J. B. GARNER AND S. C. PRESTON.

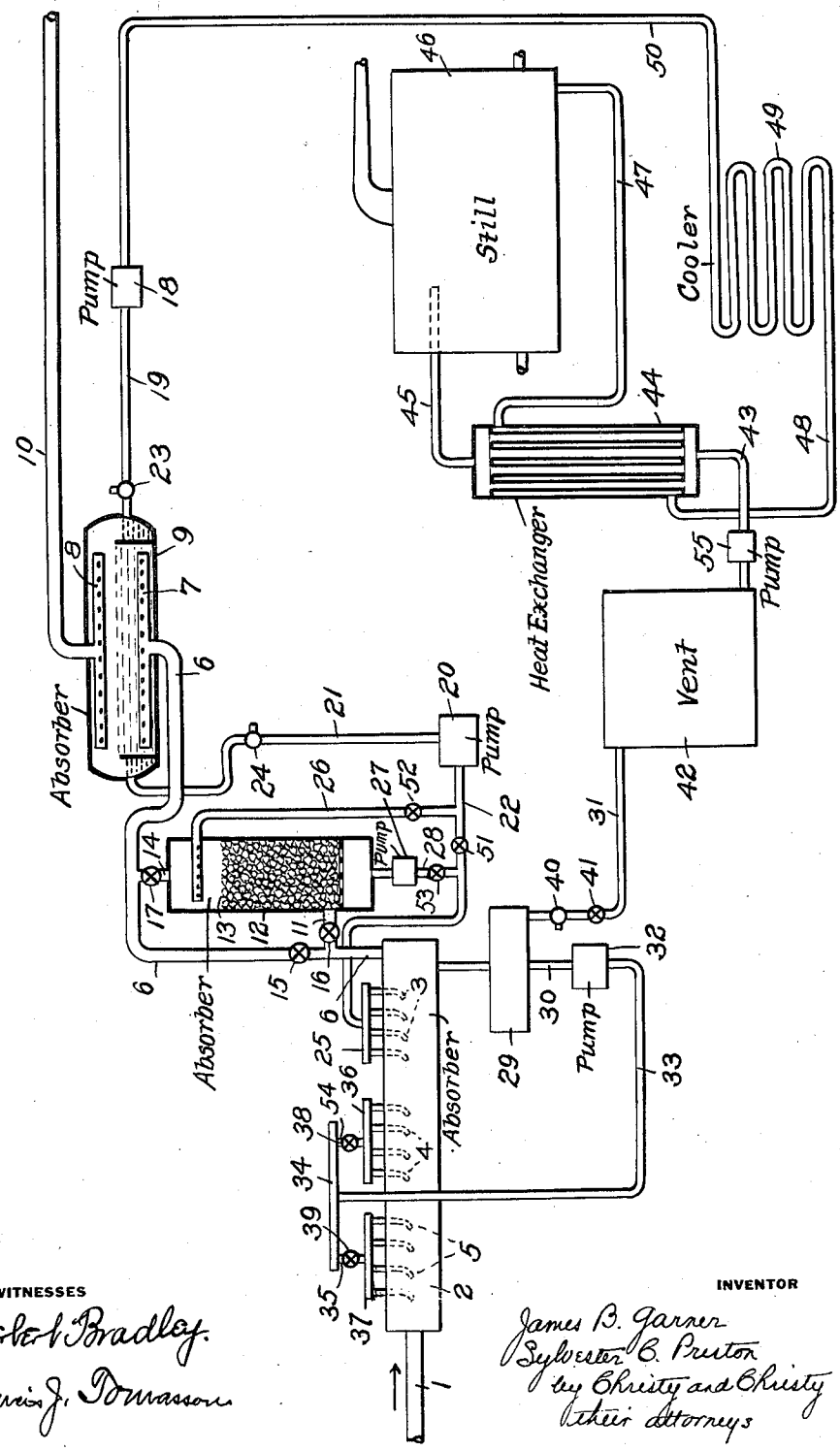
PROCESS OF RECOVERING GASOLINE FROM NATURAL GAS.

APPLICATION FILED FEB. 14, 1920.

1,437,102. Patented Nov. 28, 1922.

2 SHEETS—SHEET 1.

FIG. 1.



