Sept. 5, 1950 G. E. HADDELAND ET AL 2,521,215

PROCESS OF AND APPARATUS FOR DISPERSING AN AERIFORM BODY IN A LIQUID BODY

Filed July 1, 1946 2 Sheets-Sheet 1

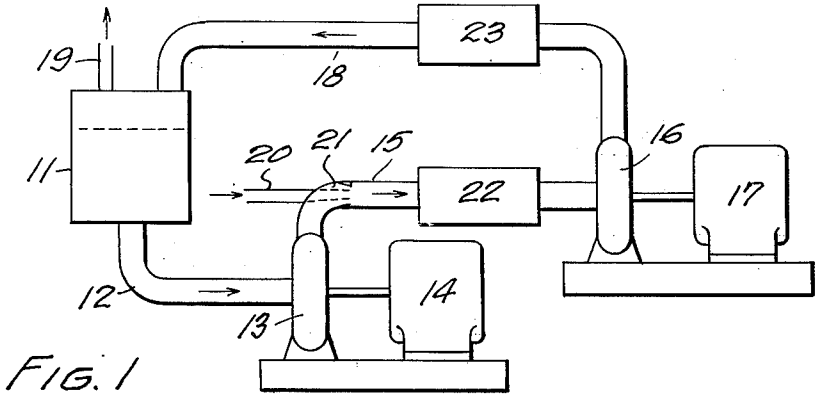


FIG. 1

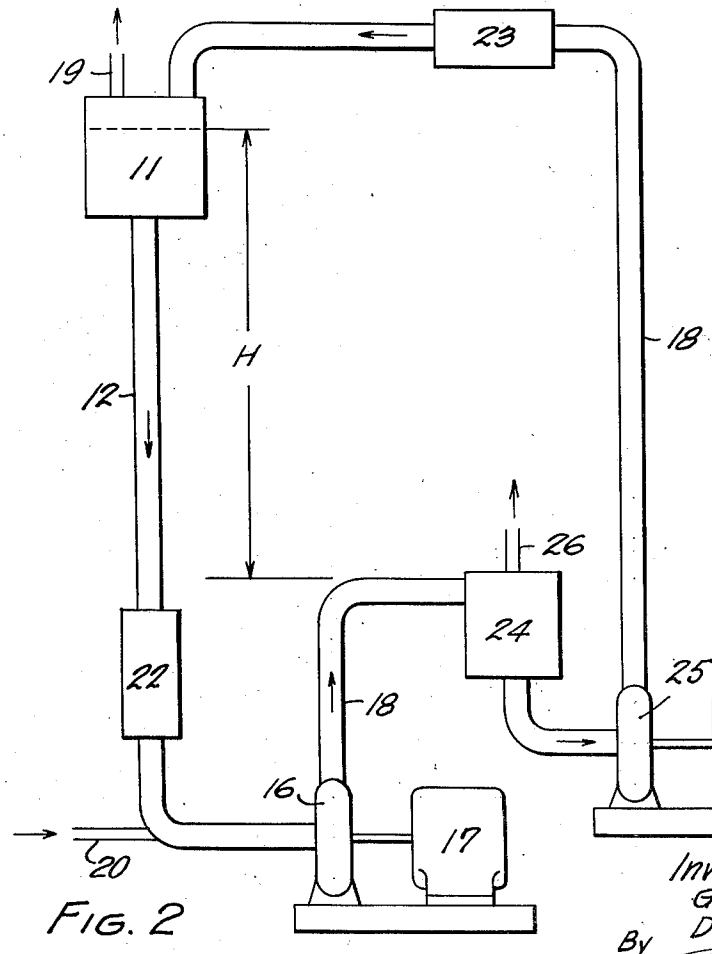


FIG. 2

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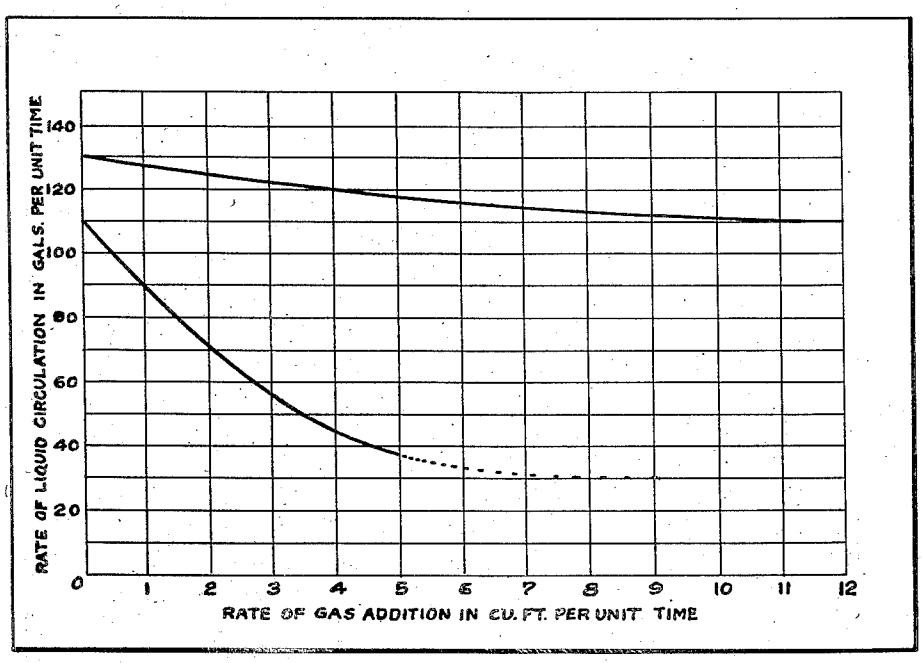


