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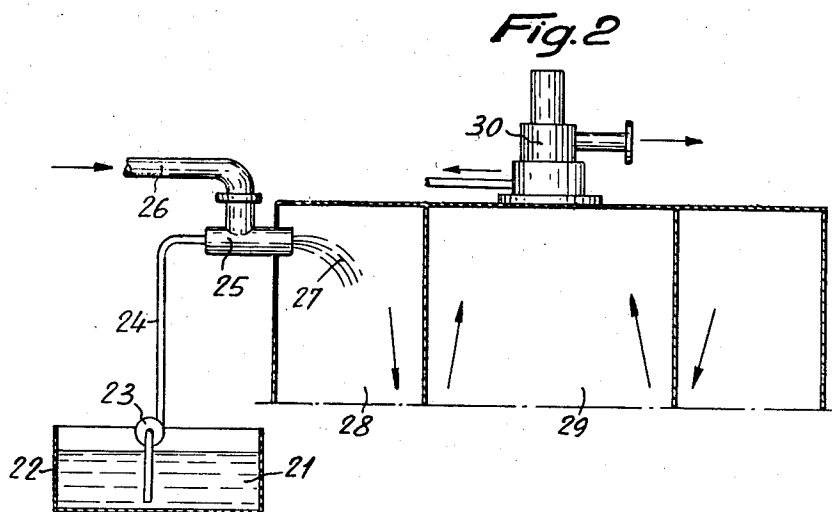
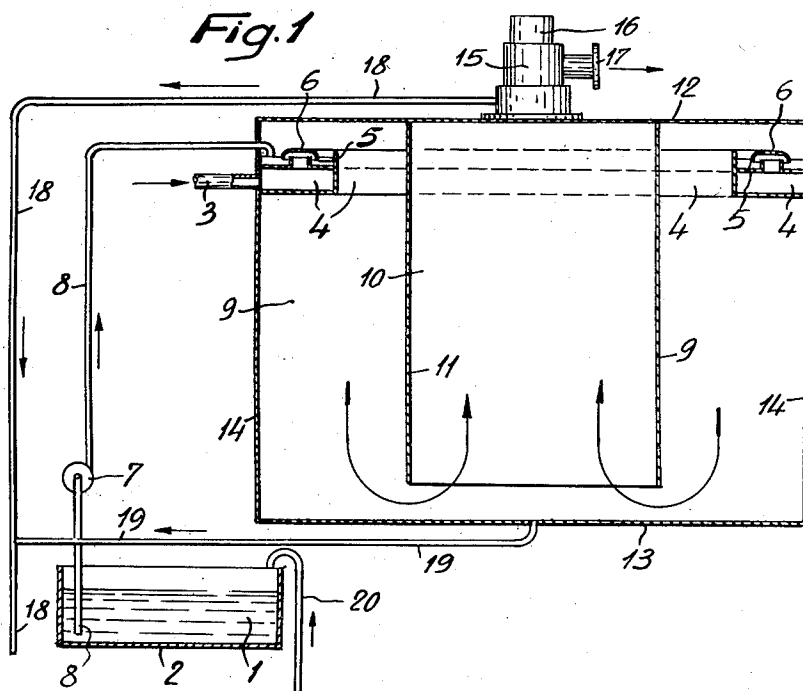
R. M. MERCIER

