Feb. 10, 1942. G. S. BAYS 2,272,503

CONTACTING DEVICE FOR HIGH PRESSURE ABSORPTION

Filed April 30, 1940 2 Sheets-Sheet 1

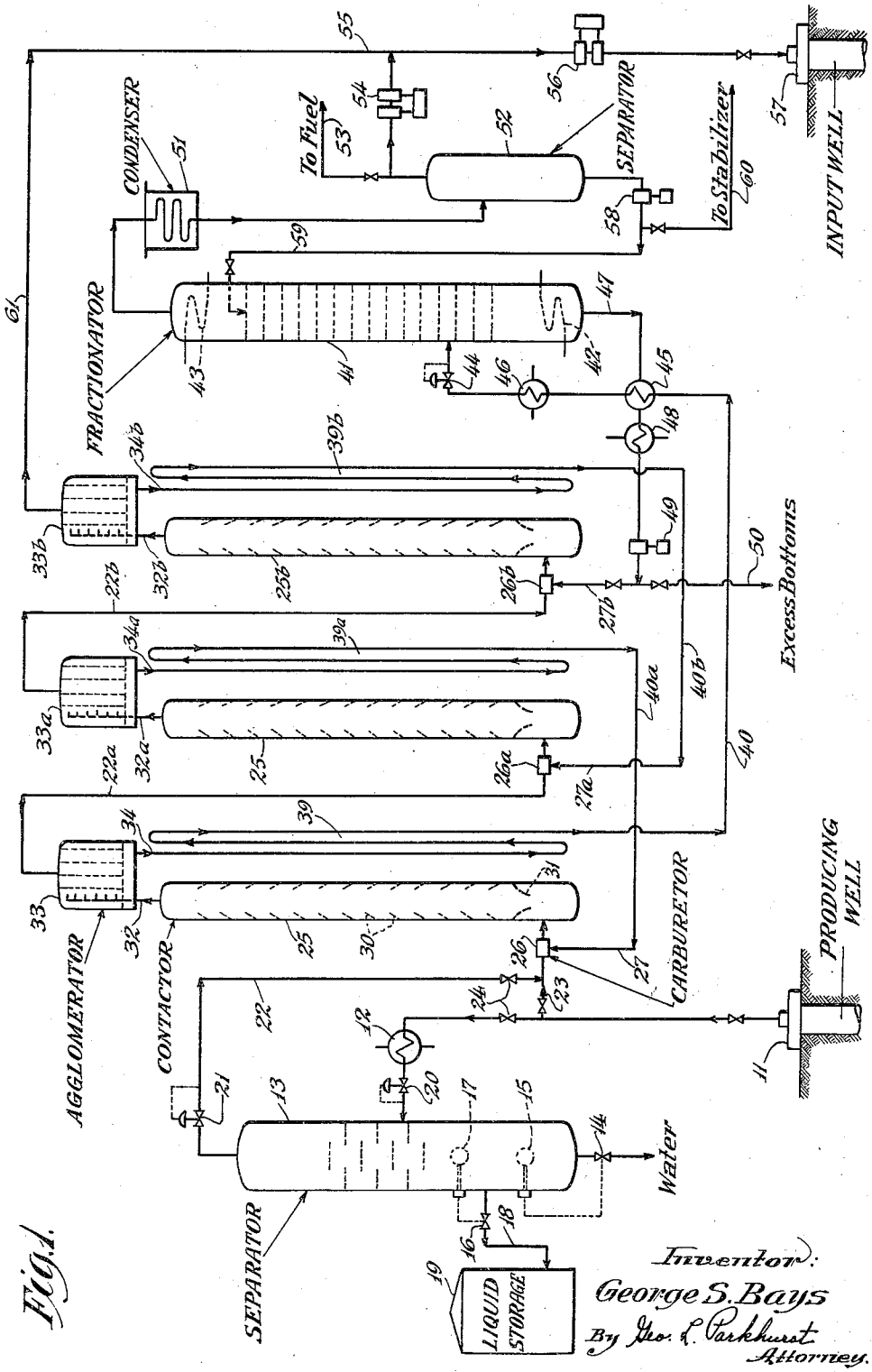


Fig. 1.

