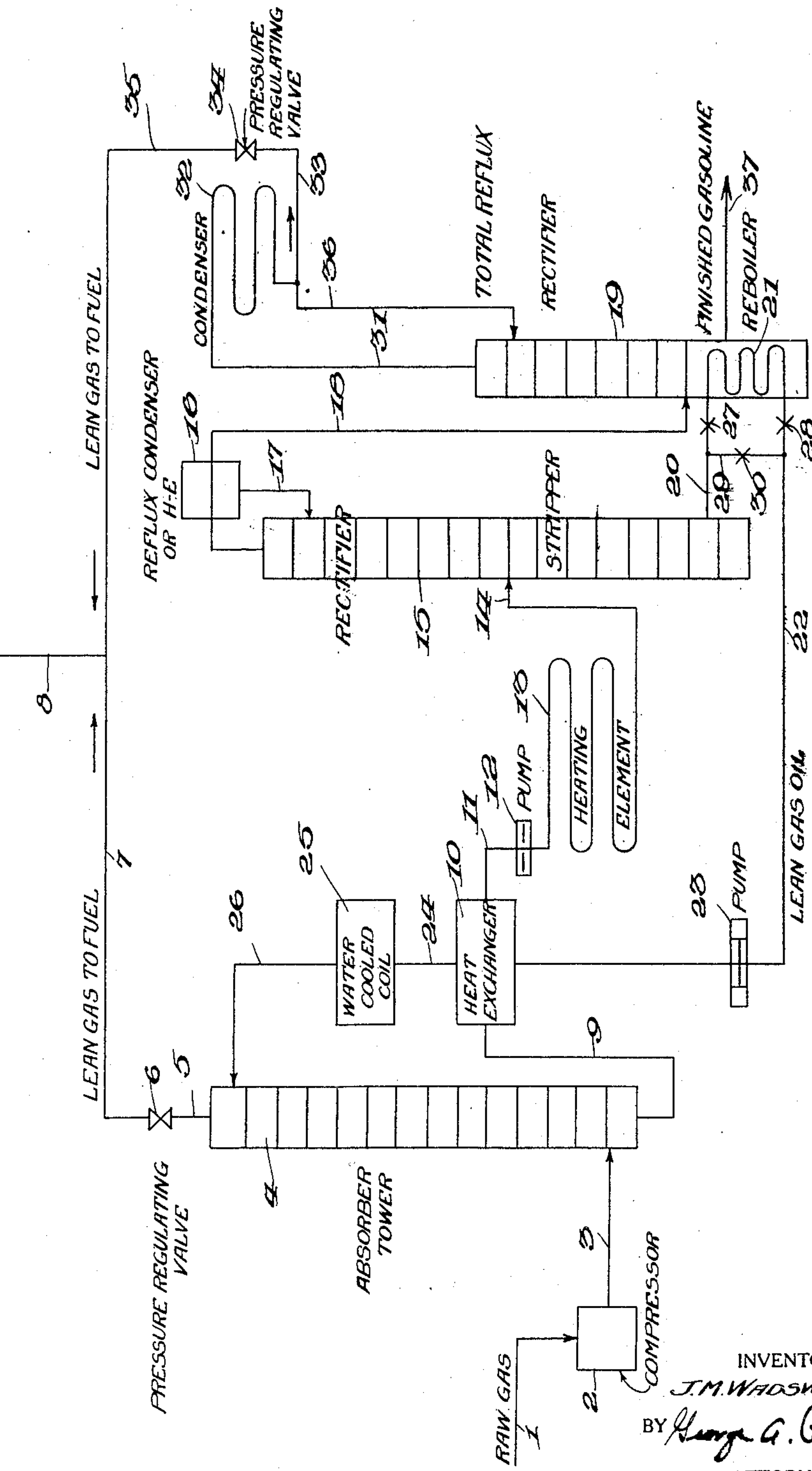
March 29, 1932. J. M. WADSWORTH 1,851,743

PROCESS AND APPARATUS FOR TREATING NATURAL GAS

Filed April 1, 1926 2 Sheets-Sheet 1

Fig. 1.



