United States Patent [19]

Hege

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[54] **HIGH ENERGY MIXING DEVICE**

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[73] Assignee: **Hege Advanced Systems Corporation,** Woodland Hills, Calif.

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[52] **U.S. Cl.** **259/95,** 259/96

[51] **Int. Cl.** **B01f 5/02,** B01f 5/10, B01f 13/10

[58] **Field of Search** 259/95, 96

[56] **References Cited**

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Assistant Examiner—Philip R. Coe
Attorney—Hugh A. Chapin et al.

[57] **ABSTRACT**

This disclosure is directed to a pumping and mixing device through which fluids are circulated. The device comprises a tank with a mixing head which contains high energy mass exchange impinging nozzles and a jet pump through which fluids from the mixing head pass under the driving force of at least one centrifugal pump. With the centrifugal pump inlet pressure increased by the use of the jet pump, large quantities of gases (or less dense fluids) may be injected at a point between the jet pump and the centrifugal pump inlet while still having the centrifugal pump produce a high discharge head (i.e., no cavitation). The fluid from the centrifugal pump outlet may be divided into two streams. One stream is passed through nozzle devices into the tank and the other is passed back through the jet pump. The device and its method of operation may be illustrated by the process of clarifying aqueous solutions of sugar and dissolving sugar crystals in water.

