

Jan. 1, 1946.

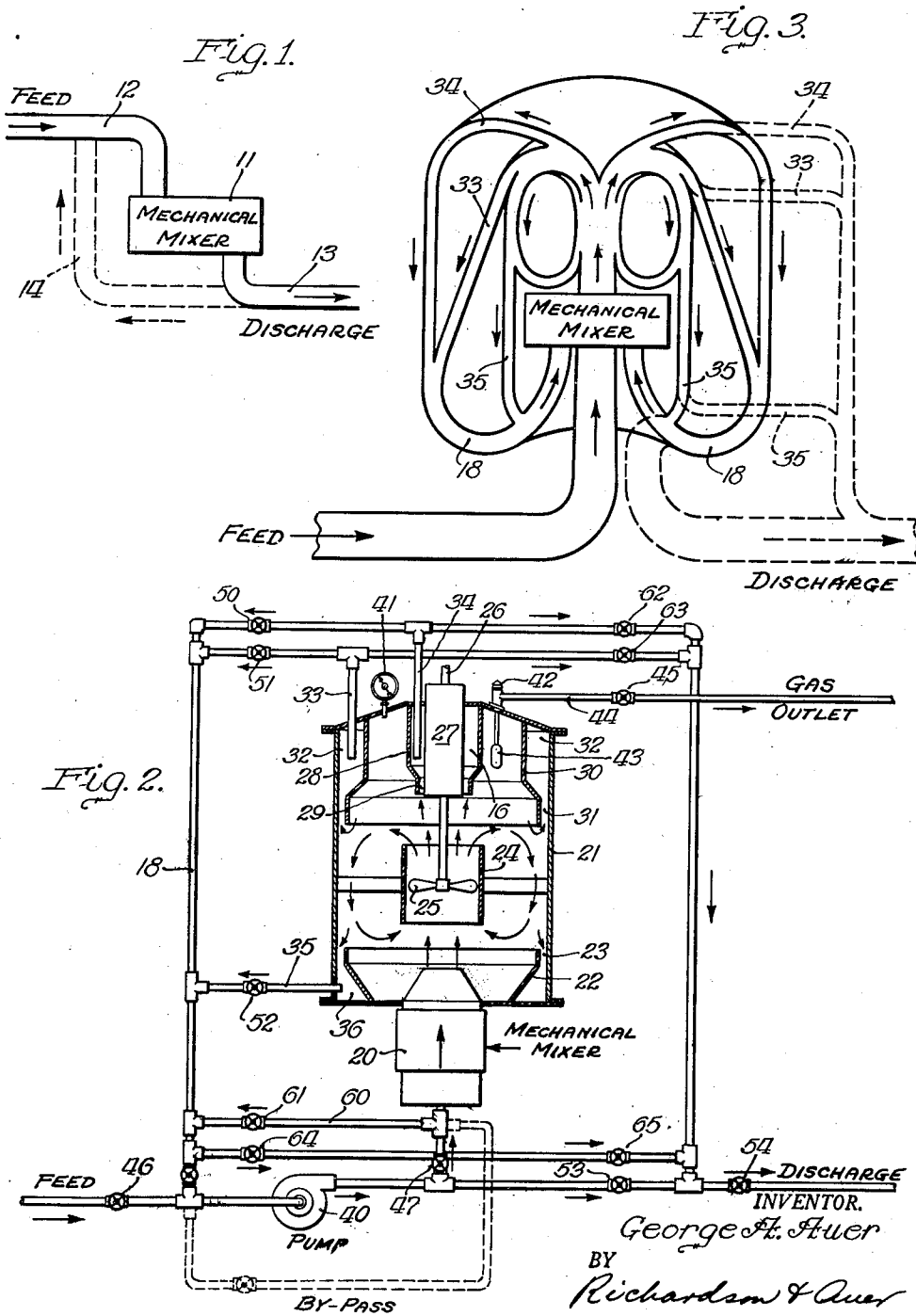
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2,391,858

STREAMCURRENT APPARATUS FOR MIXING MATERIALS

Filed July 31, 1943

6 Sheets-Sheet 1



Jan. 1, 1946.