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MEANS ENSURING CONTACT BETWEEN GASIFORM FLUIDS AND LIQUIDS

Filed April 24, 1959

3 Sheets-Sheet 1



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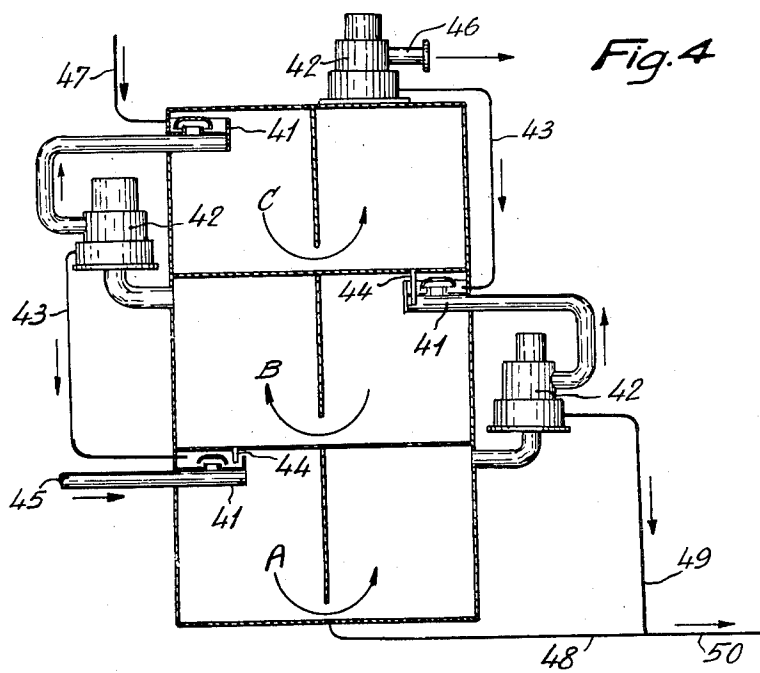
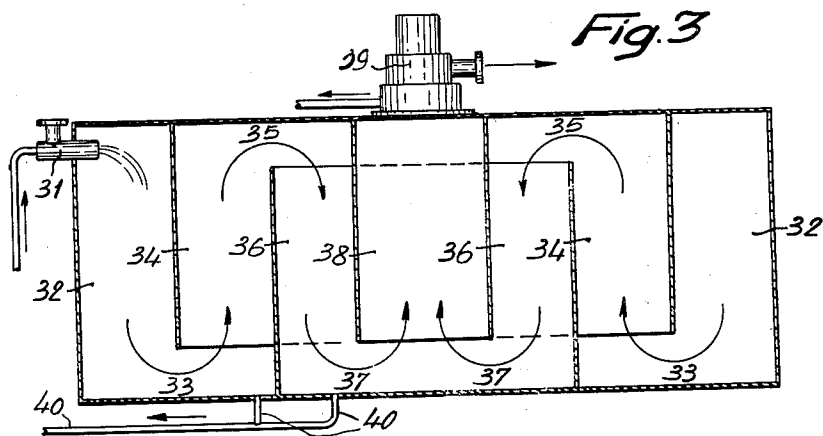
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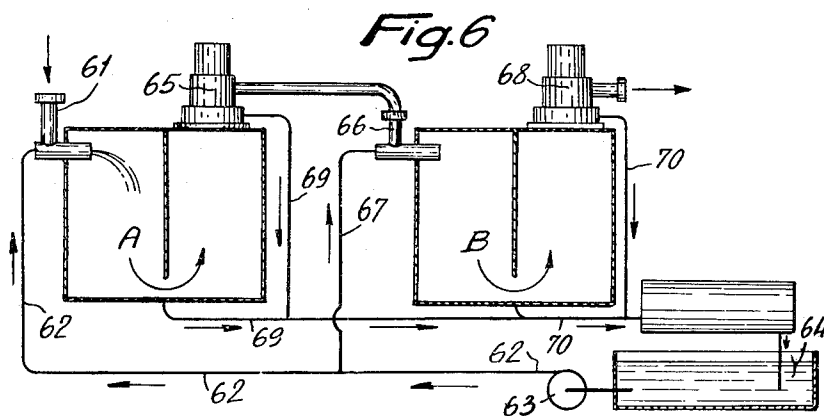
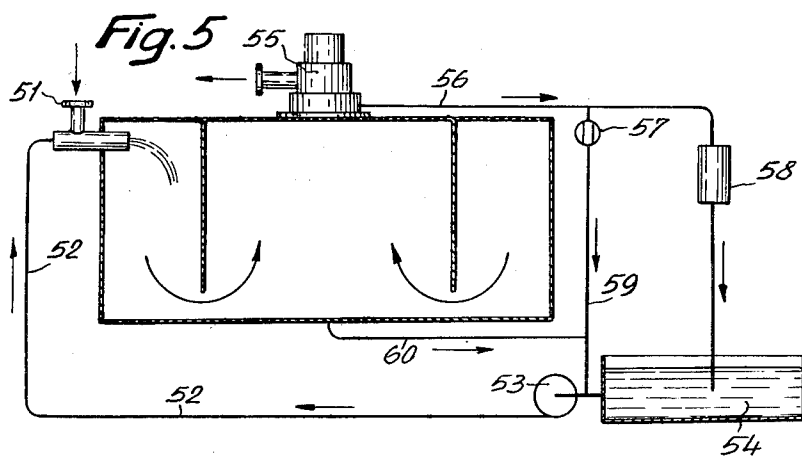
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MEANS ENSURING CONTACT BETWEEN GASIFORM FLUIDS AND LIQUIDS