13 Claims, 7 Drawing Figures

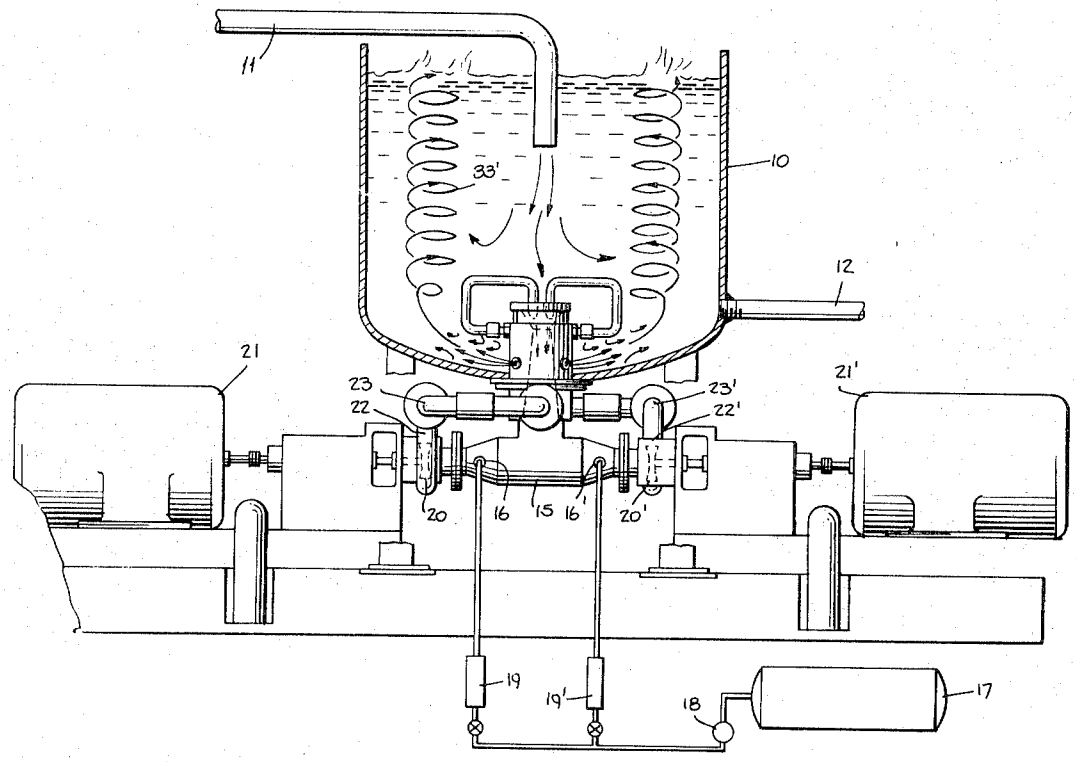
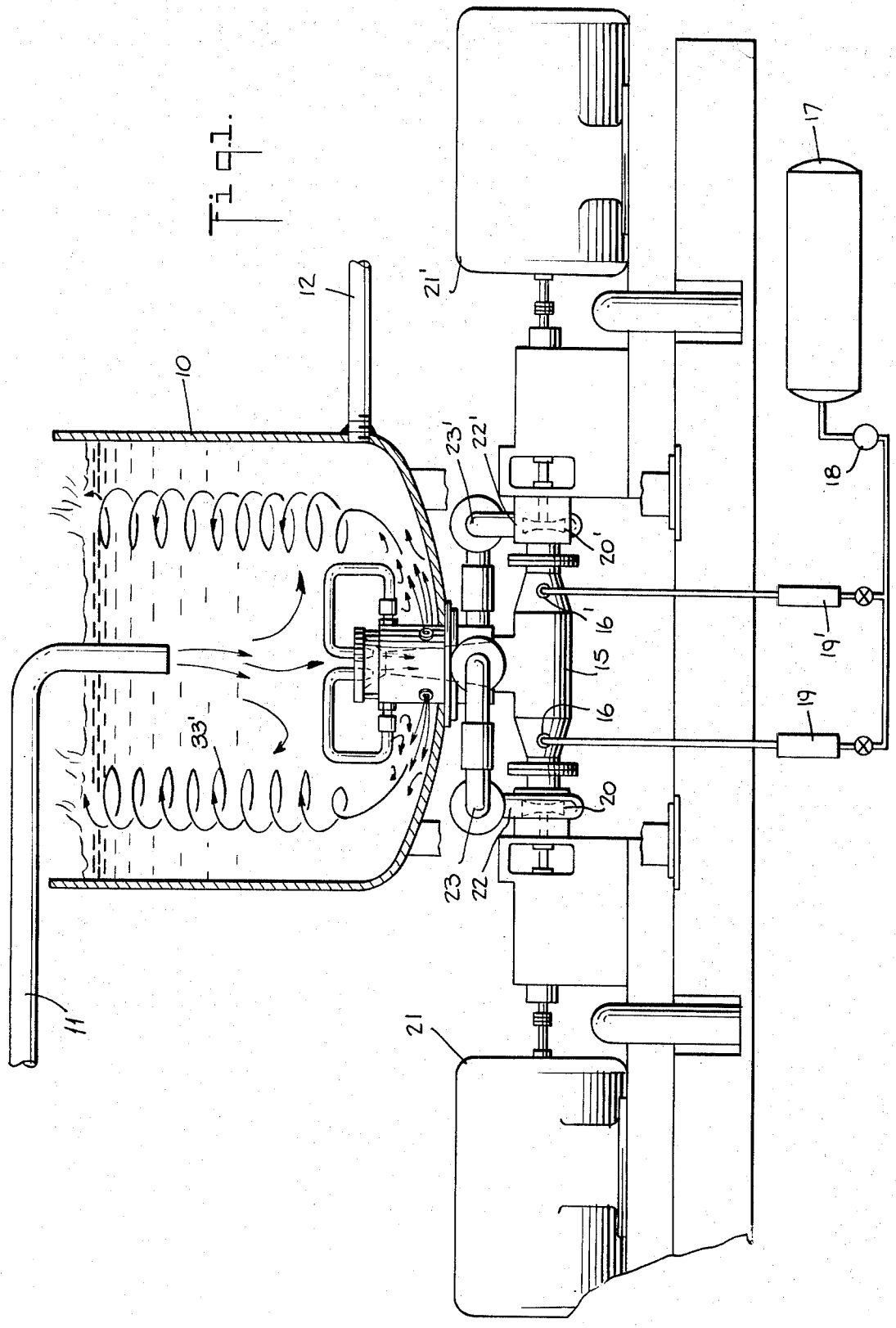


Fig. 1.



