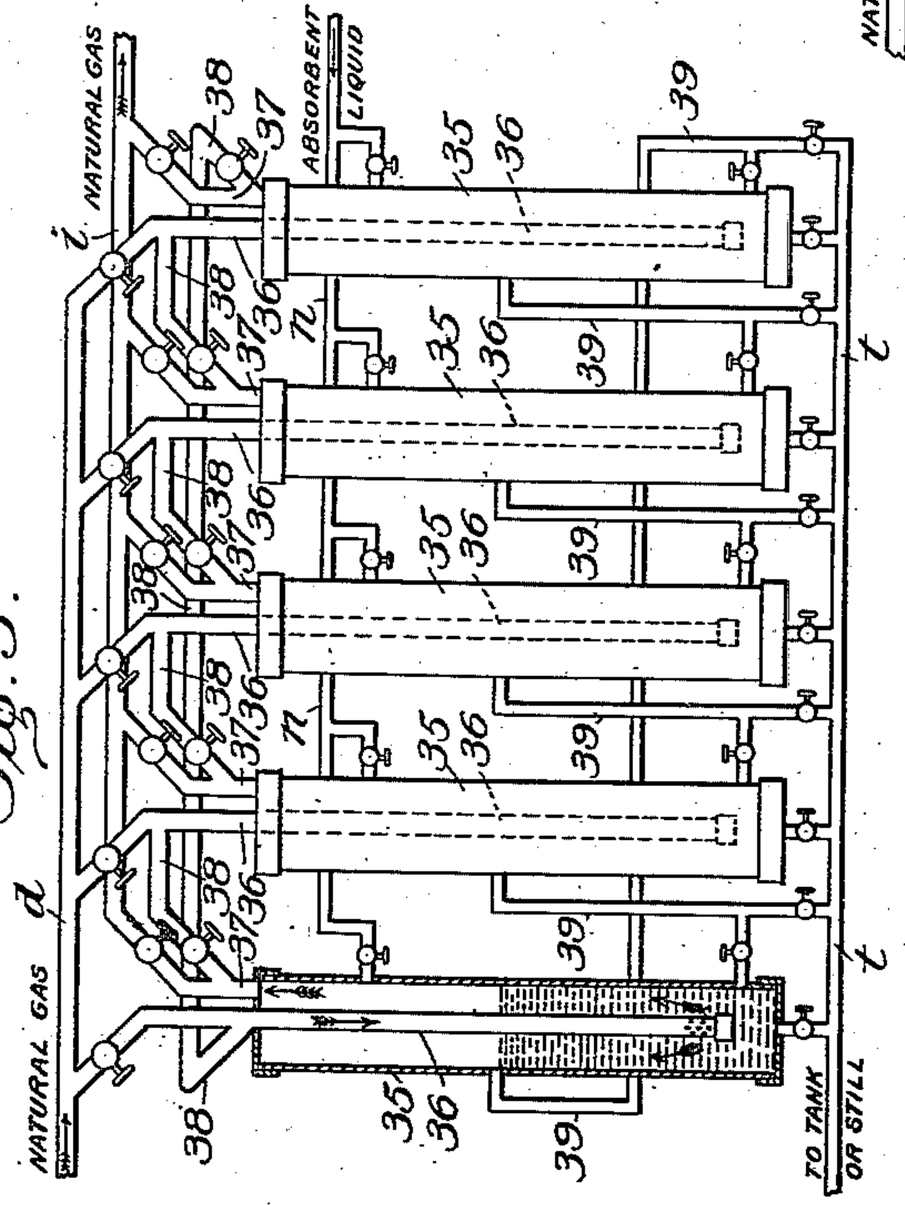
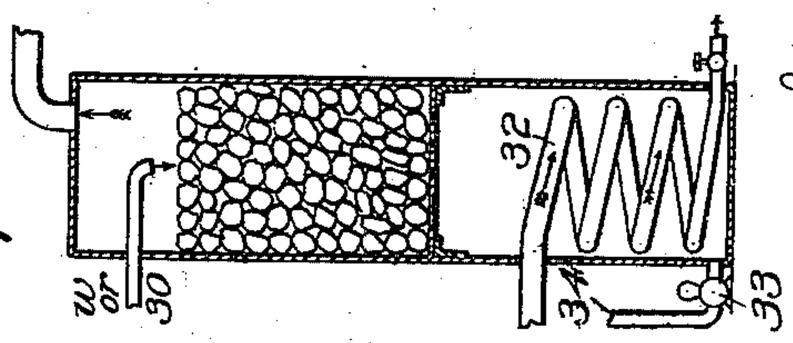


Fig. 6.



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UNITED STATES PATENT OFFICE.

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OBTAINING NAPHTHA FROM NATURAL GAS.

989,927. Specification of Letters Patent. Patented Apr. 18, 1911.