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7 Claims. (Cl. 183—2.5)

It is a well known fact that one of the most favorable manners for physically or chemically contacting gases or vapors with liquids is to combine them as a froth wherein very small volumes of the gasiform fluid are enclosed inside a capillary liquid wall.

The arrangements disclosed in my French patent dated June 14, 1951 and carrying number 1,038,802 showed the drawbacks of operating within very narrow limits for the ratio between the volume of the gases and the volume of the liquid and also of constraining a mechanical froth breaker to execute the entire work of froth destruction. In the industrial applications of such methods, it is as a matter of fact necessary to take into account the facts that:

The formation of the froth absorbs energy.

The shifting of a mass of vertically moving froth also absorbs energy.

The operation of a mechanical froth breaker which is to ensure at the end of the operation the opening of the liquid walls so as to separate the gases from the liquid requires still a further amount of energy.

My present invention has for its object a device for reducing the amount of energy absorbed in the movement and in the breaking of the froth bubbles.

It has also for its object to resort to the use of the froth structure, even if the ratio between the volumes of liquid and of gasiform fluid are very different from $\frac{1}{10}$ th which is the ideal ratio, as provided by experience.

My invention will be readily understood upon reading of the following description of certain embodiments given by way of mere examples of apparatus adapted to execute the method referred to. In the accompanying drawings illustrating said embodiments:

FIG. 1 is a cross-sectional view of a contact-producing apparatus forming froth through bubbling.

FIG. 2 is a sectional view of a further contact-producing apparatus forming froth through the operation of an ejector.

FIG. 3 illustrates a contact-producing apparatus with multiple circuits.

FIG. 4 illustrates a contact-producing apparatus of a multiple-stage, methodical circulation type.

FIG. 5 illustrates a contact-producing apparatus intended for use with very low values of the liquid/gas ratio.

FIG. 6 illustrates a contact-producing apparatus intended for use with very large values of the liquid/gas ratio.

Turning to FIG. 1, the frothing liquid is set into contact with a vapor or a gas, as provided by storing the liquid 1 inside a container 2 and the gas is fed under a slight pressure through the pipe 3 feeding a header 4 of a suitable size located at the upper end of the apparatus; said header carries a flange 5 forming an annular trough over said header, and furthermore it feeds the gas into bubbling tunnels or caps 6 lying in said troughs and the number of which is sufficiently large. The liquid is fed into the trough by the pump 7 and a pipe 8 or through the agency of any other system, so as to form inside the trough a body of liquid, the depth of which may be held constant under the action of means which are conventionally used for industrial purposes.