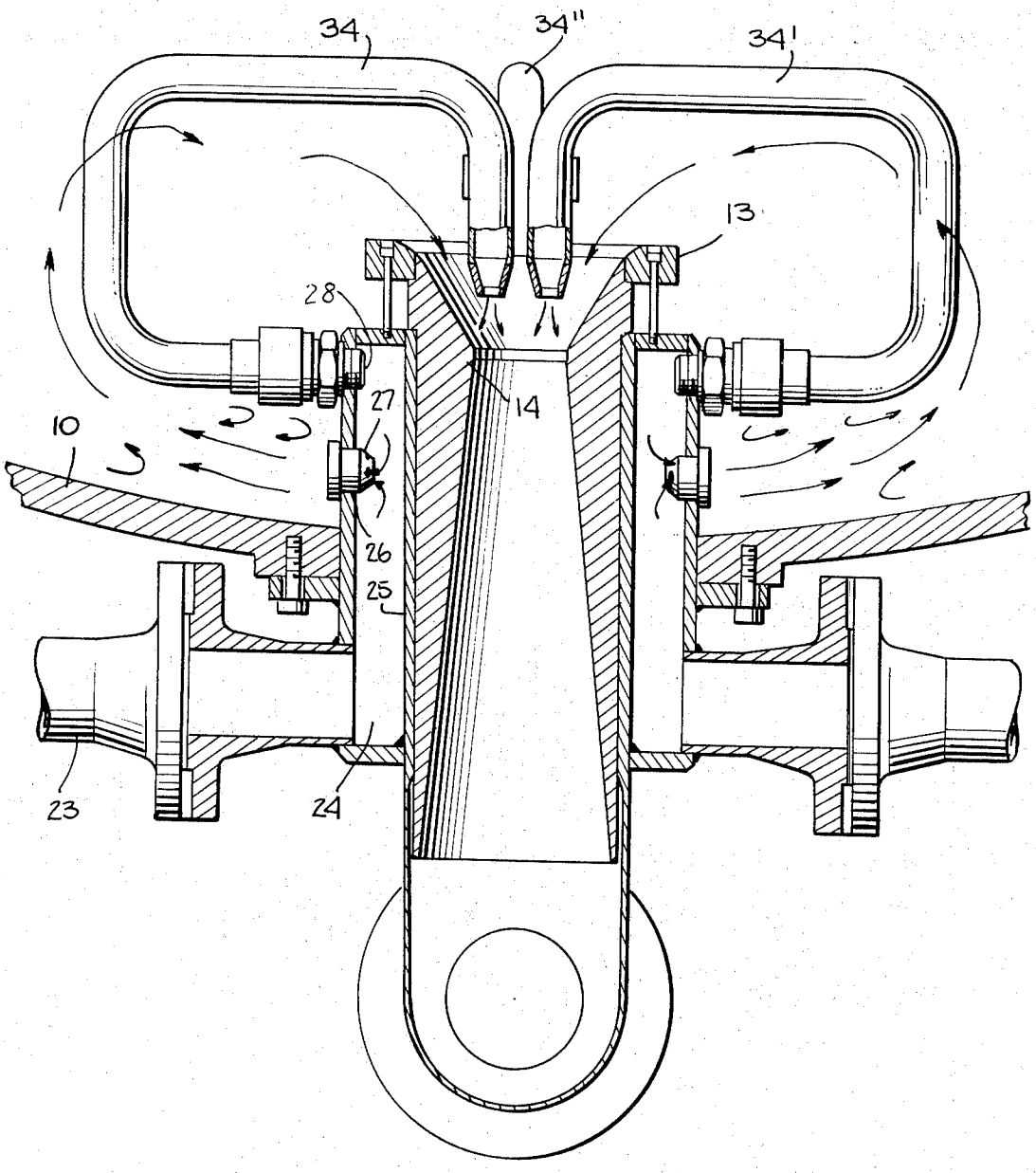