INVENTOR
J. M. WADSWORTH,
BY George G. Prevost
ATTORNEY.

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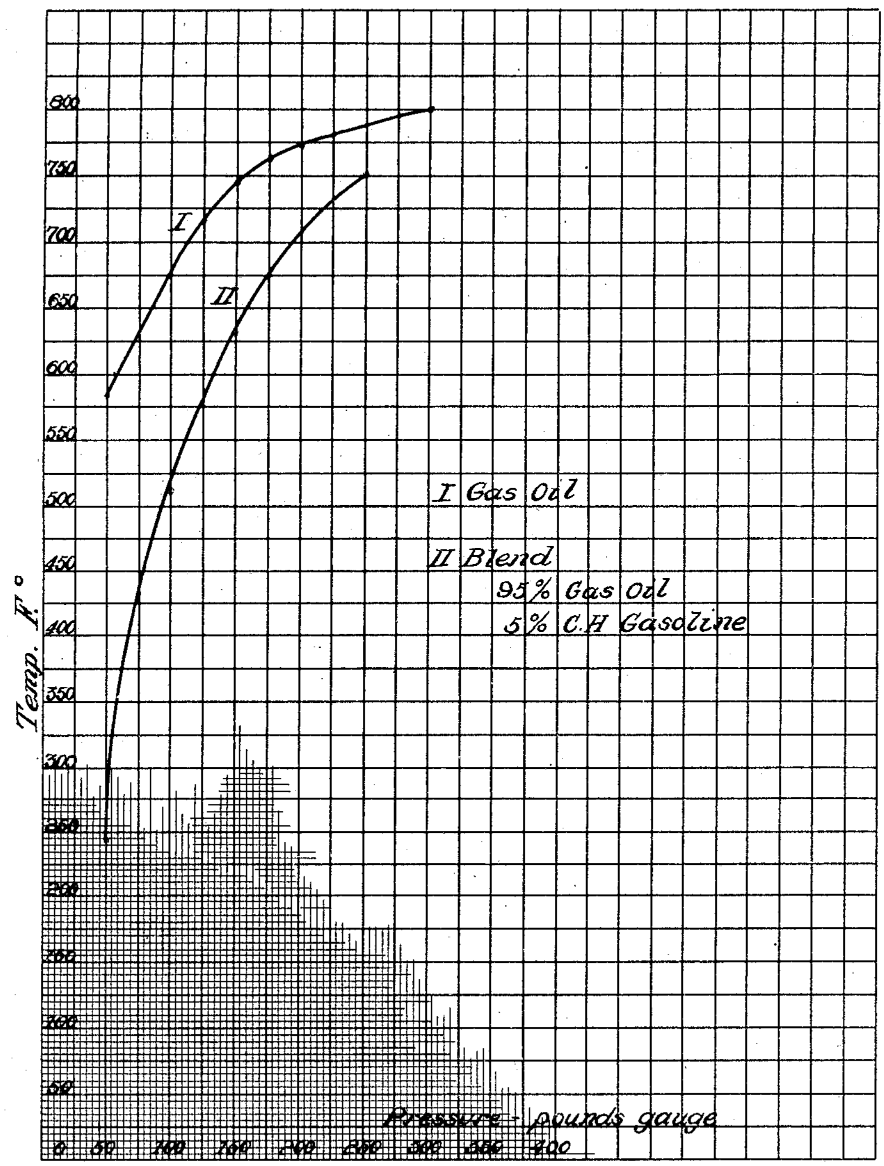

Fig. 2

Inventor
J.M. Wadsworth

By George A. Prevost

Attorney

Patented Mar. 29, 1932 1,851,743

UNITED STATES PATENT OFFICE

JAMES M. WADSWORTH, OF SAND SPRINGS, OKLAHOMA

PROCESS AND APPARATUS FOR TREATING NATURAL GAS

Application filed April 1, 1926. Serial No. 99,008.