WITNESSES

J. Herbert Bradley.

Francis J. Donasson

INVENTOR

James B. Garner
Sylvester C. Preston
by Christy and Christy
their attorneys

J. B. GARNER AND S. C. PRESTON.

PROCESS OF RECOVERING GASOLINE FROM NATURAL GAS.

APPLICATION FILED FEB. 14, 1920.

1,437,102. Patented Nov. 28, 1922.

2 SHEETS—SHEET 2.

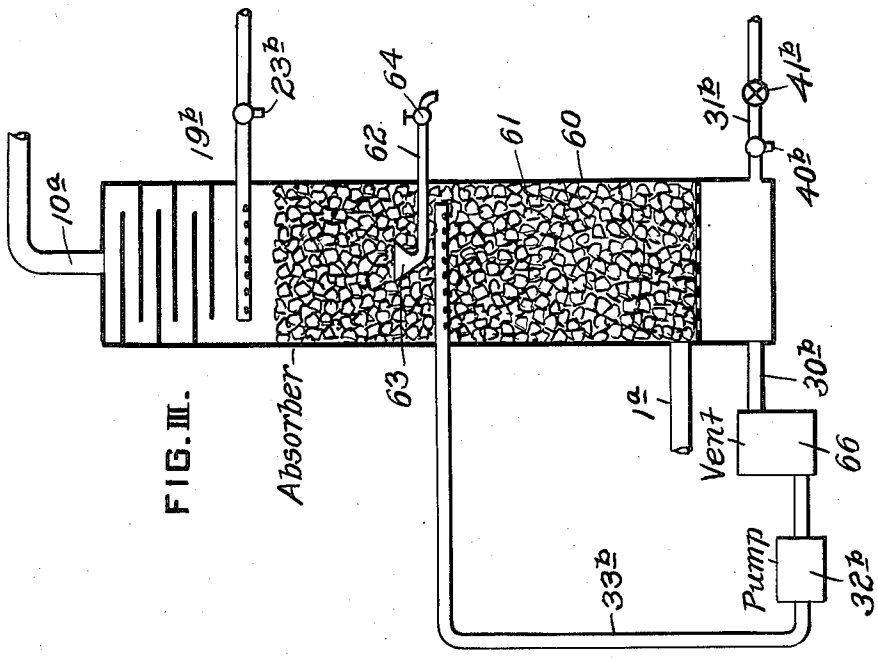


FIG. III.

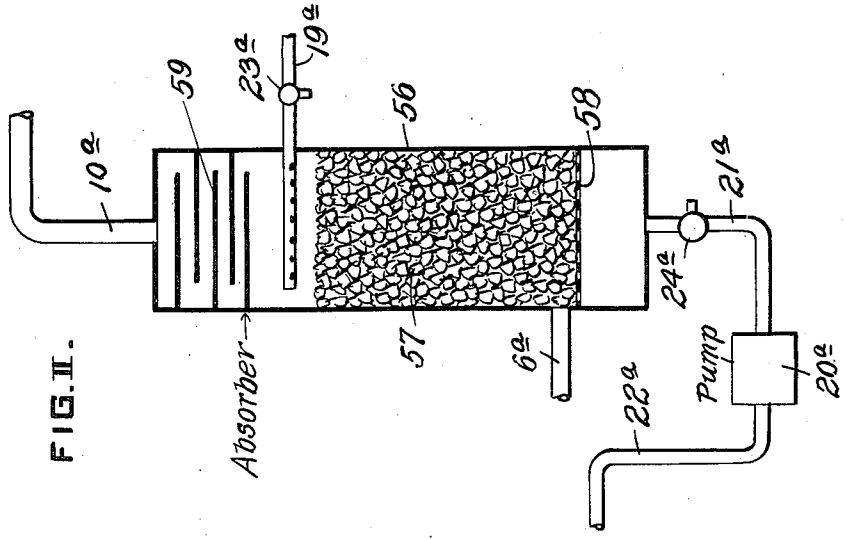


FIG. II.

WITNESSES

J. Herbert Bradley.

Francis J. Donasson

INVENTOR

James B. Garner
Seylvester C. Preston
by Christy and Christy
their attorneys

Patented Nov. 28, 1922. 1,437,102

UNITED STATES PATENT OFFICE.

JAMES B. GARNER AND SYLVESTER C. PRESTON, OF PITTSBURGH, PENNSYLVANIA, ASSIGNORS TO HOPE CONSTRUCTION & REFINING COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF DELAWARE.