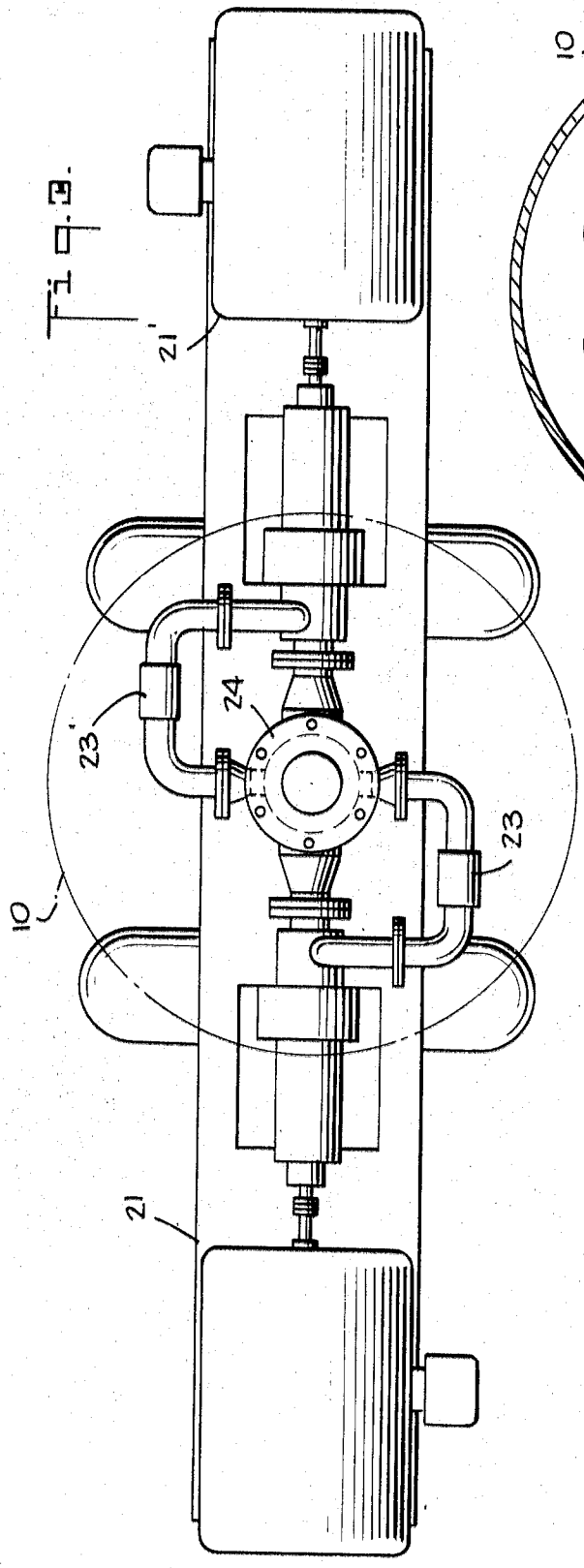