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To all whom it may concern:

Be it known that I, GEORGE M. SAYBOLT, a citizen of the United States, residing at Jersey City, in the county of Hudson and State of New Jersey, have invented new and useful Improvements in Obtaining Naphtha from Natural Gas, of which the following is a specification.

This invention relates to the obtainment of naphtha from combustible gas of natural origin and underground source, which gas is obtainable by means of wells sunk into the ground to the proper horizon and is capable of use as fuel. Natural gas wells sometimes do and sometimes do not yield oil also. In oil-yielding gas wells (or to state the matter conversely, in gas-yielding oil wells) the natural gas may rise with the oil; or a separation between them may take place underground. From the wells the gas is piped to the places of consumption, which may be longer or shorter distances away. This natural gas is and long has been obtained and used in enormous quantities. One single well for example has been known to yield thirty-six millions of cubic feet of gas in twenty-four consecutive hours. While therefore the naphtha exists in the gas in the form of vapors under small tension and consequently in an attenuated condition and while it composes only a small proportion of the gas, at least ordinarily, the amount varying in the gas from different wells, yet in the aggregate a large quantity of naphtha is daily burned as fuel, along with those combustible constituents of natural gas (hereinafter referred to as the lighter combustible constituents of the gas) which are gaseous at atmospheric pressure and temperature. Naphtha is volatile; but it is liquid at atmospheric pressure and temperature, say fifteen pounds to the square inch, and 60° Fahrenheit, or thereabout. It may be defined generally as including all hydrocarbons, and each of them, which are liquid at atmospheric pressure and temperature, and which have lower boiling points than the normal hydrocarbons of burning oil (kerosene). It exists in vapor form in natural gas by reason of its association with the other constituents thereof.

There exists, and for some years back has existed, a great demand for naphtha. It is mainly obtained from petroleum; and the crude oils from fields developed in recent years contain it in less proportion than does Pennsylvania oil. It is therefore, and for some years has been highly important to enlarge the available supply of naphtha. The present invention has this object in view.

In accordance with this invention, natural gas, as defined above, is subjected to an absorbent menstruum; by the aid of this menstruum a separation is effected of the naphtha from the lighter combustible constituents of the natural gas; and the absorbed naphtha is afterward separated from the menstruum and is recovered apart therefrom in the form of a liquid product; or, if the product of the naphtha absorbing operation without separation of the absorbed naphtha and the absorbent menstruum from each other should be desired, then in such case the said product, or so much of it as should be desired, would be collected and the separation from each other of the naphtha and the menstruum would be dispensed with.

The naphtha obtained from natural gas in accordance with the invention can be utilized for the ordinary purposes of naphtha of similar gravity, with or without being further operated upon, in any appropriate way, according to the case. When necessary or desired it can, for example, be subjected to treatment with sulfuric acid and alkali; and it can be fractionated into liquids of different gravities, for various purposes.

In the accompanying drawings, Figure 1 is a diagram in plan view of apparatus in accordance with the invention having a still to separate the naphtha from the menstruum; Fig. 2 is a diagram in vertical section and elevation of the main portion of the same apparatus; Fig. 3 is a diagram in vertical section and elevation, illustrating another form of means for separating naphtha and menstruum from each other; Fig. 4 is a diagram in vertical section and elevation, exhibiting another form of still; Fig. 5 is a diagram in vertical section and elevation, and Figs. 6 and 7 are diagrams in plan and in vertical section and elevation, respectively, illustrating other forms of means for absorbing the naphtha of natural gas; and Fig. 8 is a diagram in vertical section and elevation of another form of naphtha absorbing and naphtha distilling means.

Referring to Figs. 1 and 2, gas conveying pipes lead from wells *a* to the main gas line *b*, which extends beyond the drawing to

places of consumption. Gas holders in the main gas line, or in the tributary lines leading from the wells *a* can be used or not as may be preferred, and if used they can be placed wherever desired. Sometimes the well pressure may suffice to effect the conveyance of the natural gas through the line *b* in sufficient quantities to meet the wants of consumers; but in order that extra pressure may be applied to the gas when desired so as to force it through the line a pump *c* is shown. It has appropriate pipe connections with the line *b;* and valves are indicated in said connections and in the line for controlling the flow of gas through the same. The branch *d* leads from the gas line *b* to the means for subjecting the natural gas to the naphtha absorbing menstruum and for enabling a separation of naphtha from lighter combustible constituents of the gas to be effected by the aid of said menstruum. Said branch *d* thus serves to connect said means with the underground sources of the gas, which sources are tapped by the wells *a*.

The separation of the naphtha by the aid of the absorbent menstruum from at least the main body of the lighter combustible constitutents of the gas is best effected in the absorbing operation; but it is believed that it might possibly be effected by the aid of the absorbent menstruum afterward; say for example, by absorbing the main body of said lighter combustible constituents along with the naphtha and then allowing the former to escape while the naphtha is held by the absorbent menstruum.