Inventor:
George S. Bays
By Geo. S. Parkhurst
Attorney.

Feb. 10, 1942. G. S. BAYS 2,272,503

CONTACTING DEVICE FOR HIGH PRESSURE ABSORPTION

Filed April 30, 1940 2 Sheets-Sheet 2

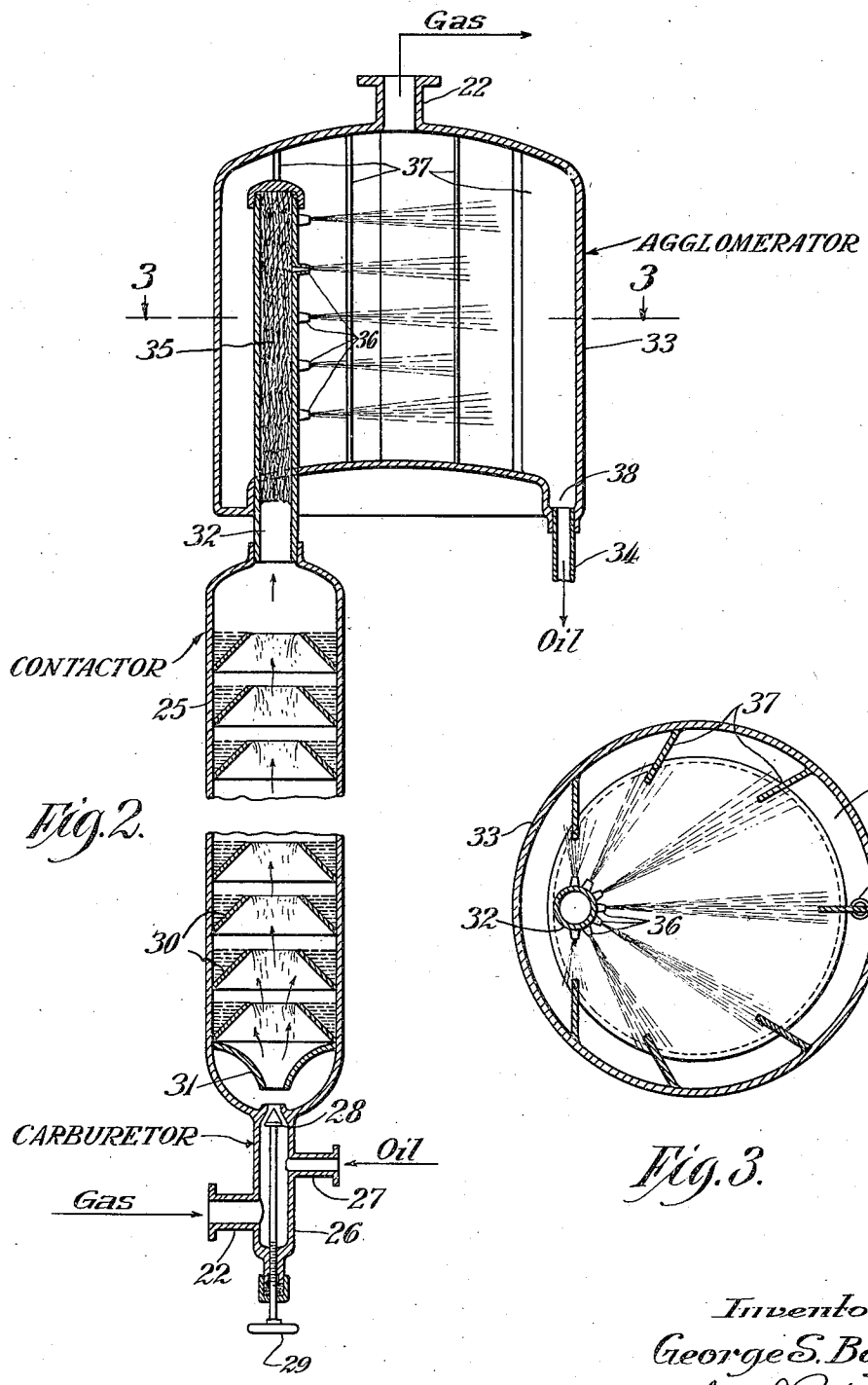


Fig. 2.

Fig. 3.

Inventor:
George S. Bays
By Geo. L. Parkhurst
Attorney.

Patented Feb. 10, 1942

2,272,503

UNITED STATES PATENT OFFICE

2,272,503

CONTACTING DEVICE FOR HIGH PRESSURE ABSORPTION

George S. Bays, Tulsa, Okla., assignor to Stanolind Oil and Gas Company, Tulsa, Okla., a corporation of Delaware

Application April 30, 1940, Serial No. 332,566

1 Claim. (Cl. 261—111)

This invention relates to apparatus for absorption at elevated pressures and particularly to apparatus for recovering normally liquid hydrocarbons from high pressure fluids produced by wells of the so-called distillate type.

As drilling operations have been carried to greater and greater depths in the search for oil and gas deposits, a large number of wells have been discovered in which the hydrocarbon fluids are apparently present in the reservoir at very high pressures, often ranging from 2000 pounds per square inch to as high as 10,000 pounds per square inch. While some of these reservoirs contain a minor amount of liquid phase hydrocarbons, all or the bulk of the hydrocarbons are usually present in the reservoir in the gas phase although this gas phase contains substantial amounts of normally liquid hydrocarbons. In most instances a distillate reservoir is at a pressure in excess of the critical pressure of the hydrocarbon system present therein, or at least in excess of the critical pressure of the hydrocarbon system produced therefrom, and in such instances it may be more accurate to speak of the phase condition as a high density super-critical phase which is not distinctly either gas or liquid.