FIG. 3

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PROCESS OF AND APPARATUS FOR DISPERSING AN AERIFORM BODY IN A LIQUID BODY

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4 Claims. (Cl. 261—28)

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This invention relates to a process of and to apparatus for dispersing an aeriform body in a liquid body and the primary object of the invention is to provide a simple, easily controlled and economically operable process of and means for effecting the dispersion of an aeriform body, at high rate, into a liquid body. Another object is to provide a process and apparatus, as aforesaid, by means of which the aeriform body may be introduced at high rate into a stream of the liquid body with but small depression of the flow rate of the liquid. Still another object is to provide a process and apparatus, as aforesaid, which will serve equally well under conditions in which the aeriform body is merely dispersed in the liquid or in which it dissolves in or reacts with the liquid, with or without release of another gas and regardless of whether the reaction is exothermic or endothermic. A further object is to provide a process which does not require special or expensive apparatus for its carrying out but which permits use of ordinary, readily obtainable apparatus. A still further object is to provide a process, as aforesaid, peculiarly adapted for dealing with corrosive bodies, in that the apparatus required is readily obtainable made of corrosion resisting material. An additional object is to provide apparatus, as aforesaid, in which the gas dispersing means and its driving means are readily accessible instead of being contained in a closed reaction or other vessel. Various other objects and the advantages of the invention may be ascertained from the following description and the accompanying drawings.

The term "aeriform body" is to be understood as including bodies which are true gases or vapours at the temperature prevailing in the process and also gases or vapours containing finely dispersed droplets of liquid.

It has been proposed to disperse a gas into a liquid by introducing the gas into a stream of the liquid on the intake side of a centrifugal pump, or other liquid circulating means. If the rate of gas input is small, relative to the rate of liquid circulation, the gas is dispersed in the liquid during passage of the two through the pump. If, however, the rate of gas input is increased beyond a certain value, the flow of both gas and liquid becomes erratic and the gas is not well dispersed. If the gas input is still further increased, the pump ceases to function in developing pressure and the circulation of the liquid stops.

We have discovered that if suitable pressure is applied to the circulating liquid on the intake side of the dispersing pump, outwardly of the point of gas input, the aforesaid limitation on the gas input rate is very greatly reduced and

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relatively high gas input rates may be used without producing erratic operation and with only slight decrease in the liquid circulating capacity of the dispersion pump. Smooth operation over a wide range of gas input rate is not disturbed, even when the gas dissolves in or reacts with the liquid and is accompanied by release of another gas within the dispersing pump.

Broadly speaking, the invention consists, as to process, in circulating a stream of liquid through a dispersion zone, applying pressure to the liquid stream prior to entering the dispersion zone, and introducing a stream of an aeriform body into said liquid stream at a point between the dispersion zone and the point at which pressure is applied to the liquid stream; and consists, as to apparatus, in the combination of means for mechanically dispersing an aeriform body in a stream of liquid, means for applying pressure to the liquid stream on the intake side of the dispersing means, and means for introducing the aeriform body into the liquid stream at a point between the pressure means and the intake of the dispersing means.

In greater detail, the invention consists in the features and combinations of features herein disclosed, together with all such modifications thereof and substitutions of equivalents therefor as are within the scope of the appended claims.

For convenience, in the following description, the aeriform body will be referred to as "gas," but it will be understood that the invention is not thereby limited to true gases.

In the accompanying drawings, which illustrate an embodiment of the invention now preferred and a modification thereof, but to the details of which the invention is not limited:

Fig. 1 is a diagram of apparatus employing a pump for imposing pressure on a liquid stream.

Fig. 2 is a diagram of apparatus adapted to impose pressure on a liquid stream by the action of gravity.

Fig. 3 is a graph illustrating the comparative results of operations with and without imposition of pressure on the liquid stream.