PROCESS OF RECOVERING GASOLINE FROM NATURAL GAS.

Continuation of application Serial No. 301,165, filed June 22, 1919. This application filed February 14, 1920. Serial No. 358,730.

To all whom it may concern:

Be it known that we, JAMES B. GARNER and SYLVESTER C. PRESTON, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, both citizens of the United States, have invented or discovered certain new and useful Improvements in Processes of Recovering Gasoline from Natural Gas, of which improvements the following is a specification.

This application is a continuation of and is substituted for our application filed June 2, 1919, Serial No. 301,165.

In United States Letters Patent No. 989,927, granted to G. M. Saybolt, there is disclosed a process for obtaining naphtha or gasoline from combustible gas of natural origin and underground source, or in other words from what is commonly known as natural gas. The method, briefly stated, consists in subjecting the natural gas under pressure to a gasoline-absorbing menstruum for the purpose of separating from the gas such gasoline as is liquid at atmospheric temperatures and pressures, and then preferably removing the gasoline from the menstruum.

The object of our invention is to improve the process disclosed in the above mentioned patent. The process as we have improved it is applicable generally to the recovery of liquids carried in vapor form by gases, and is not limited to the specific case of gasoline recovery from natural gas. This will be noted again in the sequel. In a copending application, Serial No. 339,555, we describe and claim apparatus, in the use of which the process is accomplished.

In the practice of our invention natural gas is passed successively through two bodies of a gasoline-absorbing menstruum, preferably a liquid petroleum hydrocarbon having a specific gravity of from about 28° to 55° Baumé at 60° F., and these bodies are circulated and controlled in such a manner that largely increased percentages of the gasoline content of the natural gas are economically recovered.

The first body of menstruum through which the gas passes is so circulated that, in a subdivided state, it contacts a plurality of times with a flowing body of gas. By thus increasing the number of contacts which the menstruum, in a subdivided state, makes with the gas, we have found that, due to absorption of gasoline from the gas, the Baumé gravity of the menstruum may be raised a substantial amount above that which has heretofore been attained, or, having due regard to the practical considerations of the entire process, have been thought possible to attain. We have found, in point of fact, that the Baumé gravity of the menstruum may be raised as much as eight degrees, and the entire process be otherwise successfully conducted, provided the second body of menstruum through which the gas passes be circulated and controlled in the manner presently to be explained. Among the important incidental advantages of thus building up the Baumé gravity of the menstruum, it may be noted, first, that much less menstruum need be heated for separating or distilling from the menstruum a unit volume of absorbed gasoline, and, secondly, that when the menstruum is used in a closed cycle as is the usual practice, much less cooling facilities need be provided for cooling the menstruum after having been heated.

It will be understood that rise in Baumé gravity means fall in specific gravity, and vice versa.

We have found that, by multiplying the contacts of the first body of menstruum with the gas, and so building up the Baumé gravity of the menstruum, largely increased percentages of the gasoline content of the natural gas may be absorbed. We have found by practice that the gasoline may be absorbed nearly to the theoretical maximum extent: the point at which the partial pressure of the gasoline vapor remaining in the gas is equal to the vapor tension of the gasoline in the menstruum. As a specific example, we have found that, conditioned upon the above mentioned control of the second body of menstruum, the gasoline may be so completely absorbed from the gas that there will remain in the gas only about fifteen gallons of gasoline per million cubic feet of gas, the gas being measured at a pressure of eight ounces above atmospheric and at a temperature of 60° F., whereas in the

process as usually practiced there remains in the gas from fifty to ninety gallons of gasoline per million cubic feet of gas.

Still further, we have found that by multiplying the contacts of the first body of menstruum with the gas, certain lighter constituents of the gas, not desired in the gasoline, though initially absorbed by the menstruum, are, as the operation progresses, to a considerable extent displaced by desired constituents. Thus, less separating of the lighter constituents from the menstruum is required after absorption and prior to the separation of the gasoline from the menstruum.

The second body of menstruum through which, according to our invention, the gas passes, is so controlled that the absorption of gasoline by the menstruum will raise the Baumé gravity of the menstruum but a small amount, as compared with the rise in specific gravity of the first body of menstruum. Preferably, the gravity of the second body of menstruum is not permitted to decrease more than will be indicated by a rise of 1° Baumé. We have found that the above described beneficial results arising from the repeated contacts of the first body of menstruum with the gas may be realized only by controlling the second body of menstruum in the manner just explained.