Well fluids produced from distillate reservoirs necessarily encounter a reduction in both pressure and temperature in progressing up the well and since the reservoir pressure in the case of typical distillate-type reservoirs is in the so-called retrograde condensation range the reduction in pressure as well as the reduction in temperature tends to precipitate liquid hydrocarbons as a distinct liquid phase. However, under the high pressure conditions existing at the well head, for instance at least 1200 or 1500 pounds per square inch and more typically 2000 to 5000 pounds per square inch or still higher, the gas or super-critical phase retains a very large part of the normally liquid hydrocarbons present.

Processes have been devised for recovering a large amount of these normally liquid hydrocarbons. Thus, for instance, the well fluids can be further cooled after leaving the well and can can then be expanded to some lower pressure within the retrograde condensation range.

The retrograde condensation range is the range in which the amount of liquid phase increases with decreasing pressure. This effect persists down to some minimum pressure which varies to a considerable extent with the particular hydrocarbon system involved and with the temperature but which is typically in the neighborhood of 700 to 1000 pounds per square inch. Below this pressure which constitutes the base of the retrograde condensation range, further pressure reduction tends to cause liquid hydrocarbons to pass into the gas phase, thus decreasing rather than increasing the yield of total liquids.

For this reason prior art processes have in many instances limited the pressure reduction to a separator pressure within the retrograde condensation range. In general it has been necessary to lower the pressure to some value not greatly in excess of the base of the retrograde condensation range in order to obtain the desired high yields. Thus separator or absorber pressures of 700 to 1200 pounds per square inch have been typical.

