Some Recent Developments in the Manufacture of Natural Gas Gasoline

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That gasoline can be extracted from natural gas and casinghead gas has long been known, but its production has only within the past few years become of commercial importance, owing to the increase in the number of internal combustion engines.

In 1904 there were only two small plants producing casinghead gasoline. Both of these plants were somewhat crude, and their production for the year was only 400 barrels. At that time there was very little demand for gasoline, the product mostly desired being kerosene, lubricants, and fuel oil. In 1911 there were 176 plants in operation, and the production was 7,425,000 gal. In 1920 there were 650 plants, with a production of 483,000,000 gal. These figures portray the rapid growth of the industry.

Chemistry of Natural Gas

In the gasoline industry, natural gas is popularly classified into two great divisions—wet gas and dry gas. The gas coming from gas wells is generally classified as dry gas, and that coming from oil wells, if carrying any gasoline vapors, is considered as wet gas.

Natural gas is a mixture in which the hydrocarbons of the paraffin series predominate. Small proportions of nitrogen, carbon dioxide, and water vapor are usually present. In some cases natural gas contains as high as 35 per cent carbon dioxide. There is a record of one natural gas which contains 98 per cent carbon dioxide. A gas in which there is a large quantity of nitrogen may also contain helium. The recovery of this very light gas for use in the inflation of balloons is being attempted by the War and Navy Departments.

When a gas bubbles through or over a liquid, it takes up and carries along vapor or minute particles of the liquid. The proportion by weight of the vapor taken up increases as the temperature rises and as the pressure of the gas decreases, but is practically independent of the nature of the gas as long as no chemical reactions occur. When a natural gas comes in contact with petroleum in the earth, principally those fractions of the petroleum having the lower boiling points are taken up, inasmuch as their vapor pressures are higher than those of the other fractions at the prevailing temperature. These vapors are carried with the gases in the same manner that water vapor is carried in air. Gases in oil-bearing formations thus mix with oil vapors, and the content of vapor in the gas in these formations is dependent upon the pressure and temperature, as well as upon the intimacy of contact between gas and oil. The effect of pressure is largely exerted through its influence upon the rate of diffusion of the vapor.

Obviously, gas from an oil well yielding a crude that contains no gasoline will not pick up any vapors. This condition exists in wells in the Gulf Coast District.

Other factors controlling the amount of vapor picked up by gas are as follows: the porosity of the oil-bearing strata, the depth of the well, and the rapid expansion of the gas which causes variations in temperature.

Inasmuch as the yield of gasoline from natural gas is largely dependent upon the proportion of the vapor of the liquid paraffins in the gas mixture, the character of the oil in a sand is of considerable importance. Crude oil is a mixture of several series of closely related complex hydrocarbons and of various other organic substances. There are often present several different compounds corresponding to a particular molecular weight, the boiling points of which lie so closely together that their separation by fractional distillation is impossible. The liquid hydrocarbons of chief concern to the gasoline industry are the pentanes, hexanes, and heptanes.

Natural gases in the oil fields of the United States are principally mixtures of methane, ethane, propane, butane, pentane, and hexane. Methane is always present in a stratum in the gaseous condition. Ethane becomes a liquid at 95° F. if the pressure reaches the value of 664 lbs./sq. in. Therefore, if a gas consisted of ethane alone and was subjected to a pressure in the earth of 664 lbs., it would probably be liquefied. In the case of a gas containing 50 per cent ethane and 50 per cent methane, a pressure of at least 2 × 664, or 1328 lbs., would be required to liquefy the ethane at 95° F. This fact is explained by discussion of the effect of partial pressures.