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Thus, the gas fed through the pipe 3 is conveyed through the bubbling caps into the liquid carried by the trough and it is transformed into a froth which flows over the flange 5 into the compartment 9, the lower section of which communicates with the adjacent compartment 10 underneath the lower end of the partition 11 separating said compartments. The compartments 9 and 10 form a reaction chamber bounded by its cover 12, its bottom 13 and a wall 14, all of which are fluidtight, the two compartments being separated by the partition 11 extending from the cover 12 down to a level slightly above the bottom 13 of the chamber. Thus, the froth which has filled the compartment 9 can progress only inside the compartment 10 and towards the mechanical froth-breaker 15 driven by the motor 16. The latter acting on an inner rotor breaks the froth and allows the exhaust of the gases through the pipe 17 while the liquid separating therefrom is exhausted through the pipe 18.

It is apparent that the path followed by the froth and illustrated by the arrows provides for a methodical circulation of the said froth and if the differences in level between the bottom 13 and the froth-reducing caps 6 and froth-breaker 15 which are not all necessarily positioned in a common horizontal plane are suitably selected, it is possible to reduce by the desired amount the load and the losses of head produced by the weight of and by the friction exerted by the circulating froth.

On the other hand, the froth cannot remain in a mass of an indefinite height without its partial or total destruction at a more or less rapid rate and, therefore, it is possible, by suitably selecting the height of the apparatus to obtain a partial or total self-destruction of the froth which reduces the work to be executed by the mechanical froth-breaker. The destruction of the froth through crushing releases then some liquid over the bottom 13 of the vat or reaction chamber and said liquid returns through the pipe 19 to mix with the liquid flowing out of the froth-breaker at 18.

The extension of the pipe 18 provides for the exhaust of the reflux liquid as a whole and feeds it, if required, into means providing for a regenerating treatment after which the liquid is returned through the pipe 20 into the vat 2.

The reaction chamber bounded as mentioned by the walls 11, 12, 13 and 14 is designed in a manner such that the volume of gases and liquid flowing into it as a froth may remain therein during a period which is suitable for obtaining the physical action required or the chemical reaction which is to be produced, taking into account the fact that the compartment 10 may be entirely filled or partly filled with froth or even empty, according to the self-destroying effect to be obtained through a crushing of the froth.

The shape illustrated in FIG. 1 for the chamber 11, 12, 13, 14 is that of a cylindrical chamber subdivided by an annular partition, but any other shape would lead to the same results, which latter are defined, on the one hand, by the vertical travel of the froth along a U-shaped path and, on the other hand, by the difference in level between the froth-breaker and the froth producer. It is also possible to design a similar apparatus wherein the froth generated inside the central chamber is broken and exhausted through the upper part of the peripheral chamber. Lastly, if required, it is possible to maintain a liquid body above the bottom 13, said liquid body allowing in fact a cutting out of the container 2.

In the case where the liquid or the gas to be treated is subjected to a high pressure or in the case where the frothy properties of the liquid make the transformation into a froth a difficult matter, or again when the proportion between the liquid and the gas forms also a difficulty in the obtention of a froth, it is possible to substitute for

the bubbling caps froth-forming ejectors of the type used for producing fire extinguishing froths as illustrated in FIG. 2.

In this last embodiment, the froth-forming chamber is similar to that illustrated in FIG. 1, but it is illustrated only partly for the sake of clarity of the drawing; the liquid 21 stored inside the vat 22 is sucked out by the pump 23 and is delivered through the pipe 24 into one or more ejectors 25 located in the upper part of the outer compartment 28, said ejectors being fed with the gas to be used which is delivered through the pipe 26 and projecting froth jets 27 into said compartment 28.

After following its U-shaped path, the froth is admitted as illustrated in the case of FIG. 1 into the chamber 29 of which the sole exhaust means are constituted by the froth breaker 30. The operation of the arrangement is exactly similar to that illustrated in FIG. 1.