Heretofore appliances of many kinds have been devised for bringing gas into contact with other material with a view of separating one or more of its constituents from the rest of the gas. The means of the present invention for subjecting natural gas to naphtha absorbing menstruum may include generally such appliances of any desired kind; but by way of example in Figs. 1 and 2, the means shown contain appliances for showering a liquid naphtha absorbing menstruum through the natural gas. The absorbers *e* consist each of a tower filled with pieces of solid material, as broken stone for example, or pieces of coke, or the like. Natural gas from branch *d* enters at the bottom of each tower and rising therein meets the descending menstruum, which is introduced near the top of the tower through a rose or sprinkler *f*, the rising gas and the descending menstruum being subdivided and brought into more thorough contact with each other by the pieces of solid material. As shown, menstruum from the bottom of each absorber is returned to the top thereof by means of pump *g* and circulating pipe *h*, each pump returning the menstruum to the top of more than one absorber. Above the menstruum inlet (rose *f*) of each absorber is shown a short column which contains pieces of solid material and through which the outflowing gas passes. It serves to prevent menstruum being carried over mechanically by the flow of gas.

Naphtha, with or without lighter combustible constituents of the gas, is absorbed by the menstruum in each of the absorbers *e;* and by arranging the appliances whereby the pressure and temperature of the gas are controlled in such manner that the pressure in the absorbers at the therein existing temperature is insufficient to effect the absorption of the main body of the lighter combustible constituents of the gas, the main body of the gas will return by branch *i* to the line *b*.

The absorbers *e* are arranged to receive a previously produced menstruum. The latter, supplied from any suitable source, can be delivered through the pipes *h* connected with the roses *f* of the absorbers. As shown, the tank *j* is for receiving the menstruum from say either or both the pipes *k*, *l;* and it can be withdrawn from tank *j* by pipe *m* for delivery to the absorbers; or the menstruum can also be supplied direct from pipe *n*, without entering the tank *j*.

The ratio in which the menstruum and the natural gas are respectively supplied to the absorbers is governed by the valves in the gas supply branch *d* and the menstruum supply pipes *m*, *n*, through whichever the menstruum supply may be taken. The volume of the natural gas supply should be many times that of the menstruum, in order that the menstruum may absorb a considerable content of naphtha; but the extent of the absorption can be regulated according to the wishes of the operator, within the absorbing capacity of the menstruum employed under the conditions of its employment. By circulating the menstruum by pumps *g* through the absorbers *e*, the same particles of menstruum can be brought as much as desired into contact with natural gas. The circulation of the menstruum and its continuous renewal through pipes *m*, *n*, or one of them, and the arrangement generally of the absorbers *e* allow an uninterrupted flow of the natural gas from line *b* by way of the branch *d*, absorbers *e*, and branch *i*, back to line *b*.

When the natural gas is delivered from the wells *a* under a satisfactory condition of pressure and temperature, such condition being oftentimes more favorable to naphtha absorption than is the condition of atmospheric pressure and temperature, it is preferred to subject the natural gas at its natural condition of pressure and temperature to the absorbent menstruum. Thus the expense of compression and cooling (or of cooling, if the pressure should not be in-

creased) is avoided. The branches *d*, *i*, are shown arranged to receive and to return the gas at such natural condition (barring changes due to friction and the like), they being shown connected with gas line *b* between the wells *a* and the line connections of pump *c*. For producing artificially a condition more favorable to absorption than that available naturally, a pump *p* is shown for increasing the pressure, and a cooler *q* for reducing the temperature of the compressed gas, or (if compression should not be desired) of the uncompressed gas.

Instead of subjecting the natural gas in a single stream to the action of the absorbent menstruum, the gas supply is advantageously divided into a number of parallel streams; and the absorbing vessels *e*, which each of them confine and convey such a stream, are of comparatively small diameter. They are thus better able to withstand internal superatmospheric pressure, than would be an absorber of sufficient diameter to carry singly the whole supply of gas. As shown, two absorbers *e* are represented in parallel; but in practice as many of them would be employed in parallel as should be thought necessary or expedient.