<table>
<thead>
<tr>
<th>Fractionation of a Typical Wet Gas</th>
<th>Per cent</th>
</tr>
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<tbody>
<tr>
<td>Methane</td>
<td>87.1</td>
</tr>
<tr>
<td>Ethane</td>
<td>5.0</td>
</tr>
<tr>
<td>Propane</td>
<td>6.5</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.4</td>
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<table>
<thead>
<tr>
<th>Fractionation of a Typical Dry Gas</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>36.6</td>
</tr>
<tr>
<td>Ethane</td>
<td>32.6</td>
</tr>
<tr>
<td>Propane</td>
<td>24.1</td>
</tr>
<tr>
<td>Butane-pentane</td>
<td>3.9</td>
</tr>
<tr>
<td>Hexane</td>
<td>0.5</td>
</tr>
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</table>

It will be seen that 9.5 per cent of this gas is liquefiable in plant practice. Based on 1000 cu. ft. of gas, the condensable portion will be 95 cu. ft. It takes about 32 cu. ft. of pure vapor of this character to make 1 gal. of gasoline. The 95 cu. ft. condensed would be about 3 gal. of liquid gasoline. The yield of such gas is usually expressed as about 3 gal. per 1000 cu. ft.

Description of Methods

The two most important methods of producing gasoline in the natural gasoline industry are the compression and the absorption processes. When using compression at pressures...
less than 100 lbs. the discharge from the compressors is passed through water-cooled coils into an accumulating tank where the condensate collects. The gas then passes out into the fuel lines, and gasoline is trapped off into stock tanks. Where high pressures are used, two-stage compressors are employed. Low-pressure cylinders compress the gas to about 50 lbs. per sq. in., pass it through water-cooled coils and then through an accumulator where a portion of the vapor is condensed and trapped off to stock tanks. The gas passes out from the top of this accumulator and into the suction line of the high-pressure cylinders. It is then discharged through high-pressure water-cooled coils where additional condensate is obtained. In most cases the gas is next discharged into the fuel system. Compressing the gas to 250 lbs. pressure and cooling with water-cooled coils does not entirely strip it of its gasoline; therefore, further means of extraction are employed. One of them is to refrigerate the gas by means of an ammonia plant. Another way is to cool the gas by means of expansion in the following manner:

The gas, after leaving the water-cooled coils and accumulating tanks, passes through the inner pipe of a set of double pipe coils and into an accumulator. This takes place at 250 lbs. pressure. The gas then is used to drive an expander, which, in effect, amounts to using gas at 250 lbs. pressure to drive a prime mover; and this in turn compresses the exhaust gas from the power cylinders of the expander after it has been used as a cooling medium to compress the gas for distribution through the residue fuel system. By using high-pressure gas in this manner, heat is extracted from it in proportion to the work done, and the exhaust gas is consequently brought to a temperature in the neighborhood of -75° F. This exhaust gas, or expanded gas passing through the outer pipe of the double pipe coils, refrigerates the gas passing through the inner pipe. This causes it to drop out additional gasoline as it passes through the accumulator tank on its way to be used to drive the expander.

The temperature of the gas to be cooled may be lowered by this means to the neighborhood of 0° F.

Instead of using an expander, some plants use an absorber on the gas leaving the plant, in order to strip the remaining gasoline from the residue gas. The medium used as an absorbent is put through either steam or fire stills after it has scrubbed the gas, and the gasoline is driven off through condenser coils and blended with the regular plant product.

In order to understand changes that take place in a mixture of gases as it passes through the compressor, knowledge of the principles governing the pressures exerted by gas mixtures is essential, and it is necessary to become familiar with the general thermal relationships encountered.

One physical law must be explained—namely, that of partial pressures. We say that at sea level atmospheric pressure is about 15 lbs./sq. in. Three pounds of this pressure are due to oxygen in the air and 12 lbs. to nitrogen. When a vapor is mixed with other gases or other vapors and pressure applied, only a part of the total pressure is exerted on the first-named vapor, or, more correctly, is exerted by the first-named vapor. In case this vapor constitutes 10 per cent by volume of the mixture measured at total pressure, then the pressure on this vapor alone, or exerted by this vapor, is 10 per cent of the total pressure. A total pressure of 150 lbs. is required in order that a pressure of 15 lbs. be exerted on the first-named vapor and that condensation be made possible at the temperature of its boiling point. If we take noncondensable gas and add gasoline vapor to it to the extent that the mixture includes 10 per cent vapor and 90 per cent other gas, then, in order to place 15 lbs. pressure on this vapor, it would be necessary to place 150 lbs. pressure on the entire mixture; or, if the percentage were increased so that of the total mixture 20 per cent of this was condensable vapor, it would be necessary to apply only 75 lbs. pressure to obtain 15 lbs. pressure on the vapor. It must be understood that it is assumed that these vapors in question will be the first to condense, and that, of course, under these conditions condensation merely begins.