In order to prevent retrograde vaporization within the reservoir and thus increase the ultimate recovery, as well as for purposes of economy and conservation, it is customary to cycle the gas from which the liquid phase hydrocarbons have been recovered to the sub-surface reservoir from which they were produced or to another sub-surface reservoir. This necessitates recompression and the cost of such recompression increases very rapidly as the pressure of the distillate recovery operation is reduced. Thus it is extremely desirable to recover the liquid phase hydrocarbons at as high a pressure as possible.

Using the ordinary retrograde condensation type of operation, however, the pressure must be reduced to some value not greatly in excess of 1200 pounds per square inch in order to obtain the desired high yield of normally liquid hydrocarbons.

The amount of such liquid hydrocarbons recovered at a given pressure can be materially increased if a suitable absorption medium is contacted with the well fluids. Moreover, the recovery pressure can also be increased while still retaining the advantage of improved recovery. Suitable absorption media include the heavier ends of the distillate recovered, various types of heavy absorption media such as aromatic or naphthenic hydrocarbon fractions boiling predominantly above the end point of the distillate to be recovered and other types of absorber oils.

Such high pressure absorption processes have had, however, serious disadvantages. Due to the high pressures which must be used to secure economical processing, the density difference between the gas and liquid phases present in the absorption step is much less than in ordinary low pressure absorption operations with the re-

sult that countercurrent absorption in a bubble tower, packed tower, baffled tower or the like tends to be very difficult if not impossible. Such towers tend to foam or "puck" and separation is extremely difficult. Furthermore, these conditions lead to highly inefficient operations in which the advantages of countercurrent processing are not obtained to any worthwhile degree.

On the other hand, if the absorption medium and well fluids are contacted in concurrent fashion and then separated by the use of settling chambers, mist extractors or centrifuges, the result is the same as for a batch process or, in other words, the same as for a countercurrent tower of only one theoretical plate.

It is an object of my invention to provide apparatus which makes possible a high pressure absorption process of the type particularly adapted to distillate recovery operations which combines the advantages of both concurrent and countercurrent operations. Another object of my invention is to provide apparatus for recovering distillate hydrocarbons from distillate well fluids at pressures higher than those possible heretofore, with consequent economy in recompression costs. A still further object is to provide a superior contactor for use as described. Other and more detailed objects, advantages and uses of my invention will become apparent as the description thereof proceeds.

I contemplate, in general, taking high pressure fluids from a well of the distillate type, removing, if so desired, the liquid hydrocarbons formed in the passage of the well fluids out of the well together, if desired, with such additional liquid hydrocarbons as can be recovered by some moderate reduction of the temperature and/or pressure of the well fluids and then passing the remaining gas or super-critical phase hydrocarbons (or the total well fluids, if desired) into a high pressure absorption system operating at a pressure of at least 1200 pounds per square inch and in most instances at a pressure of at least 1500 pounds per square inch. The pressures in the absorption system will be as high as is consistent with the desired operation and will depend in large measure on the particular well fluids with which one is concerned and with the particular apparatus available. However, such pressures may be as high as 3000 or even 4000 pounds per square inch or in some instances still higher.

In this high pressure absorption system the well fluids, or the desired portion of them, are contacted with a suitable absorption medium having a lower volatility or higher average boiling point than that of the distillate to be recovered. This contacting is conducted in concurrent fashion thereby avoiding the difficulties encountered in the operation of a countercurrent tower and making possible the use of higher pressures than can be used in the case of a countercurrent tower. However, I obtain all the advantages of countercurrent operation by using a plurality of these concurrent contacting stages and passing the liquids and vapors between the various stages in countercurrent fashion. All of this will become apparent from the succeeding description as will various other detailed but important features of my invention.

While it is obvious that my invention can be embodied in a great variety of forms, it will be described with particular reference to the accompanying drawings in which:

Figure 1 is a flow sheet of one form of my process illustrating one type of apparatus in accordance with my invention;

Figure 2 is an elevation partly in section of one of the contactors shown in Figure 1 together with its associate agglomerator; and

Figure 3 is a sectional plan taken along the line 3—3 of Figure 2.