The first body of menstruum may be subdivided in any suitable manner, as for example, by means of spray nozzles, or by being caused to flow downwardly through a vertical absorber provided, in the well known manner, with a mass of coke, broken rocks, steel turnings, lattice work of lath, or other equivalent. The second body of menstruum is preferably maintained in the form of a pool through which the gas bubbles. In such a pool particles of the menstruum carried by the gas from the subdivided first body of menstruum are filtered out with substantial completeness. However, the second body of menstruum may, as the gas passes through it, be in a subdivided state, the menstruum, for example, being caused to flow through such a vertical absorber as has just been characterized.

In the accompanying drawings we have diagrammatically illustrated the general construction and arrangement of apparatus for practicing our invention. Figure I shows a complete layout of apparatus, and Figures II and III show absorbing units adapted to be used in the general arrangement of apparatus shown in Figure I.

Having reference first to Figure I, natural gas from a suitable source of supply, and under any desired pressure, flows through a pipe 1 into a horizontally disposed spray absorber, consisting of a tank 2 within which is arranged a plurality of sets of spray nozzles 3, 4, and 5. From the tank 2 the gas may be caused to take either of two courses. It may flow through a pipe 6 to a perforate header 7 in a pool absorber 9, and, caught again in a second perforate header 8, it may flow from the pool absorber through a pipe 10 to the point of consumption; or, prior to flowing through the pool absorber 9, the gas may flow through pipe 11 into a vertical tower absorber 12 provided interiorly with means, such as a mass of broken stones 13, by which a descending stream of menstruum is subdivided. From the tower absorber 12 the gas flows through pipes 14 and 6 to the pool absorber 9, and thence through pipe 10. For controlling such alternative flow of gas, the pipes 6, 11, and 14, are provided with suitable valves 15, 16, and 17, as indicated in the drawing. The alternative flow of gas is here shown, primarily for the purpose of illustrating two arrangements of plant construction. In practice, the tower absorber 12 may or may not be present.

The menstruum is preferably caused to flow continuously through the absorbers counter current to the flow of gas. As indicated in the drawing, the oil which forms the above described second body of menstruum is, by means of a pump 18, caused to flow through a pipe 19 into one end of the absorber 9, and forms a pool therein, through which bubbles the gas discharged through the perforations in the header 7.

From the absorber 9 the menstruum is, by means of a pump 20, continuously withdrawn through a pipe 21 and discharged into a pipe 22, through which it is conducted in a manner presently to be explained. The rate of flow of the menstruum through the absorber 9 is so governed and controlled that the rise in Baumé gravity is much less than the rise of the first body of menstruum. As previously stated, the rise in Baumé gravity of the menstruum while in the absorber 9 is preferably not more than about 1°. For maintaining such control of the gravity of the menstruum, samples thereof may from time to time be taken from the pipes 19 and 21 (suitable pet-cocks 23 and 24 being provided for this purpose), and the Baumé gravity of the samples compared.

The menstruum pumped into the pipe 22 may be conducted directly through such pipe to a header 25 to which the several spray nozzles 3 of the absorber 2 are attached, or it may be carried first through the vertical absorber 12, provided the plant includes such an absorber, and afterward introduced into absorber 2. When it is to be introduced into the vertical absorber 12, the menstruum flows from pipe 22 through a pipe 26; pipe 26 entering the upper end of the tower 12 and is provided with perforations through which the menstruum is discharged in subdivided streams upon the top of the body of broken stone 13. The menstruum, sub-

divided further, flows downwardly through the tower, is collected at the bottom, and, by means of a pump 27, is discharged through a pipe 28, back into the pipe 22, and thence to the header 25. The pipes 22, 26 and 28 are provided with the valves 51, 52, and 53 for controlling the described alternative flow of the menstruum to the header 25.