This invention relates to an improved method and apparatus for making finished gasoline from natural gas, and more particularly to a novel method and apparatus for stripping gasoline from absorbent oil and rectifying said gasoline.

It is customary in the natural gasoline industry, to pass natural gas through a tower and to contact the gas in said tower with a liquid absorbent, such as oil; to subsequently distill the gasoline vapors from the absorbent oil, and to finally retify the gasoline, in order to remove propane, ethane and methane, by resorting to extremely low cooling temperatures or the use of an after compresser.

The primary object of the present invention is to improve this system, and to this end I utilize the vapor pressure of the absorbing oil enriched by the gasoline vapors, to build up any desired pressure in the distilling apparatus, so that proper rectification of the light gases can be obtained without resort to extremely low temperature cooling mediums in the reflux condensers, or extremely high compression in the compressors. In my system, the distilling apparatus itself becomes a compressor, in which the heat is in part converted to work in compressing, and better thermal efficiency is realized in this conversion of heat to work than is accomplished by mechanical means.

The graphs, made a part of this specification, illustrate the vapor pressure set up at different temperatures by an ordinary 34° Bé. gravity gas oil, and a blend of this gas oil with five per cent of casing head gasoline to the gas oil, very considerably raises the vapor pressure for any given temperature, and that sufficient pressure can be obtained through the use of this phenomena for the rectification of gasoline vapors before cracking temperature of the mixture is reached. It has been found in practical operation that the fractionation of these gasoline vapors from the uncondensible gases can be very satisfactorily done at pressures not in excess of 200 lbs. gauge, with ordinary cooling water conditions. In the method, as described, it is possible to vary the operating pressure of the system, of course, through the range of vapor pressure set up by the mixture of absorbent oil and vapors undergoing treatment, and it is also possible to considerably increase the operating pressure through the selection of an absorbent medium of higher vapor pressure. In operating the system, it is necessary to maintain a pressure through utilization of the vapor pressure of the mixture of absorbing oil and vapors, so that the gasoline to be recovered exists in the liquid phase at normal cooling water temperatures.

From the foregoing it will be understood that another object of my invention is to provide a novel method of securing the necessary pressure for proper rectification of the light gases, so that said gases may be rectified under ordinary cooling water temperatures. With the system which I have devised, it is possible to retain a relatively large percentage of butane in the rectified gasoline, so that the latter may be used for blending, or I may eliminate substantially all of the butane, so as to obtain a finished gasoline practically free of butane and lighter gases, and this gasoline may be sold directly to filling stations without resorting to blending.

With the foregoing objects outlined and with other objects in view which will appear as the description proceeds, the invention consists in the novel features hereinafter described in detail and illustrated in part in the accompanying drawings, and more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a diagrammatic view of my improved apparatus employed in carrying out the new process.

Fig. 2 shows graphs illustrating the vapor pressures set up at different temperatures, in treating certain substances.

In the drawings, 1 designates the pipe for the incoming raw natural gas, which if it is not under sufficient pressure, is discharged into a compressor 2, the latter forcing the compressed gas through a pipe 3 into the lower end of an absorbing tower 4, which is preferably of the bubble plate type. The denuded or lean gas which leaves the top of the tower by pipe 5, passes through a pressure regulating valve 6 into the discharge line 7 which has an outlet 8. By means of the valve 6, any desired pressure may be maintained in the tower 4.