In the arrangement illustrated in FIG. 3, the froth produced by the ejector or by the bubbling means 31 flows downwardly from the upper part of the compartment 32 to be filled by it, and after passing through the passageway 33 it enters in an upward direction the compartment 34 and thence it enters through the upper passageway 35 into the next compartment 36 and so on through the passageway 37 into the central compartment 38 which carries on its upper wall the mechanical froth breaker 39. The liquid released by the natural crushing of the froth is delivered through the pipe 40.

It is thus apparent that the apparatus illustrated in FIGS. 1, 2 and 3 are capable, provided a frothing liquid of a suitable grade is used, of ensuring the desired contact between the liquid and the gas during the desired lapse of time while a minimum amount of driving energy is required for the formation, the circulation and the destruction of the froth, since these apparatus do not produce any raising of a column of froth and cooperate to a certain extent in the self-destruction of said froth through crushing.

The apparatus according to FIGS. 1, 2 and 3 may, through suitable contrivances, or through a suitable relative positioning of their parts, satisfy particular requirements to be described by way of examples of applications of my invention.

With the apparatus illustrated in FIG. 4, it is possible to treat a gas by a liquid associated in a froth condition in accordance with a so-called methodical circulation procedure.

The apparatus illustrated in vertical cross-sectional view in FIG. 4 includes by way of example three identical cells A, B, C, incorporating each the U-shaped circuit of the apparatus of FIGS. 1 and 2. Each cell is provided with a froth producer 41, a froth breaker 42, and means 43 for recycling the refluxes from the froth breakers 42 while the liquid obtained through the natural destruction of the froth is recycled at 44.

The gas to be treated enters through the pipe 45 and is exhausted after complete treatment by the froth-breaker pipe 46. On the other hand, the treating liquid which has not yet served enters at 47 and is exhausted through the pipes 48, 49 and 50. It is thus apparent that the grouping of a number of cells allows a methodical circulation in counter current relationship for the gases and the liquid to be put in contact with each other.

In FIG. 5, an apparatus of the type illustrated in FIG. 1 may serve for treating chemically in a froth phase a gas by a liquid, even when the volumetric ratio required between the gas and the liquid is extremely low and would not normally allow the formation of a froth.

To this end, a contacting chamber of the type illustrated in FIG. 2 is fed with gas by a pipe 51 opening into the ejectors, which receive the driving liquid through the pipe 52 fed in its turn by the pump 53 which sucks said liquid out of the vat 54. The froth breaker 55 releases the treated gas in a dry condition and returns through the pipe 56 the exhausted treating liquid. Said liquid is di-

vided into two fractions of which one is directed downwardly towards the vat 54, through an arrangement 58 providing for regeneration if any, while the other fraction passes through an adjusting valve 57 and a pipe 59 towards the pump 53. A pipe 60 feeds the suction end of the pump 53 with the liquid released by the natural crushing of the froth. It is thus apparent that it is possible to feed the froth producer with an amount of frothing liquid including the desired amount of fresh treating liquid, admixed with a practically unlimited amount of frothing liquid, which has been recycled and is chemically inert.

This reserve supply of recycled liquid acts only as a frothing liquid and it allows however obtaining a satisfactory compacity of the froth, which compacity could not be obtained by the fresh treating liquid if used alone.

Turning to FIG. 6, there are shown a number of apparatus of the type illustrated in FIG. 2 inserted in series, which allows treating a gas with a liquid in spite of a volumetric ratio between the gas and the liquid which is too high for the normal formation of a stable froth.

To this end, the gas enters the cell A through the pipe 61 of the ejector fed with liquid by the pipe 62 which is fed in its turn through the delivery end of the pump 63 sucking out of the storage vat 64 the fresh treating liquid.

The froth is destroyed after standing for a predetermined period by the froth breaker 65 which sends the gas into the ejector 66 of the next cell B which latter is fed with fresh treating liquid through the pipe 67 connected with the delivery pipe 62 of the pump 63.

After said predetermined standing period, the froth in the cell B is destroyed by the froth breaker 68 out of which the treated gas is exhausted in a dry condition.