A Low-Pressure Method

Under suitable conditions, gasoline vapor is condensed by removing its latent heat of condensation. In turn, gasoline will be evaporated by supplying the latent heat of evaporation. If by any means, therefore, we cause the evaporation of a given amount of gasoline, it must absorb heat from some source, and if we cause the evaporation of the gasoline to occur in heat-extracting relationship to a gasoline vapor (radiation losses being disregarded), the latent heat of condensation of the gasoline would be used by the vapors being evaporated. Approximately equal weights of gasoline and gasoline vapor may thus be removed, the two processes occurring simultaneously.

It has been shown that an increase of partial pressure will decrease the total pressure required to produce liquefaction at a given temperature. By evaporating gasoline for its cooling effect and by returning this gasoline vapor through vacuum pumps and compressor, it becomes intimately mixed with the gases entering from the field, thereby increasing the gasoline content of the gas to be handled by the plant. Such

\[ \text{This diagram shows the operation of the expander system. A is a gathering pump from which gas, by means of line 1, passes through cooling coils I by means of line 2, to compressor B. From this, by line 3 through coils C into accumulator Ci, where any condensate that may be realized at 250 lbs. pressure is dropped out. Coils C will, of course, consist of high- and low-pressure coils, as at this pressure two stages will be used. From the accumulator tank C by means of line 4 the gas enters coils D, which are made up of smaller pipe on the inside of a larger pipe. Passing through coil D and into accumulator tank E, the ordinary procedure is for the gas to leave by means of line 5 and go directly to the expander G, which is nothing more or less than a means of using gas at 250 lbs. pressure as a means of power and to obtain the low exhaust temperatures accompanying its expansion. The exhaust gas leaves the expander cylinders by means of line 6, entering the other pipe of the double-pipe coils D, and after passing through this coil is allowed to escape into the fuel system, or, if the pressure makes it necessary, it goes into the compressor cylinders, driven by expander G, which are directly connected to the expander. Sometimes the gas, after passing through the double-pipe coils D, and out of the accumulator tank 5, will be very cold and used as a cooling medium before entering the expander. This means that its temperature will be higher when entering the expander and will be probably somewhat higher upon leaving the expander than it is in the case of the first-named arrangement. By this arrangement the gas, after leaving accumulator tank D, by means of line 5, enters the double pipe coils E, going into accumulator tank 2B, then through coils D, and by means of line 7 is led to the expander to be used as power, and the exhaust gas, by means of line 8, is used to cool gas going through coils E.} \]
an increase in gasoline content provides that a greater percentage of the total pressure exerted on the gas is applied to the condensable part. It is then necessary that we extract from the gasoline vapors present in casinghead gas, only enough heat to reduce the kinetic energy to a value corresponding to that of the liquid state.

![Low-Pressure Evaporation Diagram](image)

**Low-Pressure Evaporation**

This diagram shows the arrangement used when the low-pressure evaporation system described in this paper is used. A vacuum pump which gathers gas in the field. B is a single stage-compressor. Gas passes from A through inner-cooled coils by means of line 1 and by means of line 2 enters compressor B, being discharged through line 8, is passed through coil C, into accumulator C1, where any gasoline that may be condensed at this pressure and temperature is collected. By means of line 4 the gas enters double-pipe coil D1, passing downward through this into accumulator tank D2, where the remaining condensate is dropped out, owing to low temperature. This gas is dry and cold, and may be either discharged directly into the fuel lines or passed back through the top sets of coils to be used as a precooling agent and then delivered into the fuel lines. Gasoline from the accumulating tanks C1 and D1 is automatically trapped by means of trap T, off to stock tank. The amount of gasoline necessary for evaporation purposes, in order to refrigerate gas, is taken from accumulator tanks C1 and D1 at a point above the trap outlet, and is introduced at point marked X into the outer pipe of the double-pipe coils, or inner pipe, whichever the arrangement may be, where a slight vacuum is maintained, causing this gasoline to evaporate and absorb heat from the gas to be cooled. This evaporation is drawn off to point Y and drawn back to the vacuum pump where it is mixed with gas coming from the field.