The absorbent oil containing the absorbed gasoline vapors which it has extracted from the gas, leaves the lower end of the tower by way of pipe 9 and passes through a heat exchanger 10, which is heated by the absorbent oil after the latter has left the distilling column, which will be described hereinafter. The preheated mixture of oil and gasoline leaves the heat exchanger by way of pipe 11 and enters a pump 12, which forces the mixture through the main heating element 13, from which it is finally discharged by pipe 14 into the rectifier-stripper 15. This rectifier-stripper is a combination of a stripping still and a rectifying column, and at its upper end it is provided with a reflux condenser or heat exchanger 16. The heated mixture of absorbent oil and gasoline enters the column 15 under pressure and is maintained under pressure in this column. In the column the mixture undergoes fractional distillation, gasoline vapors passing upwardly and the condensates of the absorbent oil moving downwardly. This action is facilitated by the reflux condenser 16, which functions to condense a portion of the vapor, and this condensate is fed back into the column by way of pipe 17. The gasoline vapor which is not condensed in 16, passes through pipe 18 and enters the rectifier 19. The heat for this rectifier may be provided by any suitable means but for economic reasons, I prefer to heat the same in the following manner. The absorbent oil in its heated condition leaves the bottom of the tower 15 by way of pipe 20 and passes into a coil 21 arranged within the lower portion of the rectifier 19. The absorbent oil leaves the coil 21 by pipe 22 from which it enters a pump 23 and is forced through the heat exchanger 10, then through a pipe 24, water cooled coil 25, and pipe 26 back into the top of the absorber tower 4. Valves 27 and 28 are provided to regulate the flow of the oil through the coil 21, and a by-pass pipe 29 is arranged between the pipes 20 and 22 for by-passing some or all of the stripped absorbent oil if necessary. A valve 30 is arranged in the by-pass 29.

The rectifier 19, also operates under pressure and the lightest vapors pass out of the top of the column through a pipe 31 and enter a condenser 32. Uncondensed gases pass from the condenser 32 by way of pipe 33, pressure regulating valve 34, and pipe 35, into the discharge line 7. Condensate from the condenser 32 passes through pipe 36 and is reintroduced into the upper portion of the rectifier. The finished gasoline is removed by pipe 37 from the lower portion of the rectifier 19.

In operation, the compressor and pumps are so actuated as to facilitate the maintenance of certain pressures, and the pressure regulating valves are also set to keep the desired pressures in the various points of the apparatus. The enriched absorbing oil is moved through the heat exchanger 10, by means of the initial pressure in the system, and then this enriched oil is forced by the pump 12 through the heating element 13. This pump forces the preheated enriched oil into the tower 15, which is also of the bubble-cap plate type. As before stated, the upper portion of this stripping column serves as a rectifier and is equipped with the reflux condenser or heat exchanger 16, in which a portion of the vapor leaving the column is condensed and returned to the head of the column. The uncondensed vapor from the member 16 passes through pipe 18 and enters the rectifier 19 slightly below the middle of the latter. Vapor leaving the top of the column 19 enters the condenser 32 from which all the condensate is returned to the top of the tower 19 as a reflux. The uncondensed or dry gas passes out by way of the valve 34, while the finished gasoline, stabilized to the desired degree, is discharged from the lower end of the column 19.

In a specific example, raw natural gas enters the plant through the pipe 1, and passes to the inlet of the compressor. This gas is compressed up to about 30 or 40 lbs. pressure above atmospheric, and discharged into the bottom of the absorption tower 4, where the uprising gases are scrubbed with lean absorption oil entering the tower through the conduit 26, at about 70° F. temperature. The gases leaving the tower through the pipe 5 and pressure regulating valve 6, pass direct to a point of consumption, and they test from zero to about one-quarter gallon gasoline content per M. cubic feet by the charcoal method.

The completeness of the gasoline removal on these gases depends, of course, upon the amount of absorption oil used per foot of gas, and when properly supervised, the gases can practically be denuded of all gasoline. The lean absorption oil entering the absorption tower through line 26, tests:

Gravity	33–34
Initial	300–400
% over at 410	Max. 1%

The enriched absorption oil leaving the bottom of the absorber through the pipe 9, passes through the heat exchanger counter current to the lean absorption oil, and the temperature on this heat exchanger averages about as follows:

Enriched oil, in at 70 and out at 300–375.