Referring more particularly to the drawings, and especially to Fig. 1 thereof, 11 designates a storage tank for the liquid in which a gas is to be dispersed, the lower part of which tank is connected by a conduit 12 with the inlet of any suitable sort of pressure applying means 13, such as a centrifugal pump, gear pump or other pump capable of substantially uniform delivery, having any suitable driving means 14, such as an electric motor. Liquid discharged from the means 13 passes through a conduit 15 to the intake of any suitable sort of means 16 for dispersing a gas in

a liquid, such as a centrifugal pump or an impeller or paddle wheel operating within a casing, having a suitable driving means 17, such as an electric motor. Liquid, with gas dispersed therein, discharged from the means 16 may flow through a conduit 18 leading to the upper part of the tank 11. The top of the tank is preferably closed and provided with an outlet 19 for gas which may separate from the liquid. At a suitable point in the conduit 15, a gas supply pipe 20 leads into the conduit. The arrangement may embody merely a simple T-connection of the pipe 20 and the conduit 15 or the pipe 20 may, in effect, extend into the conduit 15, as shown at 21, in such a way as to produce a venturi effect giving a negative pressure, or suction, in the gas line 20. If desired, gas escaping at the tank outlet 19 may be conducted to the gas inlet 20 for recirculation. Means 22 and 23, which may be heat exchangers or may be simple loops or coils, may be inserted in the conduits 15 and 18, respectively, to provide heating or cooling effect as may be required to promote dispersion of gas in the liquid or to promote reaction of the gas and the liquid or to remove the heat of reaction; or may serve merely to prolong the time of contact of the gas and liquid.

In the alternative form of apparatus illustrated in Fig. 2, the tank 11 is located at such elevation above the rest of the apparatus as to provide a hydraulic head H imposing a pressure on the liquid equivalent to that imposed by the means 13 of Fig. 1. In this form of apparatus, there is inserted in the conduit 18, a closed holding tank 24 and any suitable sort of liquid raising means 25, such as a centrifugal pump, for raising liquid back to the tank 11. The holding tank is provided with a top vent 26. In this modification the gas supply pipe 20 leads into the conduit 12 on the intake side of the dispersing pump 16 and is therefore located between it and the pressure source, as in the previously described form.

The preferred capacity relation of the dispersing means 16 to the pressure means 13 or to the hydraulic head H is such that the capacity of the means 16 corresponds, with no gas input, to the delivery capacity of the means 13 or the capacity of the hydraulic head H to deliver liquid to the means 16. If the capacity of the dispersing means 16 is materially greater than as aforesaid, the liquid flow and gas dispersion are irregular and if the capacity is materially smaller, it adds to the fluid flow resistance of the system and consequently decreases the gas dispersing capacity of the system.

The pressure on the inlet side of the dispersing means 16 created by the pressure means 13 or by the hydraulic head H must be sufficient to overcome the fluid friction loss (modified by the input of gas) caused by the venturi 21, if used, by the dispersing means and conduits, including the heat exchangers or other means 22 and 23.

The advantage of applying pressure to liquid flowing to the dispersing means is illustrated by the graph, Fig. 3, which is based on dispersion of air in water, and in which the lower curve shows the relation of liquid circulation rate to gas input rate when no pressure is applied to liquid entering the dispersing means; while the upper curve shows the relation of these rates when pressure is applied according to this invention. In the lower curve, it will be observed, the circulation rate drops sharply as the gas input rate increases. The portion of the curve shown in broken line indicates erratic flow of gas and liquid and poor dispersion of the gas, both increasing with increase in the rate of gas input, to a point at which flow substantially stops. By comparison, the upper curve shows only a slight drop in circulation rate at a gas input rate higher than that at which circulation ceases in the lower curve. The upper curve shows the performance of apparatus according to Fig. 1, while the lower curve shows the performance of the same apparatus with the pressure means short circuited. Dispersion efficiency using the pressure means 13, as observed visually in a glass section of the conduit 18, showed only a slight decrease but no sharp break until the flow friction became greater than the maximum discharge pressure of the dispersing pump.

When circulation is not required, that is, when the liquid need pass through the dispersing zone only once, the apparatus may be modified by elimination of the conduit 18 of Fig. 1 and the elimination of the holding tank 24, the liquid raising means 25 and the conduit 18 of Fig. 2.

The process of this invention is applicable to gases and liquids having densities and viscosities within a wide range and may be used in carrying out a great variety of physical and chemical processes.

Having thus described our invention, we claim:

1. Apparatus for dispersing an aeriform body in a liquid body, which apparatus comprises a conducting system for a stream of liquid, including a centrifugal pump, a conduit for conveying the liquid stream to the centrifugal pump, means for applying pressure to the liquid in said conduit, thereby to maintain a flowing stream of liquid, and a supply pipe for introducing the aeriform body to said conduit at a pressure greater than the positive pressure applied to the liquid, said supply pipe being connected to the said conduit between the pump and the said means for applying positive pressure to the liquid.

2. Apparatus according to claim 1 in which the pressure applying means is a pumping means;

3. Apparatus according to claim 1 in which the pressure applying means is a part of the conducting system leading to the intake of the centrifugal pump, disposed at such elevation above the centrifugal pump as to establish a column of the liquid sufficient to apply pressure in excess of the pressure drop in the system due to friction and to the introduction of the aeriform body.

4. In a method of dispersing an aeriform body in a liquid body by passing the two together through a centrifugal pump, the steps of applying positive pressure to a stream of the liquid only on the inlet side of the pump, introducing the aeriform body into the stream of the liquid body at a point between the pump and the point of application of said positive pressure to the liquid and at a pressure greater than the positive pressure applied to the liquid, and discharging the resultant dispersion at a pressure lower than said positive pressure applied to the liquid.

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