In order more thoroughly to extract the naphtha from the gas and at the same time to obtain a larger content of naphtha for the menstruum, the natural gas first meets menstruum containing more naphtha and afterward that containing not so much. To accomplish this, the absorbers *e* are connected in series, the gas from the top of the first absorber *e* of a series passing by pipe *r* to the bottom of the absorber next in series, and the menstruum which has been circulated in one absorber being delivered by pipe *s* to the preceding absorber of the series. Absorbers arranged in two parallel series of two in each series are shown; but the number in series can in practice be as large as may be considered necessary or expedient; and there may be as many series in parallel as may be desired; or a single series arrangement can be used, if that should be preferred. As shown, the fresh menstruum from pipes *m*, *n*, or one of them, enters the the pump *g* appropriate to the last absorbers of both series; and in connection with menstruum which flows from the bottoms of said absorbers it is delivered into those absorbers near their tops through the corresponding branches of the circulating pipe *h* and the roses *f* at the ends of said branches. Some of the naphtha containing menstruum from the last mentioned circulating pipe *h* is delivered by pipe *s* to the circulating systems of the preceding absorbers in both series and is mingled with the menstruum of larger naphtha content which is returning to the upper parts of these absorbers. By opening pipe *x*, the fresh menstruum can be supplied without distinction to all the absorbers. In that case also the natural gas would first meet menstruum containing more and afterward that containing less naphtha; for the menstruum would begin to absorb naphtha immediately on its entrance into each absorber and would continue to do so during its descent therein; and in the absorber which should first receive the natural gas it would absorb the most naphtha before reaching the bottom (where the gas enters) so that the body of menstruum in this absorber would hold more naphtha in absorption therein than would the body of menstruum in a succeeding absorber in the series; although there might be no difference between them in naphtha content when discharged by the respective roses *f*. With pipe *x* open one pump *g* would suffice to circulate the menstruum of all the absorbers; for the open pipe *x* would put the bottoms of all the absorbers in communication with each other; while the open pipe *s* establishes communication between the upper parts of all.

The menstruum, containing as much naphtha as it can absorb under the conditions of the case, is carried away by the pipe *t;* from which it can pass by pipe *u* into tank *v*, to be thence delivered by pump *z* to one or other or to both of the pipes 3, *w;* or it can pass from pipe *t* direct to one or other or to both of said pipes 3, *w*, without entering the tank *v*. The valves in pipes *l*, *m*, *n*, *t*, *u*, can be adjusted to maintain a sufficiently uniform quantity of liquid in the absorbers *e*.

Whether the naphtha containing menstruum from the absorbers *e* should be allowed to enter the tank *v*, or should be sent direct to one or other or to both of pipes 3, *w*, it can be held under the pressure existing in the absorbers; or the pressure can be reduced in passing an appropriate valve or valves. Without reduction of pressure, the tank *v* would serve for a temporary storage; with reduced pressure therein, it would serve, as shown, either or both the purposes of temporary storage and of separating from the naphtha enriched menstruum such lighter combustible constituents of the gas as might be absorbed with the naphtha in the absorbers and be liberated on the reduction of pressure. For this latter purpose, it is shown provided with a gas pump *y* for withdrawing the gaseous constituents from the tank *v* and delivering the same either into the gas return branch *i* or into the gas supply branch *d*. The latter connection would be opened in case it should be found that the gas should contain enough naphtha to render its return to the absorbers worth while.

If desired, the naphtha containing menstruum from tank *v* can be returned to the

absorbers *e* by means of pump *z* and pipe 2. Such return might sometimes be useful, in case the menstruum should not be sufficiently charged with naphtha. If the condition in absorbers *e* should be such that not only the naphtha but also the main body of the lighter constituents should be absorbed, which might be possible under extreme pressure and low temperature in the absorbers, but which is not considered advantageous, then in such case the separation of the naphtha enriched menstruum might take place in the tank *v*, by maintaining therein a condition of pressure and temperature less favorable to absorption; so that the menstruum on entering tank *v* would liberate the main body of the lighter combustible constituents of the gas, which would be withdrawn therefrom by pump *y*. The tank *v* could be at any desired distance from the absorbers; but in some cases at least it would best be in proximity to the absorbers *e;* and it is so shown.

The pipes 3, *w*, are respectively provided, the pipe 3 for allowing the menstruum holding in absorption therein natural gas naphtha separated from at least the main body of combustible constituents of the gas to be withdrawn without recovery of the naphtha from the menstruum, the pipe *w* for conveyance of the said menstruum to means for recovering the naphtha therefrom.

As shown in Figs. 1 and 2, the pipe *w* leads to the coils or pipes of a heat exchanger 4, in which the temperature of the naphtha enriched menstruum is raised by exchange of heat with the separated menstruum returning by pipe 5 from the bottom of the continuous steam still 6, which constitutes the means shown in these figures for separating the naphtha and the absorbent menstruum from each other. The pipe 7 delivers the heated product from the exchanger to the top of the still. This latter as shown consists of a column filled with pieces of solid material, as of broken stone or coke or the like; and it is provided with a pipe 8 delivering steam from boiler 9 into the bottom of the still, and with pipes 10, 11, for drawing off respectively the separated menstruum and the water which results from condensation of steam in the still. The evolved naphtha vapors, accompanied by uncondensed steam, pass through a small section of the column located above the inlet of the naphtha enriched menstruum and containing pieces of solid material; and then they pass by pipe 12 to the condenser 13 wherein condensation takes place, the naphtha being reduced ordinarily to a product liquid at atmospheric pressure and temperature. A trap 14 at the outlet of the condenser is shown for separating the naphtha and the water from each other by settling and decantation in the known manner. Uncondensed gas which may accompany the water and naphtha escapes by the pipe 15 and is disposed of as may be desired. It may, for example, be piped to a place of consumption on the premises, say by pipe 16 to the furnace of steam boiler 9; or it may be sent to the gas line *b*, say by way of pump 17, pipe 18, and return gas main *i;* or it may be disposed of otherwise. At 19 is shown a storage tank for the naphtha, which is supplied thereto from trap 14 by way of pipe 20.