Various means may be provided for causing the menstruum in the spray absorber 2, the first body of menstruum as we herein consistently designate it, to contact in subdivided state a plurality of times, with the gas flowing through the absorber. In the apparatus shown in the drawing the right-hand end of the absorber 2 is connected to a trap or sump 29, into which menstruum collecting in absorber 2 descends. To the sump two pipes 30 and 31 are connected, the former leading to a pump 32, and the latter leading to apparatus, presently to be explained, for separating from the menstruum its absorbed gasoline as well as lighter normally gaseous constituents. A pipe 33 leads from pump 32 to a header 34; and header 34 in turn is, by means of branch pipes 54 and 35, connected to branch headers 36 and 37, to which the two series of spray nozzles 4 and 5 are attached. The pipes 54 and 35 are preferably provided, respectively, with controlling valves 38 and 39, and the spray nozzles 5 are preferably constructed to divide the menstruum into a finer spray than do the spray nozzles 4. Preferably, also, the spray nozzles 4 divide the menstruum into a finer spray than do the nozzles 3. The desired degree of fineness of spray may be controlled and determined by proper regulation of valves 38 and 39.

The pump 32 is of such capacity and run at such speed that it circulates the menstruum the number of times required to obtain the desired number of contacts of the gas with the menstruum. For example, if it were desired to multiply six-fold the contact of menstruum with gas, the pump 32 would be so operated that the number of gallons of menstruum pumped per minute would be five times the number of gallons of menstruum flowing per minute through the sprays 3 into the absorber, the rate of flow of the menstruum from the absorber 2 through the pipe 31 being maintained the same as the rate of flow of the menstruum through the nozzles 3 into the absorber 2. Thus one contact of the menstruum would be made by the menstruum issuing from the nozzles 3 and the remaining five contacts would be made by the menstruum issuing from the nozzles 4 and 5.

For ascertaining the Baumé rise in gravity of the menstruum, due to its repeated contacts with the gas in the absorber 2, samples of the menstruum may from time to time be withdrawn from the pipe 31, through a pet-cock 40, and the gravity of such samples compared with the gravity of samples removed through the pet-cock 24 in pipe 21. If the Baumé rise in gravity is not as great as it should be, the pump 32 may be operated at increased speed, to effect an increased number of contacts. As previously stated, we have found that the gravity of the first body of menstruum, that is to say the menstruum in the absorber 2, may be advantageously raised 8° Baumé. We have found this to be true of natural gas containing initially about 500 gallons of gasoline per million cubic feet of gas. The gravity may be raised less or more than 8° Baumé, depending to some extent upon the amount of gasoline in the gas.

The menstruum flowing from the absorber through the pipe 31 may flow under the pressure of the gas in the absorber 2, the rate of flow being regulated by a valve 41 so as to be equal to the rate of flow of the menstruum through the pipe 22 into such absorber. From the pipe 31 the menstruum may flow into a vent tank or primary still 42, where such lighter normally gaseous constituents as have been absorbed may under atmospheric pressure (with substantial completeness) escape. From the tank or still 42 the menstruum flows, or is pumped by means of a pump 55, through pipe 43, heat exchanger 44, and pipe 45, to a still 46, in which the absorbed gasoline is removed in the form of vapor. Subsequently the vaporous distillate is condensed in the usual, or in any desired, manner. Distillation and condensation are conducted at or above atmospheric pressure, preferably at a pressure of about 25 pounds above atmospheric pressure. The heated menstruum flows from the still, through a pipe 47, back through the alternate passages of the heat exchanger 44, and thence through pipe 48, cooler 49, and pipe 50, to pump 18, for recirculation through the absorbers.

The second body of menstruum is, according to the designation which we consistently employ, the body through which the gas last passes, the body from which the gas emerges to flow directly to the point of consumption. The first body of menstruum is all of the menstruum through which the gas passes, prior to passage through the second body so defined. That the two bodies of menstruum may be variously brought into contact with the gas will be understood, when we shall have described the process as practiced with the use of the modified forms of absorbers shown in Figures II and III.

Instead of maintaining the second body of menstruum in the form of a pool, it may be subdivided, as by being caused to

flow downwardly through a vertical absorber or coke tower 56 such as diagrammatically shown in Fig. II. The tower may be provided with a mass of broken stone or coke 57, over the top of which the menstruum, entering the tank through the pipe 19^a, is sprayed. At the bottom of the tower the menstruum is collected and flows through a pipe 21^a to a pump 20^a whereby it is discharged into the pipe 22^a, which corresponds to pipe 22 of Fig. I and leads to the primary absorber or absorbers. Through pipe 6^a gas from the primary absorber or absorbers enters tower 56, and, after passing upward through the menstruum-inundated mass of broken material 57 escapes through pipe 10^a to the point of consumption. To remove from the gas such particles of menstruum as might otherwise be carried off by it, baffles such as the alternately arranged plates 59 may be arranged in the upper portion of the tower. Thus it will be seen that the vertical tower 56 may be used in place of the pool absorber 9 in the complete assembly of units illustrated in Figure I.