There is no reason why we should arbitrarily assume that any particular pressure is necessary to condense gasoline from gas. We may take, for example, pentane, a constituent of casinghead gasoline. As a pure vapor, it would be necessary only to hold pressure on it which would equal its vapor tension at any given temperature. For instance, pentane has the following vapor pressures: 11.8 lbs./sq. in. at 86°F; 5.41 lbs./sq. in. at 50°F; and 3.5 lbs./sq. in. at 32°F. Any one of these pressures suffices at the corresponding temperature.

The above-mentioned principles have been applied in several commercial plants; one of the writers having installed five of them.

It has been found in some instances that the boiling point of the liquid evaporated is as low as 60°F. The loss due to radiation through insulating material is overcome to a certain extent by precooking with cold dry gas expanded to field pressure, and it is assumed that the cooling realized by this cold dry gas is sufficient to offset the loss due to radiation in the evaporation coils proper. The amount of gasoline which it is necessary to evaporate is calculated, therefore, from the amount of gasoline recovered in the double-pipe coils. If a million cubic feet of gas which carries one-half gallon to the thousand are to be handled, and no water-cooled coils are used, it is then necessary to evaporate only slightly more than 500 gal. (0.5 of a gal. for each thousand cubic feet) of gasoline. The evaporation of the excess over 500 gal. provides for cooling the gas. This amount is very small, however, owing to the low specific heat of the gas.

The benefit of the principle of partial pressures and the advantages to be derived from increasing the partial pressure on the condensable part of the gas, are realized by the intimate mixture of the vaporized gasoline drawn from the evaporation coils with the gas coming from the field. This has the effect of increasing the amount of gasoline produced by the low-pressure coils, makes less work for the high-pressure cylinder of the compressor, at the same time effecting a greater amount of condensation even in the high-pressure coils. Results so far obtained indicate that the greater part of the gasoline evaporation in the double-pipe coils is recovered in the water-cooled coils, together with that part which would be recovered in the water-cooled coils if the evaporation coils were not in operation. If this were not the case the process would not be practical, since the gasoline recovered in the evaporation coils is due to evaporation of other gasoline, and this evaporated gasoline, if not recondensed before it reaches the evaporation coils, would make it necessary to evaporate twice as much, since there would be twice as much gasoline to recover. This gasoline would continually accumulate and in a very short time the apparatus would become inoperative. By increasing the percentage of condensable vapor in the gas, a greater percentage of the total pressure is exerted on the condensable part and, as explained before, because of this pressure more gasoline is condensed. The possibility of low temperature causing freezing of these coils was at first considered serious, but all inconvenience due to this source has been eliminated. One hundred and twenty-five pounds is the maximum pressure required under any circumstances in plant operation. In some instances, 70 lbs. has been found sufficient.

The question may be raised as to the horse power required to handle the additional amount of gasoline due to the evaporation of gasoline in the evaporation coils. As stated before, about 1 gal. of gasoline is evaporated in these coils for every gallon condensed, and in the case of a gas carrying 1 gal. per 1000 cu. ft. for a million feet there would be approximately 1000 gal. evaporated. This would amount to only 32,000 cu. ft. of gas for the entire million feet handled.

As to the actual horse-power requirements (based on the pressure of 125 lbs. which is used as a maximum), the following figures are presented in order to show the least possible difference we could expect to realize between the power necessary to operate this process compared with that necessary to operate under the high-pressure method.