Turning now to the drawings in more detail, well fluids from distillate well 11 can, if desired, be passed through cooler 12 into separator 13. This cooler can be so operated as to remove all or the bulk of the water present in the well fluids and this water can be removed from the bottom of separator 13 through valve 14 which is under the control of interfacial level controller 15. Liquid hydrocarbons existing as such in the reservoir or precipitated in the progress of the well fluids up the well will also in general be recovered in this separator and can be removed therefrom through valve 16 under the control of liquid level controller 17 and passed through line 18 to storage tank 19. If the well fluids are at very high pressure, the pressure can be reduced to some extent by means of pressure reduction valve 20 which is preferably located between cooler 12 and separator 13 as shown. A second pressure reduction valve 21 can be located in gas line 22 between separator 13 and the high pressure absorption system so that further pressure reduction with consequent temperature reduction can be effectuated before the high pressure absorption operation is carried out.

However, if the well fluids are not at an extremely high pressure, both of these pressure reduction valves can be omitted or left wide open or in fact the well fluids can be passed directly from the well head to the high pressure absorption system as illustrated, for instance, by valved by-pass line 23, valves 24 being closed. The well fluids can be cooled and/or the pressure can be reduced before entering the high pressure absorption system.

In any event the wet gas carrying additional amounts of desirable normally liquid hydrocarbons passes into contactor 25 in which it is contacted in concurrent fashion with an absorption medium. This contactor together with the rest of the absorption system is operated at a pressure in excess of 1200 pounds per square inch and preferably at considerably higher pressures as previously described.

As shown in Figure 1, the absorption medium is introduced into the gas by means of carburetor 26 but it will be apparent that it can be introduced into the gas in other manners or that the gas and absorption medium can be introduced separately at points near the bottom of the contactor in such manner as to disperse the absorber oil in the gas. One form of carburetor is shown in Figure 2. The absorber oil enters through line 27 and the gas through line 22. The two are carburetted by means of nozzle 28 which is under the control of adjusting screw 29.

The preferred type of contactor is best shown in Figure 2. This contactor is equipped with upwardly pointed annular baffles 30. Any drain-back liquid can be caught by these annular baffles or vanes and from them overflows into the ascending gas stream, thus causing the liquid to be resuspended in the gas phase.

In general the upward velocity of the stream of mist imposed by the gas and suspended liquid is great enough to prevent any appreciable drain back and/or collection of liquid in the bottom of the contactor. Such accumulation can, if neces-

sary, be completely prevented by the provision of a throat 31 near the bottom of the contactor. This throat tends to cause any back-draining liquid to be redispersed in the mist and to be carried upward and out of the contactor proper.

As the mist leaves contactor 25 it passes upward through line 32 into agglomerator 33 (best seen in Figures 2 and 3) where provision is made for removal of the liquid from the mist and its collection and withdrawal through pipe 34. While the type of agglomerator shown is particularly advantageous other types of agglomerators, mist extractors, separators, etc. can be used. Centrifugal separation devices can also be used with particular advantage.

In the form of agglomerator shown, the upper end of pipe 32 (Figure 2) is packed with glass wool 35 and transforms the mist containing very finely divided liquid particles into a mist of larger particles. The upper end of pipe 32 within agglomerator 33 is equipped with nozzles or jets 36 which direct the mist outwardly in a fan-shaped spray along the wall of the agglomerator 33. On the wall of agglomerator 33 are numerous baffles 37 set at angles such that baffles are roughly parallel to the spray directed at them by jets 36. This arrangement is appropriate for the collection of the mist liquid.

The liquid thus collected drains into a circular collection trough 38 at the bottom of agglomerator 33 and thus out through pipe 34.