Fig. 2.

Fig. 3.



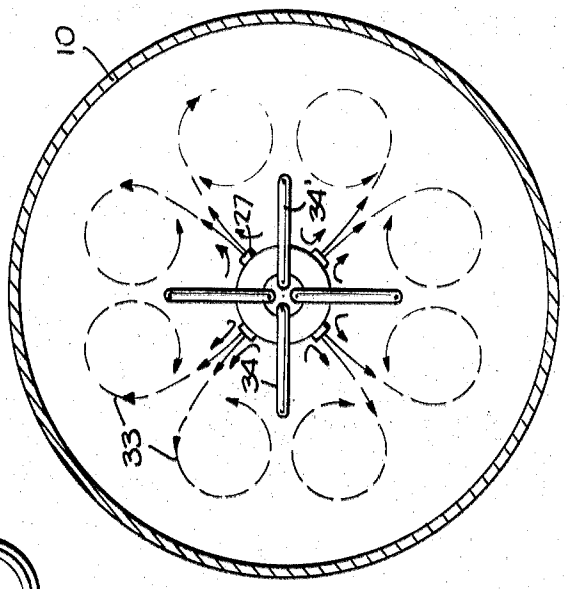
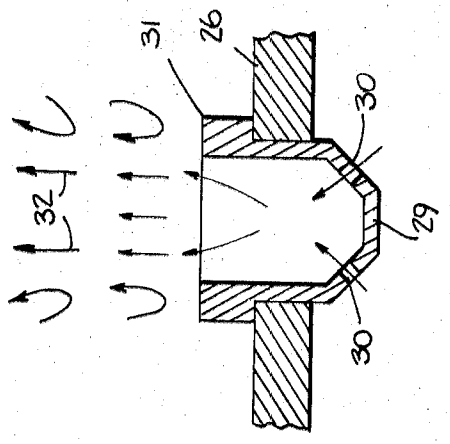


Fig. 5.

Fig. 4.



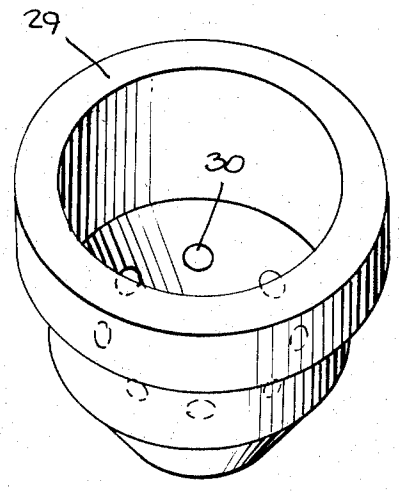
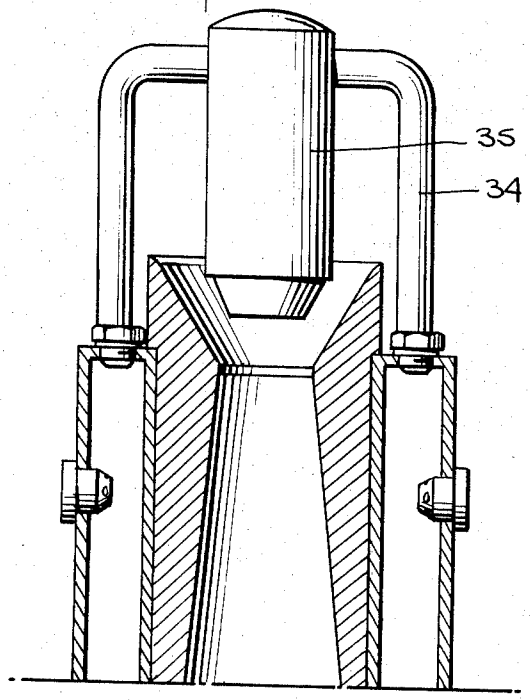


Fig. 6.

Fig. 7.



HIGH ENERGY MIXING DEVICE

THE INVENTION

This invention is directed to a method and device for the high energy mixing of fluids. The nature of the fluids can vary widely and may comprise one or more liquids with a gas and/or a solid which may be soluble in the liquid. The device comprises a mixing chamber into which the fluids are pumped. The fluid passes through a jet pump at the bottom of the mixing chamber which is connected to one or more centrifugal pumps which recirculate the fluids back to the mixing chamber. Air, other gases or lighter fluids may be injected into the fluid at a location between the jet pump outlet and the centrifugal pump inlet. The centrifugal pump outlet discharges the fluid through nozzles which are designed to form streams which impinge upon each other for mass transfer to increase the mixing efficiency of the process. A portion of the fluid from the pump outlet may be diverted back into the jet pump.

The process and device are illustrated in greater detail by the accompanying figures.

FIG. 1 is an overall view of the mixing and pumping apparatus.