The menstruum from which the naphtha has been separated would best, in most cases, it is believed, be utilized by subjecting a fresh supply of natural gas thereto. As shown it is conducted from the still 6 to the space around the coils or pipes of exchanger 4 by pump 5′ and pipe 5; and thence it passes by pipe 21 to a cooler 22, in which its temperature is further reduced before it is delivered by pipe *n* to the circulating systems of the absorbers *e*. But a menstruum which it is desired to utilize either by working up into one or more products or by applying to some useful purpose without being further operated upon, or which it may be desired to dispose of without utilization (should such a case ever arise), can be withdrawn by pipe 23. It could also be run by pipe *l* into the tank *j* and then be withdrawn therefrom. The means for separating the naphtha and the menstruum from each other can be placed at any desired distance from the naphtha absorbing means; but in some cases at least they would best be in proximity thereto and they are so shown.

Instead of taking the supply of natural gas from which naphtha is to be obtained from the gas line *b* in advance of the pump *c*, it can be taken therefrom after it has been compressed by the latter, the heat generated by the compression in pump *c* being removed before the gas is subjected to the naphtha absorbing menstruum. By placing the gas supply branch and the return gas branch at a suitable distance, as indicated for pipes 24, 25, at the right of Fig. 1, the heat will be removed without expense by conduction from the walls of the gas line *b* to the surrounding air or ground.

In Fig. 3, in place of a still for separating the naphtha and the absorbent menstruum from each other, the means consist of a mixer 26 and a settling and decanting vessel 27. The naphtha enriched menstruum enters the mixer 26 from pipe *w* (which may be taken to be a continuation of the similarly lettered pipe of Figs. 1 and 2); while a medium capable of parting the naphtha and the menstruum enters the pipe 28. The mixed products flow by pipe 29 into the vessel 27. Here separation takes place by gravity; the heavier liquid flowing off by pipe 30; and the lighter escaping by pipe 31. Assuming that the naphtha composes the

lighter liquid, while a solution of the absorbent menstruum and the separating medium compose the heavier, the said pipes 30, 31 are noted as leading the latter to a tank and the former to a still, which may be of any suitable description, for recovering the absorbent menstruum. If a steam still should be unsuitable therefor, a dry heat still would be used; and it may be used in any event. In Fig. 4 a form of such still is represented; although other forms can be used. Such a dry heat still could be used in place of the steam still of Figs. 1 and 2, as well as in connection with the means of Fig. 3 for separating the naphtha and the menstruum from each other; and therefore the pipe which delivers thereto the liquid to be distilled is marked *w* or 30, the former being the still feed of Figs. 1 and 2, and the latter the still feed of Fig. 3. The still itself is in the form of a column filled with pieces of solid material in its upper portion and provided with a close steam coil 32 in the bottom part to supply the heat required to effect the distillation. The pump 33 and pipe 34 are for discharging the residual liquid. If naphtha enriched menstruum should be fed to the still, the menstruum would naturally be less volatile, and would constitute the residual liquid; and the pump 33 and pipe 34 would then correspond with those marked 5, 5^1, in Figs. 1 and 2. If a solution of menstruum and the medium for separating naphtha therefrom should be fed to the still, the absorbing menstruum (if the more volatile) would pass off to the condenser and be recovered as condensate for reuse in absorbing naphtha from natural gas. If it should not be sufficiently freed from the naphtha separating medium by one distillation, repeated distillations can be resorted to. And so also they can be resorted to if necessary or desired for separating the naphtha and the absorbent menstruum; only if the menstruum should be returned for reuse in the absorbers the presence of naphtha below saturation would only limit and not destroy its absorbent capacity.