The treating liquid is returned after use, through the pipes 69 and 70 into a regenerating apparatus towards the vat 54 for recycling.

It is apparent that through a suitable selection of the number of cells and subdivision of the stream of treating liquid between said cells, it is possible to obtain in each cell a froth of a suitable specific weight.

What I claim is:

1. An apparatus for intimately contacting a gaseous fluid with a liquid by forming a froth of the fluid and liquid in which the physico-chemical reactions therebetween are promoted, comprising at least one cell having a top and bottom and substantially vertical partition means therebetween dividing the interior of said cell into a plurality of compartments including at least an inlet compartment and an outlet compartment, froth forming means located near the top of said inlet compartment, means for supplying the gaseous fluid and liquid to be contacted to said froth forming means, froth breaking means disposed near the top of said outlet compartment, and conduit means extending from said froth breaking means to separately convey the gaseous fluid and liquid separated from each other by destruction of the froth, said partition means dividing each of said inlet and outlet compartments from the next adjacent compartment being spaced upwardly from said bottom of the cell so that the froth leaves said inlet compartment at the bottom of the latter and enters said outlet compartment at the bottom of the latter, thereby to travel a path between said froth forming means and said froth breaking means having at least one U-shaped bend therein so that the required period of contact of the gaseous fluid with the liquid in the froth can be obtained in a cell of relatively small height and with a relatively small distance between the levels of said froth forming and froth breaking means, thereby to reduce the energy required to move the froth along said path.

2. An apparatus as in claim 1; further comprising conduit means extending from said bottom of the cell to withdraw the liquid which collects at the bottom of said compartments as a result of self-destruction of the froth therein.

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3. An apparatus as in claim 2; wherein said partition means includes an odd number of at least three vertical walls alternately extending from said top and bottom of the cell to divide said interior of the latter into at least two intermediate compartments in addition to said inlet and outlet compartments and through which said path of the froth extends.

4. An apparatus as in claim 2; wherein there are provided a plurality of said cells arranged in a series, the gaseous fluid to be treated being supplied to said froth forming means of the cell at one end of said series and the liquid to be contacted with the gaseous fluid being supplied to the froth forming means at the other end of said series, the liquid from said froth breaking means of each cell being supplied to said froth forming means of the next cell in the direction toward said one end of the series, and the gaseous fluid from said froth breaking means of each cell being supplied to said froth forming means of the next cell in the direction toward said other end of the series, so that said gaseous fluid and liquid move generally counter-currently through said apparatus.

5. An apparatus as in claim 4; wherein said series of cells is arranged vertically with said one end of the series at the bottom and said other end of the series at the top; and wherein said conduit means extending from the bottom of each cell above the lowermost cell supplies the liquid withdrawn thereby to said froth forming means of the next lower cell.

6. An apparatus as in claim 2; wherein said means for supplying the liquid to said froth forming means includes a source of fresh liquid, liquid feeding means ex-

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tending from said source to said froth forming means, and means conducting a controlled portion of the liquid separated from the gaseous fluid in said froth breaking means to said liquid feeding means so that only a part of the liquid used in said froth forming means to form a froth with said gaseous fluid is constituted by fresh liquid, thereby permitting the contacting of a relatively high proportion of gaseous fluid with a relatively low proportion of said fresh liquid.

7. An apparatus as in claim 2; wherein there are provided a plurality of said cells arranged in a series, and said means for supplying the liquid to said froth forming means of each cell includes a source of fresh liquid and liquid feeding means extending from said source to the froth forming means of each cell; and wherein only the froth forming means of the cell at one end of said series receives fresh gaseous fluid, and the froth forming means of each of the other cells of said series receives gaseous fluid from the froth breaking means of the preceding cell toward said one end of the series, so that a relatively large proportion of fresh liquid can be contacted, in the form of a froth, with a relatively small proportion of fresh gaseous fluid.

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