FIG. 2 is a detailed view of the jet pump.

FIG. 3 shows the configuration of the recirculating system below the mixing tank.

FIG. 4 is a detailed view of a mixing nozzle.

FIG. 5 illustrates the flow of fluids from the mixing nozzles.

FIG. 6 is a view in perspective of the base of the dispersant port of FIG. 4.

FIG. 7 is an alternative embodiment of the recirculating nozzle system.

Mixing tank **10** has an inlet pipe **11** and outlet pipe **12.** Liquid passes from the inlet pipe into the mixing tank and then into a jet pump, identified generally by the reference numeral **13.**

The jet pump is shown in greater detail in FIG. **2.** The liquid in the mixing tank passes through a reduced cross-sectional area formed by a ribbed section **14,** a venturi, in the jet pump, which increases the speed and turbulence of the liquid. The liquid then enters chamber **15** which contains air-ejector outlets **16, 16'** (FIG. **1**). A compressed air tank **17** delivers air through regulators **18** and **19, 19',** each of conventional design, into the ejectors which are directed away from the direction of the incoming liquid. An air pressure of from about 15–90 psig may be used, a lower range of 20–30 psig is satisfactory for most pruposes. The air-liquid mixture is pulled from chamber **15** by the turbine members **20, 20',** which are driven by motors **21, 21'** respectively. The air pressure from the ejectors assists in forwarding the liquid and preventing cavitation. The air-liquid mixture passes from chambers **22, 22'** into return conduits **23, 23'** and then into return chamber **24.** The return chamber **24** is within, and is formed by, the inner wall **25** and outer wall **26** of jet pump **13,** FIG. **2.** The return chamber has two types of exit ports, the dispersant ports **27** and the return ports **28.** A dispersant port is shown in detail in FIGS. **4** and **6** and the configuration of four dispersant ports in the circumference of wall **26** of jet pump **13** are shown in FIG. **5.** The dispersant ports comprise a generally concave member **29** having holes **30, 30'.** The streams emerging from the holes converge and impinge upon each other as shown by the arrows in FIG. **4.** These streams constitute a primary

mixing and momentum exchange with the system illustrated. The concave member **29** may terminate at wall **26** or, as shown, extend therefrom by collar member **31.** The flow patterns from the streams emerging from **29** are indicated generally by arrows **32.** The overall flow pattern from the dispersant ports is illustrated by the arrows **33** in FIG. **5.** This constitutes a secondary mixing and vortex generation. the currents generated rise in the tank as illustrated by arrows **33'.** The return ports are connected to return conduits **34, 34'** which discharge into the jet pump **13,** FIG. **2.**

The above described unit may be constructed in a wide variety of sizes from small units of about ten gallons capacity to large units of over 500 gallons. Representative sizes and operation will be illustrated for a unit of 500 gallons batch-capacity with a high throughput. For such a unit the tank **10,** of stainless steel, is about 4 feet in diameter and 6 feet high. The liquid enters the jet pump **13** having an opening at the top and bottom of about 5 inches and a venturi **14** width of about 2½inches. The air ejectors **16, 16'** discharge air at about 20–30 psig. The liquid movement is directed by two Tri-Flow No. 328F pumps which have a capacity of about 500 gallons per minute. The pumps, illustrated by turbines **20,20'** in chambers **22, 22',** have inlets from chamber **15** for the air-liquid mixture of 4 inches and outlets for return conduits **23, 23'** of 2 inches. The motors **21, 21'** which drive the pumps have a horsepower rating of **75.** The return conduits **34, 34'** are about 1 inch in diameter and the liquid exits back into the jet pump from the ½ inch nozzle ends of these return conduits. The dispersant ports each have an opening of about ½ inch at the outer periphery of wall **26.** The dispersant holes have a diameter of about ⅛ inch.