Turning once more to Figure 1, it will be seen that pipe 34 contains a liquid seal 39 which can suitably be in the form of a double reverse bend as shown. The purpose of this seal is to prevent the direct passage of gas between carburetor 26 and other points in the system through line 34 due to any pressure surges which might otherwise tend to blow the liquid from this line.

From liquid seal 39 the rich or fat oil composed of the absorption medium and recovered distillate passes through line 40 to a suitable recovery and stabilization system of which one simplified form is shown.

Thus the rich oil can be passed to a fractionating column 41 which can, if desired, be equipped with reboiler coil 42 and dephlemator 43 although these elements are not always necessary. This column is operated at a pressure somewhat lower than that of the absorption system and the pressure reduction is accomplished by reduction valve 44. Heat for the fractionation operation can be supplied to the incoming stream in part by the hot bottoms from tower 41 which are passed through heat exchanger 45 and in part by an extraneous heating fluid which is passed through heat exchanger 46.

Tower 41 is so operated that all gasoline range and lighter hydrocarbons pass overhead. If desired, the cut can be still higher, or, in other words, some kerosene range hydrocarbons can be taken overhead. This is notably desirable when a particularly high boiling absorber oil is used.

The bottoms from tower 41, which may typically contain the complete heavier-than-gasoline cut can be further fractionated if desired to isolate and return the preferred absorber oil, or the unfractionated bottoms, to the high pressure absorption system through line 47, heat exchanger 45, cooler 48 and valved line 27b by means of pump 49. Excess bottoms from fractionator 41 can be withdrawn from the system through valved line 50.

It will be apparent that the absorber oil can be made up in whole or in part of the heavy ends of the distillate or a fraction thereof. On the other hand, it can advantageously be made up of a foreign material distilling above the distillation range of the "distillate" produced by my process, for instance, any conventional relatively high boiling absorber oil.

The overhead from fractionating tower 41 passes through condensing coil 51 to separator 52 in which gas and liquid phases are separated.

Condenser 51 is operated at such temperature as to give practically complete condensation of normally liquid hydrocarbons together, if desired, with all or part of the butanes (or propane plus butanes) and the gases from the top of separator 52 can be passed to valved fuel line 53 as indicated or can be otherwise used, for instance by passing them through compressor 54 to high pressure line 55 where they join with residue gas from agglomerator 33b and are reintroduced by means of compressor 56 into the sub-surface reservoir from which the well fluids were produced or into another sub-surface reservoir through input well 57.

The liquid phase from separator 52, predominantly gasoline, can be reintroduced in part into the top of tower 41 as reflux by means of pump 58 and valved line 59 and can in part be introduced into a suitable stabilization system (not shown) through valved line 60.

Returning now to the absorption system, it will be seen that I have described what is from the standpoint of the gas, the first absorption stage, and from the standpoint of the absorption oil, the last absorption stage. This stage will hereinafter be referred to as the first stage.

The gas from this first absorption stage passes through line 22a to a second carburetor 26a and thus into a second contactor 25a. In carburetor 26a this gas meets absorber oil which has passed through the last stage of the absorption system. The gas and absorber oil pass upwardly through contactor 25a which can be equipped similarly to contactor 25 and thence to agglomerator 33a which can be equipped similarly to agglomerator 33. The liquid collected in agglomerator 33a passes out through pipe 34a to liquid seal 39a and thence through line 40a and carburetor 26 into the first contactor 25.

Gas from agglomerator 33a passes through line 22b to carburetor 26b wherein it meets lean oil introduced into the bottom of contactor 25b from fractionating column 41 through line 47, heat exchanger 45 and cooler 48 by means of pump 49.

Thus the fresh absorber oil having the maximum absorption capacity for the desired normally liquid hydrocarbons meets the gas which has had its content of normally liquid hydrocarbons reduced by two previous stages of absorption. In other words, the gas from which it is most difficult to absorb further distillate hydrocarbons meets the absorption oil which has the maximum absorptive capacity, thus obtaining all the benefits of countercurrent processing.