Fifty horse power are required to compress 375,000 cu. ft. of gas per day of 24 hrs. from atmospheric pressure to 125 lbs./sq. in. 210,000 cu. ft. may be compressed to 250 lbs. pressure with the same amount of horse power. This figure is based on the practice of installing a 165-h. p. engine to drive a 690,000-cu. ft. compressor. However, we are giving this installation the benefit of an extra 40,000, assuming that it would thus handle 700,000 cu. ft. with this amount 165-h. p. unit.

During a recent test at one plant, a meter-proving apparatus was installed which could be used at any time to serve the same purpose as a meter, and at different times the amount of gasoline being evaporated was checked. Since a gallon of gasoline will yield 32 cu. ft. of vapor, it was found that when the plant was handling 250,000 cu. ft. of gas per day, 22,000 cu. ft. of gas was the excess handled. These results would indicate that we could handle with 50 h. p., 345,000 cu. ft. of gas per day from the field. This test was made under average conditions—a temperature of 80°F. cooling in the water-cooled coils, and a very rich gas. The data show
that 110,000 cu. ft. more gas can be handled per day than with a 50-h.p. unit at 250 lbs. pressure.

On the basis of one million cu. ft. for a vacuum station and gasoline plant under the same roof, the capacity would be as follows, the gas carrying 29/4 gal. per cu. ft. (vacuum taken at 18 in., which is the pressure generally used in designing a vacuum plant):

**Low-Pressure Method**

<table>
<thead>
<tr>
<th>Description</th>
<th>Horse-power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000,000 cu. ft. from 18-in. vacuum to atmospheric pressure</td>
<td>77 h.p.</td>
</tr>
<tr>
<td>88,000 cu. ft. from 18-in. vacuum to atmospheric pressure which would be the excess due to evaporation</td>
<td>6.8 h.p.</td>
</tr>
<tr>
<td>1,000,000 cu. ft. from atmospheric to 125 lbs......</td>
<td>127.4 h.p.</td>
</tr>
<tr>
<td>88,000 cu. ft. from atmospheric to 125 lbs......</td>
<td>15.4 h.p.</td>
</tr>
<tr>
<td>Total required to handle from 18-in. vacuum to 125 lbs. pressure and extract the gasoline</td>
<td>142.8 h.p.</td>
</tr>
<tr>
<td></td>
<td>239 h.p.</td>
</tr>
<tr>
<td></td>
<td>316 h.p.</td>
</tr>
</tbody>
</table>

**High-Pressure Method**

<table>
<thead>
<tr>
<th>Description</th>
<th>Horse-power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000,000 cu. ft. from 18 in. to atmospheric.....</td>
<td>77 h.p.</td>
</tr>
<tr>
<td>1,000,000 cu. ft. from atmosphere to 250 lbs. pressure</td>
<td>239 h.p.</td>
</tr>
<tr>
<td>Total required from 18 in. to 250 lbs. pressure and extract the gasoline</td>
<td>316 h.p.</td>
</tr>
</tbody>
</table>

In addition, an expander would be required to secure maximum extraction with high-pressure method.

The amount of excess gas necessary to be handled is determined by the amount of gasoline left in the gas upon entering the evaporation coils, and no consideration is given here to the advantage derived from the removal of additional gasoline in the low-pressure side of a compressor, thereby causing the high-pressure side to do less work. It is quite probable that the greater part of the excess vapor is condensed in the low-pressure coils.

It was found that one of the gasoline plants, that when operating at 125 lbs. without the evaporation coils, 80° Bé gasoline was made in the water-cooled coils. In a few minutes after closing the evaporator coils in operation, the gravity of the gasoline made in the water-cooled coils was 90° Bé, indicating that considerably more gasoline is recovered in both the low- and high-pressure cylinders at 125 lbs. pressure in the water-cooled coils with evaporation coils in operation, than is recovered without them. This is due to the increased partial pressure of gasoline vapor corresponding to the increased content of gasoline, which makes possible the recovery of the additional gasoline.