Instead of using separate vessels for the first and second bodies of menstruum, a single vessel may be used, such for example as shown in Figure III. The absorber there illustrated is a tower 60, provided in the usual manner with a mass 61 of broken stone or the like. The menstruum enters the tower 60 through the pipe 19^b, flows downwardly over the mass 61, and is collected in the bottom of the tower, from which two pipes 30^b and 31^b lead off. By means of a pump 32^b the menstruum flowing in pipe 30^b is recirculated, to contact a plurality of times with gas flowing upwardly through the lower portion of the tower 60, the pipe 33^b on the discharge side of the pump entering the tower 60 about midway of its height. If desired, a vent tank 66 may be provided, whereby the menstruum flowing through the pipe 30^b may be vented for the removal of lighter normally gaseous constituents initially absorbed. A vent tank so situated may be added to the apparatus shown in Fig. I and will be found advantageous in case, when the menstruum being re-circulated carries appreciable quantities of such lighter constituents. As explained with reference to Fig. I, the menstruum from the tower 60 is caused to flow through the pipe 31^b at the same rate as it flows through the pipe 19^b. Between and connected to the pipes 31^b and 19^b there may be arranged the same apparatus for treating the menstruum as is shown in Figure I between the pipes 31 and 19.

The gas enters the bottom of the tower 60 from a supply line 1^a, flows upwardly through the first and second bodies of menstruum (which two bodies of menstruum are in this case not otherwise separated or demarcated than by the entrance of the eddy stream, through pipe 33^b), and flows from the tower into the pipe 10^a.

For controlling the Baumé rise in gravity of the second body of menstruum, samples thereof may from time to time be taken at the pet-cock 23^b and, by means of a pipe 62 arranged immediately above the end of pipe 33^b, the inner end of the pipe 62 being provided with a cup 63, at pet-cock 64.

From the foregoing it will be seen that the second body of menstruum may be either in the form of a pool or in subdivided state when brought into contact with the gas, and that the first and second bodies of menstruum may be either in separate vessels or in a single vessel. If desired, the first body of menstruum may perform its function through a series of separate absorbers, rather than in a single absorber. This is clear from a consideration of the apparatus of Figure I, in which the first body of menstruum flows through two absorbers. Manifestly, and without further illustration, the number and type of such independent absorbers may be indefinitely multiplied. In all cases, however, a relatively small Baumé rise in gravity of the second body of menstruum is maintained, as compared with that of the first body. We have found it to be impossible to absorb from the gas absolutely all of the gasoline which it carries, for the reason that the gasoline absorbed by the menstruum builds up in the menstruum a vapor tension which counterbalances the partial pressure of the gasoline remaining in the gas. Hence there is always remaining in the gas after the gas passes through the last body of menstruum some percentage of the amount of gasoline originally in the gas. During a day's run, in which 96.6% of the gasoline was recovered, 19,000 cubic feet of gas per hour were passed through the two bodies of menstruum. The menstruum consisted of liquid petroleum the initial gravity of which was about 39° Baumé. The pressure of the gas ranged from 56 to 61 pounds above atmospheric pressure, and the temperature of absorption ranged from 52° to 66° F. The first body of menstruum was recirculated in a spray absorber to contact four times with the gas, and its Baumé rise in gravity was 6.7°, while the Baumé rise in gravity of the second body of menstruum was maintained at about 1°. The gas before being treated contained 767 gallons of gasoline per million cubic feet of gas, and the gasoline recovered from the gas was 741 gallons per million cubic feet of gas treated. The apparatus was of the same type and arrangement as that shown in Figure I of the accompanying drawings, including the tower

absorber. 354 gallons of oil per hour were caused to flow through the pool absorber, a rate of about one gallon of oil to 54 cubic feet of gas.