The system of this invention employs the three fundamental mixing processes of mass transfer, eddy diffusion and molecular diffusion. The mass transfer mixing occurs largely in the high energy, high volume transfer of material which recirculates from the jet pump **13,** through the centrifugal pump system **22–23,** and back through return conduits **34.** This will be referred to as flow path I. The eddy diffusion and molecular diffusion predominate in the liquid bulk in the tank. The liquid in the tank undergoes constant movement due to the rising eddies **33'.** Liquid in the tank also flows downward with incoming liquid from inlet **11** and a portion flows outward and is caught in the eddy currents. This will be referred to as flow path II. The ratio between the flow of liquid in paths I and II is controlled by adjusting the openings of the dispersant **27** and return **28** ports. The control means may be at one or both of the types of dispersant ports or a control means may be attached at the nozzle ends of return conduits **34.** Such a control means is shown in FIG. **7** which illustrates a head member **35** in which the return conduits **34** terminate. The control means of head **35** may be of conventional design, such as adjacent rotatable perforated plates, in which the perforations can be adjusted into or out of alignment.

Two or more high energy streams of heterogenous mixtures of masses impinging on each other give a mass exchange such that the more dense substances exchange their position with the less dense substances and they then are in contact with fresh less dense material; thus enhancing mixing, dissolution, adsorption, and/or reaction. This exchange occurs primarily in

three areas: (1) between the several streams which emerge from the nozzle 27 and impinge upon each other; (2) between these streams and the bulk of the fluid in the tank; and (3) between the fluid streams from conduits 34 and the fluid from the tank drawn into the jet pump.

With the centrifugal pump inlt pressure increased by the use of the jet pump, large quantities of gases (or less dense fluids) may be injected at a point between the jet pump and the centrifugal pump inlet and still have the centrifugal pump produce a high discharge head (i.e., no cavitation). The injection of this large quantity of gases (or less dense fluids) in the jet pump discharge where the pressure is as much as 35/40 psi above tank pressure or at least 15 psi above the head tank pressure and where the gases/fluids are then subjected to an increasing pressure gradient (i.e., 60–200 psi) and a high turbulence in the pump, enhances gas/fluid diffusion as very small bubbles and its mixing, suspension, or absorption.

The method and apparatus of this invention is useful for the clarification of sugar. A sugar syrup to which phosphoric acid and lime were added was mixed in the device shown in FIG. 1 under the following conditions:

	Clarifier
Tank Size	500 gal
Volume Used	250 gal
Pump Flow Rate	540 gpm
Tank Flow Rate	290 gpm
Jet Pump Flow Rate	250 gpm
Throughput	80 gpm
Press.-manifold	190 psig
Press.-Pump Inlet	21 psig
Press.-Throat	3 inches Hg
NPSH	17 feet
HP - Horsepower/motor	55 Hp
Amps	70
Recirculation Factor	6.75
Air Flow Rate	400cc/min
Pressure - air	30 psig
Nozzles	4 out/4 receive
Tank Nozzles (4)	Pair of 0.332
Jet Nozzles (4/1)	0.472 dia
Jet Pump Throat	2.32 in
Impeller Dia.	9 inches

The resultant syrup contained from 50 to 100 ppm contaminants (average about 75 ppm) and 9,340 bubbles/cm^2. A comparable mixing procedure without the use of the jet pump gave a syrup having from 50 to 500 ppm contaminants (average about 150 ppm) and 2,577 bubbles/cm^2. The use of the jet pump therefore gave a better and more uniform product.

This invention may be used for the mixing or stirring of a wide variety of substances such as homogenization, dispersion, and reaction. The substances may be one or more liquids, which can be miscible or immiscible with each other, and may contain solids or gases which are soluble or insoluble therein. A particularly useful embodiment of the present invention is the aeration of liquids, such as industrial and municipal waste streams. The efficient aeration of such streams by the present invention reduces the pollution effects of the streams. A further embodiment is to mix other reactive gases, such as sulphur dioxide or chlorine, to effect sulphonation or chlorination of, for example, hydrocarbon streams.