Lean oil, in at 500–550 and out at 150–175.

Enriched absorption oil leaving the heat exchanger through the conduit 11, enters the pump 12 from which it is discharged into the heating coil 13 under a pressure of 175 to 250 lbs. This coil is heated from 500 to 600° F., and the hot oil and vapors from this coil enter the rectifying tower 15 near the bottom of the tower, as the lower portion of this tower is used for stripping purposes. Tower 15 is refluxed by a condensate from the water cooled condenser 16. The condensate enters the tower 15 at a temperature of about 70 to 80° F., and the temperature maintained at the top of this tower is about 75 to 200° F., such temperature depending upon the end point of the gasoline that is being recovered. The temperature at the bottom of the tower 15 averages about 500 to 550° F. Gases remaining uncondensed from the reflux condenser 16, pass to the second column 19, and enter this column a few trays from the bottom. This tower operates at a temperature of around 80 to 125° F. at the top, and about 275 to 300° F. at the bottom, and heat is supplied by passing the lean absorption oil from the column 15 through the coil 21.

Gases leaving the top of the tower 19, pass through the line 31, and a condenser 32, and everything that will condense at 70° F., is condensed in the coil 32. Uncondensed gases from this coil are vented through valve 34, and everything that condenses is returned to the tower through the line 36.

During such operation, the pressure on the two towers is carried between 50 and 75 lbs. However, it will be evident that with the temperature of the condenser 32 at 70° F., and a pressure around 50 lbs., no propane is refluxed, but a considerable amount of butane is returned to the column 19, through the pipe 36. The gasoline made under the conditions stated, tested:

Gravity	85–90
Initial	50–70
End point	250–350
Recovery	95
Color	25–30 Saybolt.

It will be noted that this initial boiling point would indicate the gasoline contained considerable butane, and at the same time, had a recovery of 95%, so that it was a stable product. I would like to emphasize, however, that in operating, as above stated, the pressure carried on the fractionating towers 15, 19, is not as high as is desirable in producing a gasoline containing all the recoverable butane. On the other hand, if one wishes to make a gasoline that is free of butane, the columns 15 and 19 will be run at somewhat lower pressures. Butane free gasoline is used at the present time for aviation purposes.

By properly controlling the pressure on the system for any cooling water condition, it is possible to make a gasoline in the tower 19 which will contain, in addition to hexane and pentane, all or most of the butane, and at the same time, to sharply fractionate out the propane. It is equally possible to make a gasoline containing hexane and pentane from which all the butane and propane has been separated.

From the above it may be understood, in my improved system the vapor pressure of the enriched absorbing oil is utilized to build up any desired pressure on the distilling apparatus so that the proper rectification of the light gases can be obtained without the necessity of working under extremely low cooling temperatures or using after compressors. The still 15 itself becomes a compressor in which the heat is in part converted to work in compressing, and better thermal efficiency is realized in this conversion of heat to work than can be obtained by mechanical means.

It is believed that the foregoing disclosure will enable those skilled in the art to construct my apparatus or carry out my process, and I am aware that changes may be made in details disclosed without departing from the spirit of the invention as expressed in the claims.

What I claim and desire to secure by Letters Patent is:—

1. In a gasoline recovery process wherein gasoline vapor is extracted from gas by the use of absorbent oil, passing the vapor enriched oil in heated condition and under super-atmospheric pressure into a first rectifying column, passing gasoline vapor from the top of said column to a second rectifying column, releasing uncondensed gases from the second column through a pressure regulating valve, utilizing said valve to maintain pressure within both of said columns, and utilizing the vapor pressure of the enriched absorbing oil to build up sufficient pressure in both columns to sharply fractionate the materials undergoing treatment at relatively high super-atmospheric temperatures.