It must be understood that the evaporation coils can be installed in connection with high-pressure as well as with low-pressure installations, and constitute a less expensive installation than an additional expander, besides having a greater heat-extracting capacity than the expander.

The advantages derived from the process herein described are: The installation cost is reduced in proportion to the horse-power requirements; with 125 lbs. maximum pressure the horse-power requirements indicate that a 40 per cent saving is to be realized in the initial expense, and a proportional saving in operating expense. In some instances where a lower pressure than 125 lbs. is adequate, there will, of course, be savings running up to as high as 60 per cent. The necessity of using an expander is eliminated, high pressure fittings and tanks are unnecessary, and an opportunity is offered to make installations of this process where the uncertainty as to the supply of gas would preclude the adoption of the high-pressure process. In most cases a plant of this type is assured of profits in a comparatively short time on account of the relatively low cost of installation.

### Absorption Method

This method consists in bringing the gas in contact with an absorbing medium in such a manner as to enable the absorbent to pick up the gasoline vapors. Plants of the usual type use an absorbing tower partially filled with absorbing medium, the gas being passed in at the bottom and out the top, while the absorbing medium passes in at the top and out the bottom. In addition, the absorbers are sometimes equipped with baffle plates, which assist in the further distribution of the gas and effect intimacy of contact between the absorbing medium and the gas.

Absorption processes may be divided into two classes — those using solid absorbing materials that present large surfaces for contact, and those employing liquid absorbents. Activated charcoal and silica gel have been used in processes usually designated as absorbents of the first type. Crude oil, mineral seal oil, naphtha or low-grade gasoline may be used in processes of the second class. Everyone is familiar, of course, with the general character of these liquid absorbents.

The solid absorbents, however, need further discussion. During the war, chemists and physicists were called upon to develop an efficient gas mask. In their investigations charcoals were prepared which were found to be capable of
absorbing condensable gases, because of the extensive surfaces within the body of the charcoal.

Investigations along these same lines have been carried out with silica gel. This gel is made by the coagulation of sodium silicate with an acid. The gel is washed and dried and is then ready for use. Certain very important precautions must be taken to prepare this material so that it will have sufficient surface to insure efficient absorption. In the use of either of these solids as an absorbent, two batteries of absorbers are required. The gas is passed through one battery until the material is saturated, when the gas is then diverted to the other battery. The saturated material is exposed to the action of superheated steam. The steam drives off the absorbed vapors that are carried with it to water-cooled coils, where both are condensed. The gasoline and water vapors are, of course, automatically disposed of. With plants using superheated steam, the necessity of drying out the material after distilling is eliminated.

It is claimed that these solid materials can be used as absorbents with considerably less expense than the ordinary method, owing to the fact that the heat losses of distillation are less. This claim, of course, reduces to a saving of fuel, and an investigation of the use of these solid materials can be limited to an investigation into the cost of fuel.

As the more popular method of absorption is the use of liquid absorbents, more detailed information is available than on the use of solids. The system is similar to that used for extracting benzene, toluene, and other vapors from gas made by destructive distillation. The gas under high or low pressures enters the absorbing towers placed in either vertical or horizontal positions and passes out the top. The oil used as an absorbent enters at the top, is sprayed downward, and leaves the absorbers at a point close to the bottom.

The absorbers usually consist of steel shells varying in diameter from 12 in. to 4 ft., although in some cases still larger diameters are used. The height varies from 15 to 45 ft. It is generally advisable to fill these absorbers partially with baffling material of some kind. In some cases there may be 6 ft. of baffling material and in others there may be 20 or 25 ft. Although the general plan has been to allow sufficient open space at the top of the absorbers for the separation of the oil and gas, one of the writers has recently installed absorbers 30 in. in diameter and 35 ft. high, filled to within 6 ft. of the top. A small separator for the outgoing gas, which removes any oil which may have been carried over, is superimposed. The baffling material varies—broken bottles, mineral-wool, broken stone, and bricks, etc., have been used. In some cases the baffling is made of wooden slats, and in still others flat revolving disks with small holes have been used successfully.