These fluids pass upwardly through contactor 25b which can be similar to the contactors previously described and into agglomerator 33b which again can be of the type to which reference has previously been made. The liquid from this agglomerator can pass out through line 34b and liquid seal 39b and thence through line 40b and carburetor 26a into the second contactor 25a. Ultimately this absorber oil carrying distillate hydrocarbons finds its way back to the first ab-

sorption stage or, in other words, to contactor **25** and the absorber oil which has the least residual sorptive capacity thus meets the fresh wet gas from which it is easiest to absorb normally liquid hydrocarbons, thereby making the absorption process particularly efficient.

While the liquid and gas phases can be passed from one absorption stage to another by any desired method, one important preferred feature of my invention is to accomplish this without the use of pumps. Due to inescapable pressure drops each succeeding contactor and agglomerator is necessarily at a slightly lower pressure than the preceding one although the pressures in all contactors are preferably above the minimum to which reference has been made. Thus in passing from the third stage to the second or from the second stage to the first the liquid phase, i. e. the absorber oil together with absorbed hydrocarbons, must pass from a zone of relatively low pressure to a zone of higher pressure. In the system shown this is accomplished without the use of pumps by virtue of the fact that the mists present in the contactors have average densities or average specific gravities lower than the densities or specific gravities of the liquid phase material in the corresponding conduit running from the agglomerator to the preceding contactor. Thus, for instance, the pressure in agglomerator **33***b* is appreciably lower than the pressure in contactor **25***a*. Nevertheless, the head of liquid between agglomerator **33***b* and the inlet to contactor **25***a* is enough higher than the head of mist between this inlet and the top of agglomerator **33***a* so that the desired flow is accomplished. This effect can, if desired, be augmented by the action of the high pressure gas in aspirating the liquid into the carburetor. However, if the contactors and agglomerators are of proper design and sufficient height the desired flow can be accomplished without the use of such aspirating effect.

Any desired ratio of absorber oil to gas can be used, for instance, one to ten gallons per thousand cubic feet, for example four gallons per thousand cubic feet.

The system shown has three stages but it will be apparent that a two stage system can be used. However, I prefer to use at least three stages and it is preferable to use a still higher number, for instance four or five, depending on the economy balance between the improved recovery possible with additional stages as opposed to the increased capital cost of the added equipment.

Residue gas from agglomerator **33***b* passes out through line **61** and is preferably compressed at least in large part for introduction into the sub-surface reservoir from which the well fluids were produced or into another sub-surface reservoir. This can be accomplished, for instance, by means of line **55**, compressors **56** and input well **57**.

As previously mentioned numerous modifications of my process and apparatus will occur to those skilled in the art in the light of the foregoing discussion and numerous improvements and details will be apparent. Thus for purposes of simplicity and to make the invention more readily comprehensible I have omitted various features of temperature, pressure and flow control as well as other items familiar to those skilled in the art. Accordingly it is not my purpose to restrict my invention to the preferred modification illustrated but only to the scope of the appended claim in which I have endeavored to define the novelty inherent in my invention.

I claim:

A device for contacting a gas concurrently with a liquid in mist form which comprises a vertically elongated contacting tower, inlet means for gas and liquid at the bottom of said tower, outlet means for gas and liquid at the top of said tower, a plurality of vertically spaced upwardly pointed annular baffles adjoined to said tower at their bottoms and adapted to form annular pools of liquid at various elevations in said tower, whereby drain back liquid is caught by said annular baffles and overflows at the top of said baffles in intimate contact with the ascending stream of gas and liquid mist passing from said inlet means to said outlet means, thus causing said drain back liquid to be resuspended in said stream, and a throat disposed below the lowermost of said baffles and above said inlet means, whereby any drain back liquid from said lowermost baffle is redispersed in the gas and liquid mist stream flowing upward from said inlet means to said baffles.

GEORGE S. BAYS.