In Fig. 5 a form of naphtha absorbing means is shown in which the natural gas bubbles up through pools of absorbent menstruum. The pipes *d*, *i*, represent the similarly lettered gas supply and gas return branches of Fig. 1. The vessels 35 of comparatively small diameter, are each provided with a gas inlet pipe 36, connected with the branch *d* and terminating near the bottom of its vessel in a perforated section or rose. Each vessel also has a gas escape pipe 37 at the top leading to the return branch *i* and also having a valved pipe connection 38 with the gas inlet pipe of the absorbing vessel 35 next adjacent to it on one side. This arrangement of pipes allows the vessels 35 to be connected in parallel or in series or in parallel series with reference to the flow of gas from the supply branch *d* to the return branch *i*. The vessels have each a valved pipe connection at the top with the absorbent supply pipe *n*, which represents the similarly lettered pipe of Fig. 1, and at the bottom with the pipe *t* which serves for drawing off the naphtha enriched menstruum and represents the similarly lettered pipe of Fig. 1. Each vessel also has a valved pipe 39 connecting the upper part of its menstruum holding space with the lower part of the menstruum holding space of the vessel next adjacent thereto and provided also with a valved branch leading to the draw off pipe *t*. By this arrangement of liquid conveying pipes, the fresh menstruum can be supplied to, and the enriched menstruum be drawn off from, each vessel individually; or the vessels can receive the menstruum in series, the first of the series receiving the fresh menstruum from pipe *n* and the last delivering the enriched menstruum to the draw-off *t*. The vessels can be disposed in parallel series; since each vessel has the same pipe connections; and any vessel not an intermediate member of a series can be cut out. Five vessels are represented; but as many as may be thought necessary or expedient may be employed. Assuming that all five were to constitute one series, in that case the menstruum might be admitted in a continuous manner to the vessel at the right and the natural gas in an uninterrupted stream into the vessel at the left. Or the pipes 39 between the vessels could be closed, and each vessel in turn could be cut out of the gas current, be filled with menstruum from pipe *n*, and be discharged of its liquid contents into pipe *t* without interrupting the continuity of flow of the natural gas through the series of vessels. Or the pipes 39 being closed, the menstruum could be supplied in a continuous manner to each of the vessels directly from the pipe *n*, the gas continuing to flow in series. Also the gas might be admitted to each vessel direct from the supply branch *d*, (the vessels being in parallel between the branches *d*, *i*,); and the menstruum could be supplied direct to each vessel in a continuous manner or at intervals, each vessel being cut out in turn to be emptied and refilled to the proper height, say about half full.

In Fig. 6 the naphtha of the natural gas from line *b* is absorbed by a menstruum as it flows in a pipe line, the gas being forced by pump 40 into the line 41, through which the absorbent menstruum is forced by pump 42. The condition of pressure and temperature in the line 41 beyond the junction therewith of the branch connection from line *b* would best be such that the naphtha vapors would be absorbed as completely as practicable by the menstruum, while the main

body at least of the lighter combustible constituents of the gas would be unabsorbed. A separation of the naphtha and such constituents would thus take place in the pipe line itself. When the separator 43 is reached, the lighter combustible constituents of the gas can be withdrawn by pipe 44, while pump 45 and pipe 46 deliver the enriched menstruum to a storage tank or to means for separating the naphtha and the menstruum from each other. The pipe line pressure can be retained in the separator 43; but it can be reduced by proper setting of a valve in the pipe line 41, and the pressure on the naphtha enriched menstruum would best be reduced previous to the separation of the naphtha and the menstruum from each other, unless it should be desired to obtain the naphtha as a product requiring at least the pipe line pressure to retain it in a liquid condition. The pressure in the pipe line can be obtained by adjustment of the speed and power of the pumps 40, 42, and by proper throttling of the pipe line fluids at the end of the line, say by the valve on the pipe line 41 near the separator 43. The respective volumes of the natural gas and the menstruum can be regulated as desired; but unless the volume of the former many times exceeds that of the latter, the enrichment of the menstruum will be only meager. The adjustment of the relative speeds of pumps 40, 42, will regulate the ratio of the gas to the menstruum.

Fig. 7 illustrates a plan for absorbing the naphtha in the natural gas as it rises in the well *a*. The menstruum is delivered through the pipe 47 into the rising gas. If the gas current is strong enough to carry along the showered menstruum in suspension in the gas, the pipe 47 would best deliver the menstruum into the lower part of the well: if the menstruum should fall through the gas, notwithstanding the current, the pipe 47 might advantageously be arranged to discharge the menstruum nearer the top of the well. Its outlet can be set at any desired level. As shown, there is a line of tubing 48 for returning the menstruum from the bottom of the well; and the gas outlet 49 discharges into a separator 50 in which it deposits the menstruum carried thereby; while the gas then passes on by pipe 51. The menstruum from the bottom of the well and that from the separator are delivered to an appropriate tank or tanks or to means for separating the naphtha and the menstruum from each other. In the separator 50, perforated division plates 52 are shown to aid in separating liquid in suspension from the gas.