This invention has been described in terms of specific embodiments set forth in detail. Alternative embodiments will be apparent to those skilled in the art in view of this disclosure, and accordingly such modifications are to be contemplated within the spirit of the invention as disclosed and claimed herein.

I claim:

1. A system for mixing a fluid which comprises a tank to hold said fluid; a jet pump, comprising a jet ejector conduit, and a venturi section, the inlet of said venturi section adapted to communicate with the fluid in said tank; a pump; means (A) to interconnect the outlet of the venturi section with the inlet of said pump, said means (A) adapted to increase the inlet pressure of said pump; means (B) to interconnect the outlet of said pump with the inlet of said jet ejector, and means (C) to interconnect the outlet of said pump with the fluid in said tank.

2. A method of mixing a material in a container which comprises

passing the material through a pump means;

dividing said material from the pump into two streams;

passing the first of said streams through dispersant ports in the form of self impinging streams;

passing the second of said streams through the inlet of a jet pump which draws with it material from the container and provides the input for said pump means, and maintaining said first and second streams to induce a circulating stream of the material in said container.

3. The method of claim 2 wherein an additional fluid is injected into said pump means to increase the pressure at least 15 psi at the inlet of said pump means.

4. The method of claim 3 wherein said fluid is air.

5. The method of claim 2 wherein said material is an aqueous solution.

6. A method of treating in a container a stream containing a fluid and a second substrate which comprises passing said stream into a jet pump, wherein the inlet of said jet pump communicates with the interior of said container, passing the output of said jet pump through a conduit into a centrifugal pump, to increase the pressure at the inlet of said pump, passing the output of said centrifugal pump into said container from which fluid passes to the inlet of said jet pump and injecting an additional fluid into the output stream of said jet pump to increase pressure at the inlet of said centrifugal pump.

7. A system for mixing a fluid which comprises a tank to hold said fluid; a jet pump, comprising a jet ejector conduit and a venturi section, the inlet of said venturi section adapted to communicate with the fluid in said tank; a pump; means (A) to interconnect the outlet of the venturi section with the inlet of said pump; means (B) to interconnect the outlet of said pump with the inlet of said jet ejector, and means (C) to interconnect the outlet of said pump with the fluid in said tank, said means (C) comprising dispersant port members, each dispersant port comprising a plate member with holes therein adapted to pass fluid from the pump into the tank in the form of converging streams.

8. The system of claim 7 comprising a chamber positioned about said jet pump, the inlet of said chamber connected to said pump, and the outlets of said chamber being means (B) and means (C).

9. A system for mixing a fluid which comprises a tank to hold said fluid; a jet pump, comprising a jet ejector conduit and a venturi section, the inlet of said venturi section adapted to communicate with the fluid in said tank; a pump; means (A) to interconnect the outlet of the venturi section with the inlet of said pump; means (B) to interconnect the outlet of said pump with the inlet of said jet ejector; means (C) to interconnect the

outlet of said pump with the fluid in said tank, and means (D) to eject air into said pump positioned in said means (A).

10. The system of claim **9** wherein said means (D) comprises ejector conduits having outlets positioned toward the inlet of said pump and inlets connected to a compressed air system.

11. A method of treating a stream containing a fluid and a second substance in a container which comprises

directing said stream from said container to flow along a first predetermined path under high-energy mixing conditions through a pump

causing said stream to be divided into

a first part which is directed into said first predetermined path and

a second part which is further divided into multiple streams which impinge upon each other and

causing the streams of said first and second part to mix with said stream in said container.

12. The method of claim **11** wherein fluid is injected into said first predetermined path.

13. The method of claim **12** wherein said fluid is air.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,762,689 Dated October 2, 1973

Inventor(s) Douglas W. Hege, Woodland Hills, California

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 50, "pruposes" should be --purposes--.

Column 3, line 7, "inlt" should be --inlet--.

Column 4, line 33, "substrate" should be --substance--.

Signed and sealed this 2nd day of July 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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