In the writers' opinion, the best baffles are steel plates. These may be about 1/4 in. thick and from 6 in. to 12 in. high, and of course, will be of varying lengths. The plates are bolted together with about 1/2-in. space between. The lengths can be made to conform to the inner circumference of the shell. If sets of these baffles are placed one on the other, each set is at right angles to the one adjacent to it, or they may be placed so as to create a whirling motion, although such a motion does not present any advantage. The object of the baffling is to present a large surface for the oil to trickle over, thereby accomplishing intimate mingling of the gas and absorbent.

By using this steel baffling, arranged as described above, the area of the cross section of the absorbers is reduced by only approximately 3 per cent, thereby insuring a low velocity of the gas passed through the absorbers, without sacrificing contact surface.

The gas passing out of the top of the absorbers goes into the fuel system or into the air, depending upon the requirements. The oil after leaving the absorbers goes to stills, passing through heat exchangers in such a manner that it will be heated by hot oil leaving the stills, which in turn is cooled somewhat. The oil leaving the stills is then passed through water-cooled coils before being pumped into the absorbers.

The apparatus for separating gasoline from the absorbent has been frequently described and will not be considered here.

The most important part of the absorption process is the action of the absorbers themselves. The amount of liquid absorbent necessary to be circulated depends upon the efficiency of the absorbers; this, in turn, depends upon the temperatures, pressures, and lengths of time of contact between oil and gas.

Henry's law states that the amount of vapor that will be absorbed by a liquid is proportional to the partial pressure of the vapor. This relationship is true, but the length of time of contact is of considerable importance in practice. For instance, the writers have noted in a plant operated at a certain pressure, and with gas of constant gasoline content, and using any given absorbent, that if the length of time of contact alone was increased, the absorbent would dissolve increased quantities of vapor. This further absorption must be understood as not being of the same efficiency from the standpoint of stripping the gas of its content of vapor, as will be realized if low saturation percentages are maintained. We may assume, for example, that in an absorber in which the gas and oil are in contact for 15 sec., all the gas passing through will be entirely stripped of its gasoline. If this same oil is recirculated in the absorbers, however, and a further amount of gas brought into contact with it for an additional 15 sec., the oil will still absorb but the saturation percentage will not be doubled. By using the oil the second time, the saturation percentage will be approximately 50 per cent of that realized during the first period of absorption. If the operation is repeated, using this saturated oil and new gas, the oil will be further saturated, but will be increased only by about 50 per cent of that realized during the first period of contact. This latter ratio will prevail approximately, decreasing slightly until about 30 per cent total saturation is reached.

It has been customary in absorption plants to use saturation percentages varying from less than 1 per cent to about 6 per cent, depending upon pressures and temperatures. There is no reason, however, why this percentage could not be higher in practice. This would be accomplished primarily by increasing the length of time of contact, either by increasing the height of baffling or by operating absorbers in series. In doing this, the counterflow principle should be used. The rich oil leaving the absorbers meets rich gas entering and the lean gas leaving comes in contact with the lean oil entering, thereby accomplishing intimate mingling of the gas and absorbent.

The effect of using this high saturation percentage would be to cut down the still capacity required, since there would be considerably less oil to be heated and the quantity of heat necessary to furnish the latent heat of evaporation would be the same. For example, if a plant with a capacity of 1,000,000 cu. ft. per day, which a total gasoline content of 1000 gal. were running at a saturation of 4 per cent, 25,000 gal. of oil per day would have to be circulated through the absorbers, and the stills would have to supply sufficient heat to raise the 25,000 gal. of oil to the required temperature—in addition to the latent heat of evaporation to be supplied for the 1000 gal. of gasoline. Now, if the saturation percentage were maintained at 20 per cent, it would be necessary to circulate only 7000 gal. of oil and to supply sufficient heat to raise the temperature of approximately 5000 gal. of absorbent to the temperature necessary to drive off the gasoline vapor plus the latent heat of evaporation of 1000 gal. of gasoline. This would reduce the still capacity required, as well as that of the...