Instead of effecting the absorption of the naphtha in the menstruum and the separation of the absorbed naphtha and the menstruum from each other in separate vessels, the two operations can be performed in the same vessels. Fig. 8 illustrates an arrangement for the purpose. Many of its parts are like corresponding parts in Fig. 5; and as they are similarly marked for reference they need not be further described. In addition a steam inlet pipe 53 is shown with which the pipe 36 of each vessel 54 has a valved pipe connection for injecting steam into the enriched menstruum when it is desired to separate the absorbed naphtha therefrom; there is also shown a vapor pipe 55, with which each vessel has a valved pipe connection, for conveying the vapors of naphtha and water which pass out of the vessels during the steaming operation; and lastly there is shown on each vessel 54 a trough 56 to which the pipe 57 can deliver a cooling liquid when desired, each trough 56 being perforated below so that the cooling liquid will flow over the outer surfaces of vessels 54. The vessels 54 can be supplied with menstruum at the start, and do not need to be supplied further unless to replenish whatever may be carried away incidentally. In other words, the menstruum after absorption of naphtha therein and after separation of the absorbed naphtha therefrom is utilized in the same vessel for absorbing more naphtha and so on. If the vessels 54 should be connected in series for absorbing the naphtha in the menstruum, they would be cut out in reverse order for separating the naphtha from the menstruum, that is the vessel which first receives the natural gas would have its gas supply shut off (the next vessel now becoming the first to receive the natural gas) and would also have its connections with the adjacent vessels 54 and with the return gas branch *i* closed. Said vessel would then have its connections with the steam pipe 53 and vapor pipe 55 opened; and its contents would be steamed until the naphtha should be expelled to the desired extent. Then these last mentioned connections would be closed; and the contents of the vessel would be allowed to stand for the water of condensation from the steam to settle, cooling liquid from trough 56 being at the same time allowed to flow down over the outside of the vessel. When settled, the water would be drawn off through pipe 58; and the flow of the cooling fluid would be continued until the temperature should be suitably reduced. Thereupon, the vessel would be connected again in the gas receiving series, at the end at which the gas leaves the absorbing vessels. More than one vessel can be cut out at the same time, say in order to give a longer time to each for the distilling (or naphtha separating) and cooling operations. If the vessels of Fig. 8 should be connected in parallel, then one or more of them could have their gas connections closed and be utilized as steam stills for separating the

naphtha from the enriched menstruum and have their gas connections restored, all without practical interruption of the flow of the natural gas between the branches *d* and *i*.

The menstruum to be used in carrying on the above described operations may be any substance or composition having an appropriate affinity for the naphtha vapors and otherwise adapted to the conditions of use. If the absorbed naphtha is to be separated by distillation from the menstruum enriched thereby, it must usually be less volatile than the natural gas naphtha to be obtained, in order to enable the separation to be effected; for unless in exceptional cases liquids of the same boiling point cannot be separated by distillation. Substances, other than hydrocarbons can be used, for example, the fatty oils and their constituent acids, also amyl alcohol, and others; but hydrocarbons are considered most suitable, and especially some form of petroleum, on account of its cheapness and abundance. As suitable non-petroleum hydrocarbons may be mentioned coal tar of gas works, oils derived therefrom, crude oils from distilling coal, shale or schist, and other non-petroleum bituminous substances for oils, products derived from such crude oils, and turpentine oil. Petroleum in almost any of its forms less volatile than the natural gas naphtha to be obtained can be used, as maltha and more fluid crude petroleum, reduced oils, tars, vaseline, distilled oils and so on; but I have discovered that petroleum hydrocarbons with boiling points separated by a considerable temperature interval, say 100 degrees F. or more, from those of naphtha hydrocarbons have a greater affinity for naphtha than those whose boiling points are closer thereto. I believe, however, that petroleum in a form but little less volatile than natural gas naphtha will have some absorbent capacity for the latter.

If the absorbed naphtha is to be separated otherwise than by distillation from the menstruum enriched thereby, the menstruum should be adapted to such separation. Ethyl alcohol sufficiently anhydrous, acetone, mixtures of acetone and methyl alcohol, absorb naphtha and on dilution with water part with it. They are suitable therefore for use where such mode of separation is preferred.

If the absorbed naphtha is not to be separated from the menstruum, the latter should be adapted to serve in connection with the naphtha for the use to which the naphtha is to be put. A petroleum naphtha less volatile than the natural gas naphtha to be absorbed thereby, enriched by such natural gas naphtha might prove a useful product for some purposes. My experience tends to show that considerable pressure or a low temperature or both would be needed to effect the absorption of natural gas naphtha in naphtha which should be less volatile, and it may be that the product would have to be held under pressure in order to retain a suitable proportion of that which should be absorbed.

I have not tried all the substances nor all the modes of working herein mentioned; but I have absorbed naphtha from natural gas and in so doing separated it from the lighter combustible constituents of such gas by causing the natural gas from a well which did not yield oil to bubble up through a body of petroleum distillate of about 30° B. gravity and about 300° F. fire test in a vessel of about 12 inches in diameter under an internal pressure of about 30 pounds to the square inch above atmospheric pressure and at atmospheric temperature; and I have recovered the natural gas naphtha from the menstruum by distillation and condensation. I believe that all the substances and modes of working herein mentioned will operate, and that a pressure of about 300 pounds to the square inch would be preferable to one of 30 pounds.