2. In a process for separating gasoline from absorbent oil and rectifying said gasoline, rectifying a mixture of absorbent oil and gasoline under super-atmospheric pressure to separate the gasoline vapors from the oil, then rectifying the gasoline vapors to separate lighter gases therefrom and maintaining a predetermined super-atmospheric pressure during the said rectifications by utilizing the vapor pressure of the enriched absorbing oil.

3. A process for separating gasoline from absorbent oil and rectifying said gasoline, consisting in charging a heated mixture of absorbent oil and gasoline vapors under pressure into a rectifying column, separating oil from the gasoline vapors in said column, passing the gasoline vapors to a second rectifying column, passing vapors from the second column through a reflux condenser, passing condensate from the reflux condenser back to the top of the second column, dis-

charging uncondensed gas from the reflux condenser through a pressure regulating valve, discharging gasoline from the second column, and utilizing the vapor pressure of the enriched absorbing oil to build up a predetermined super-atmospheric pressure in said columns.

4. A process of the character described consisting in charging gasoline vapor enriched absorbent oil under pressure and in heated condition into a first rectifying column, passing vapors from the top of said column into a reflux condenser, returning condensate from said condenser to the upper portion of said column, passing uncondensed vapor from the condenser to a second rectifying column, discharging the denuded absorbent oil from the lower portion of said first column, passing vapor from the upper portion of the second column to a second reflux condenser, discharging uncondensed gases from the second condenser through a pressure regulating valve, passing condensate from the second condenser into the upper portion of the second column, and discharging finished gasoline from the lower portion of the second column.

5. A process as claimed in claim 4, in which the denuded absorbent oil in heated condition is passed from the first column through the lower portion of the second column to furnish the heat for rectification within the second column.

6. In a process of the character described, rectifying a mixture of hydrocarbon vapors and absorbent oil to sharply separate the vapors from the oil, subsequently rectifying said vapors to separate the same into a gaseous fraction and a liquid fraction, and utilizing the vapor pressure of the mixture of oil and vapors to build up a predetermined pressure during said rectification treatments.

7. An apparatus for recovering gasoline including a first rectifying column, means for pumping, heating and feeding a mixture of absorbent oil and gasoline vapors into said rectifying column, a reflux condenser arranged at the upper portion of said column, means for conducting vapor from the top of said column to said reflux condenser, means for returning condensate from said condenser to the upper portion of said column, a second rectifying column, means for leading vapor from the reflux condenser to the second column, means for discharging vapor from the top of the second column, a second reflux condenser to receive the vapor discharged from the top of the second column, means for returning condensate from the second condenser to the upper portion of the second column, means including a pressure regulating valve for discharging uncondensed gases from the second condenser, and means for removing finished gasoline from the lower portion of the second column.

8. An apparatus as claimed in claim 7, including a heating coil arranged in the lower portion of the second column, and means for feeding denuded absorbent oil from the first column to said coil.

9. An apparatus for recovering gasoline from gas, including a first rectifying column, a heat exchanger, means for feeding vapor enriched absorbent oil through said heat exchanger, means for pumping, heating and feeding the enriched absorbent oil from the heat exchanger into said rectifying column, a second rectifying column, means for feeding gasoline vapor from the top of the first rectifying column to the intermediate portion of the second rectifying column, a reflux condenser arranged at the upper portion of the second column, means including a pressure regulating valve for discharging uncondensed gases from said condenser, means for feeding condensate from the condenser into the upper portion of the second column, and means for discharging finished gasoline from the lower portion of the second rectifying column.

10. An apparatus as claimed in claim 9, including a heating coil arranged in the lower portion of the second column, and means for feeding denuded absorbent oil from the first column through said coil.

In testimony whereof I affix my signature.

JAMES M. WADSWORTH.