The rate of flow of the menstruum is, in the practice of our invention, controlled with reference to the Baumé rise in gravity of the second body of menstruum. If such rise in gravity is higher than is permissible, according to our discovery of conditions affording maximum recovery, the first body of menstruum should be re-circulated at increased speed to increase the number of contacts with the gas. If such re-circulation does not, by increased absorption of gasoline, have the effect of cutting down the Baumé rise in gravity of the second body of menstruum, then (having reference to the apparatus of Figure I) the rate of flow of menstruum into and from the pool absorber 9 should be increased. Such increase of flow of the menstruum will of course necessitate an equal increase in the rate of flow of menstruum through the pipe 31. As previously stated, the first body of menstruum should be re-circulated a sufficient number of times to effect a large rise in the Baumé gravity thereof.

In the practice of our invention the gas may be treated under any desired pressure. As compared to the amount of gasoline recovered from the gas when treatment of the gas is under the customary high pressure of fifty or more pounds per square inch above atmospheric pressure, we have found that as much gasoline may be recovered when the gas is under a pressure of twenty pounds per square inch above atmospheric pressure or less, provided the contacts of the first body of menstruum with the gas be sufficiently repeated, and provided further that the rise in Baumé gravity of the second body of menstruum be controlled in the manner explained above.

It will be observed that, with the apparatus and according to the method now described, the stream of gas advancing counter-current to a stream of menstruum meets the stream of menstruum at successive points, and that superior conditions of absorption are maintained where the gas initially encounters the menstruum than where it ultimately encounters it. These superior conditions consist in an eddy in the menstruum stream, wherein menstruum flow is accelerated, and more or less the same bodies of menstruum are brought into repeated absorption-affording contact with the gas.

We have in the foregoing specification described our invention in specific application to the recovery of commercial gasoline from natural gas. It will be understood without further elucidation that it is a process applicable wherever a substance normally liquid is carried in vapor form by gas. In the ensuing claims we make plain the fact that the invention is of such broader aspect. And one thing more should be said: it is not necessary (although the matter so stands when gasoline is being recovered) that the absorbing menstruum be heavier than the recovered liquid; indeed, in case of the recovery of benzole from the gases which ordinarily carry it in vapor form, the absorbent liquid used will ordinarily be lighter than the benzole recovered. Accordingly, in such case, as the operation progresses, the menstruum will not, as in the case of gasoline recovery, decrease in specific gravity as the operation progresses, but will in fact increase in specific gravity, and in such case it will be understood that the process is accomplished in so adjusting the apparatus and so governing the operation relatively part to part that the specific gravity of that body of menstruum through which the stream of gas first passes will increase (not decrease) through a wider range than will the specific gravity of that portion or body of menstruum through which the gas finally passes, while the range of variation in specific gravity is variable and controllable, in the manner already described.

We claim as our invention:

1. The herein described step in the process of recovering a substance normally liquid from a gas carrying it in vapor form, which consists in forming an eddy in a flowing stream of vapor-absorbing menstruum, and passing the gas first through the eddy and subsequently through the menstruum at a point farther up the stream.

2. The herein described step in the process of recovering a substance normally liquid from a gas carrying it in vapor form, which consists in forming an eddy in a flowing stream of vapor-absorbing menstruum, circulating the menstruum in the eddy to contact with the gas a plurality of times and absorb the vapors therefrom, bringing the gas again into absorption-affording contact with the menstruum at a point further up the stream, and regulating the amount of the absorption at said second point.

3. The process of separating vapor of a normally liquid substance from entraining gas, which consists in causing the gas to flow in a stream into absorption-affording contact with a counter-current of vapor-absorbing menstruum, first in an initial chamber and subsequently in a succeeding chamber, continuously circulating a branch current of the menstruum at relatively high speed through, around, and again through said initial chamber, and limiting the absorption in said succeeding chamber to a predetermined relatively small amount.

4. The process of recovering gasoline from natural gas, which consists in causing the gas to flow into absorption-affording

contact successively with two bodies of gasoline-absorbing menstruum, circulating the first body of menstruum to contact with the gas a plurality of times and absorb gasoline therefrom, and limiting the absorption in the second body to a predetermined relatively small amount.

In testimony whereof we have hereunto set our hands.

JAMES B. GARNER.
SYLVESTER C. PRESTON.

Witnesses:
GEORGE A. SHANER,
FRANCIS J. TOMASSON.