If a sufficient supply of crude petroleum should be available, it would be best in my opinion to use it for the absorbent menstruum. After the absorbing operation, carried on, say at a pressure of about 300 pounds to the square inch above atmospheric pressure and at about atmospheric temperature, in absorbers of the form shown in Figs. 1 and 2 or in Fig. 5 or in Fig. 8, and with return of the unabsorbed lighter constituents of the gas to the gas line *b* (as described with reference to Fig. 1), the crude petroleum enriched with the absorbed naphtha could advantageously be delivered into say tank *v* of Fig. 1 under approximately atmospheric pressure, or the pressure could be relieved in vessels 54 of Fig. 8, any lighter combustible constituents liberated at this time being withdrawn. One effect of the absorption of the naphtha is to lower the gravity of the absorbent menstruum, and by observation of the gravity of test specimens withdrawn in the absorbing operation, or from tank *v*, the conduct of this operation can be regulated. After reduction of the pressure, the enriched crude petroleum can be distilled in order to separate the absorbed naphtha and the menstruum from each other, in steam still 6 of Figs. 1 and 2 or in the dry heat still of Fig. 4, or in the absorbing vessels 54 of Fig. 8, or in any other still. By this distillation the naphtha of the crude oil, as well as that of the natural gas will be obtained, they being separated together from the residual liquid. This liquid, being the residue of the crude petroleum, would then be utilized by being worked up into burning oil (kerosene) and other products as may be desired. The crude petroleum before or after the separation of naphtha therefrom could be piped any desired distance to the refinery. If the refinery could advanta-

geously utilize natural gas which should be piped to it with the crude petroleum, as indicated hereinabove with reference to Fig. 6, it might well be so piped, absorption of naphtha from the natural gas taking place in transit.

If a sufficient supply of crude petroleum should not be available, it would be best in my opinion to employ a heavy petroleum oil (say the tar of crude petroleum after removal of the burning oil, or else a heavy distillate of 30° B. or heavier) as the absorbent menstruum; and after the absorbing operation and the separation of the naphtha and the menstruum from each other by distillation to utilize the separated menstruum, by subjecting natural gas thereto in order that it may absorb naphtha from the same.

The expression "petroleum or hydrocarbon oil as specified" means primarily a liquid or semi-liquid form of petroleum, which is composed at least largely of hydrocarbons with boiling points a long temperature interval (say an interval of about 100 degrees F. or more) higher than those of the principal hydrocarbons of natural gas naphtha and which may consist of petroleum (or in other words of any natural liquid or semiliquid bitumen) in the crude state or of a product prepared therefrom by reduction, distillation or otherwise; but by extension it includes a liquid or semiliquid which is not a form of petroleum but which nevertheless is composed at least largely of hydrocarbons with comparatively high boiling points as just mentioned; and by extension it also includes in general a liquid or semiliquid which is less volatile than the naphtha of natural gas and is composed at least largely of hydrocarbons.

Mention herein of materials and of modifications in procedure and in apparatus is by way of example and is not exclusive of other modifications within the spirit of the invention.

I claim as my invention or discovery:—

1. The process of obtaining naphtha from combustible gas of natural origin and underground source of the kind supplied by means of wells and pipe lines to cities for consumption therein, which process consists in subjecting such gas in the requisite large amount on the way from its underground sources to its places of consumption and under a high pressure, not less than about thirty pounds to the square inch above atmospheric pressure, to a naphtha absorbing menstruum, and by the aid of the same under said high pressure effecting the separation in industrial quantity from said gas of a natural gas naphtha liquid at atmospheric pressure and temperature and applicable to the uses of petroleum naphtha of similar volatility, substantially as described.

2. The process of obtaining naphtha from combustible gas of natural origin and under ground source of the kind supplied by means of wells and pipe lines to cities for consumption therein, which process consists in subjecting such gas in the requisite large amount on the way from its underground sources to its places of consumption and under a high pressure, not less than about thirty pounds to the square inch above atmospheric pressure, to a naphtha absorbing menstruum, especially petroleum or hydrocarbon oil as specified, and by the aid of the same under said high pressure effecting the separation in industrial quantity from said gas of a natural gas naphtha liquid at atmospheric pressure and temperature and applicable to the uses of petroleum naphtha of similar volatility, and then recovering the naphtha in liquid form from said menstruum by distillation under a low pressure, not more than about atmospheric pressure, substantially as described.

3. The process of obtaining naphtha from combustible gas of natural origin and underground source of the kind supplied by means of wells and pipe lines to cities for consumption therein, which process consists in subjecting such gas in tthe requisite large amount on the way from its underground sources to its places of consumption and under a high pressure, not less than about thirty pounds to the square inch above atmospheric pressure, to a naphtha absorbing menstruum by causing the gas to bubble up through pools of the menstruum, and by the aid of the same under said high pressure effecting the separation in industrial quantity from said gas of a natural gas naphtha liquid at atmospheric pressure and temperature and applicable to the uses of petroleum naphtha of similar volatility, substantially as described.

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

GEORGE M. SAYBOLT.

Witnesses:
BENJ. F. CUMMINGS,
MARY E. DICKSON.