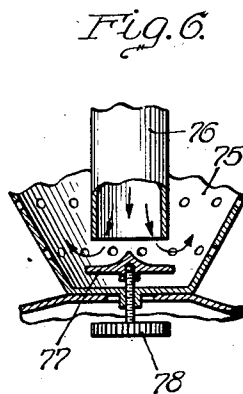
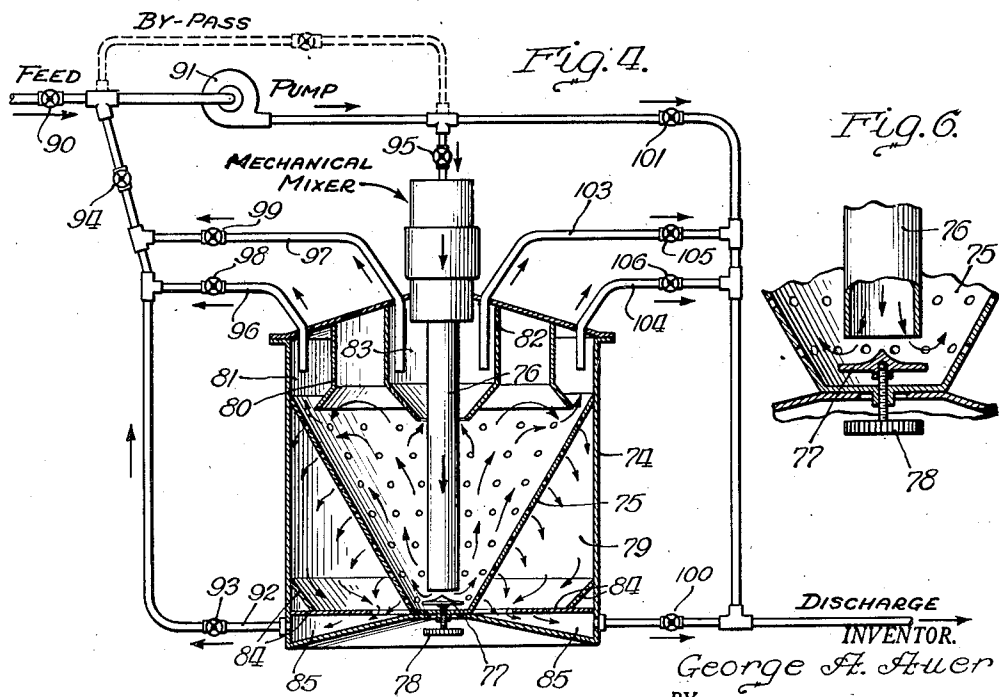
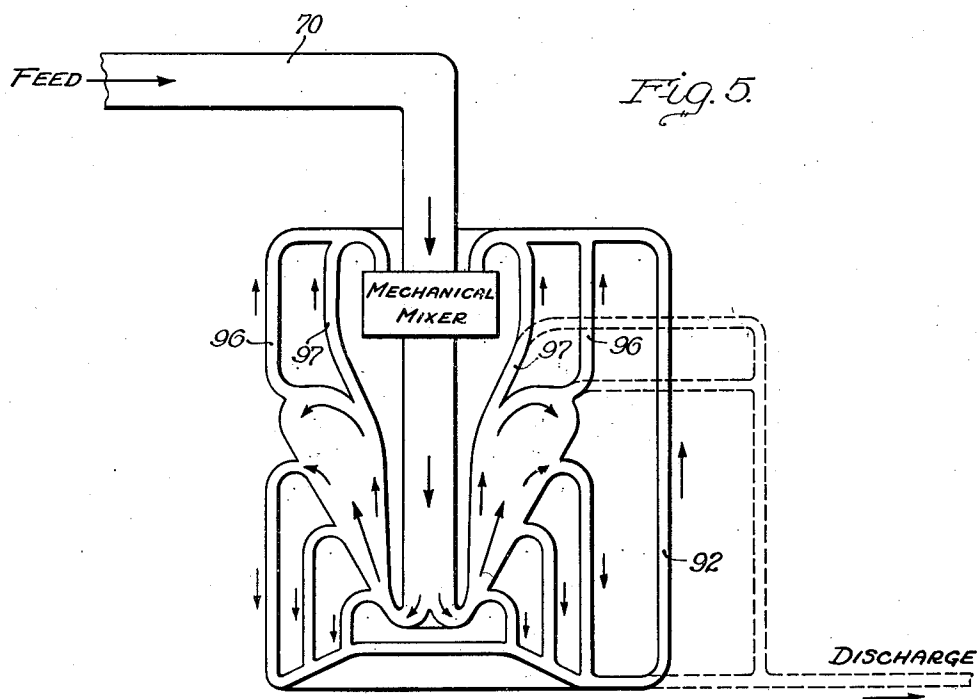
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STREAMCURRENT APPARATUS FOR MIXING MATERIALS

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6 Sheets-Sheet 2



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STREAMCURRENT APPARATUS FOR MIXING MATERIALS

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6 Sheets-Sheet 3

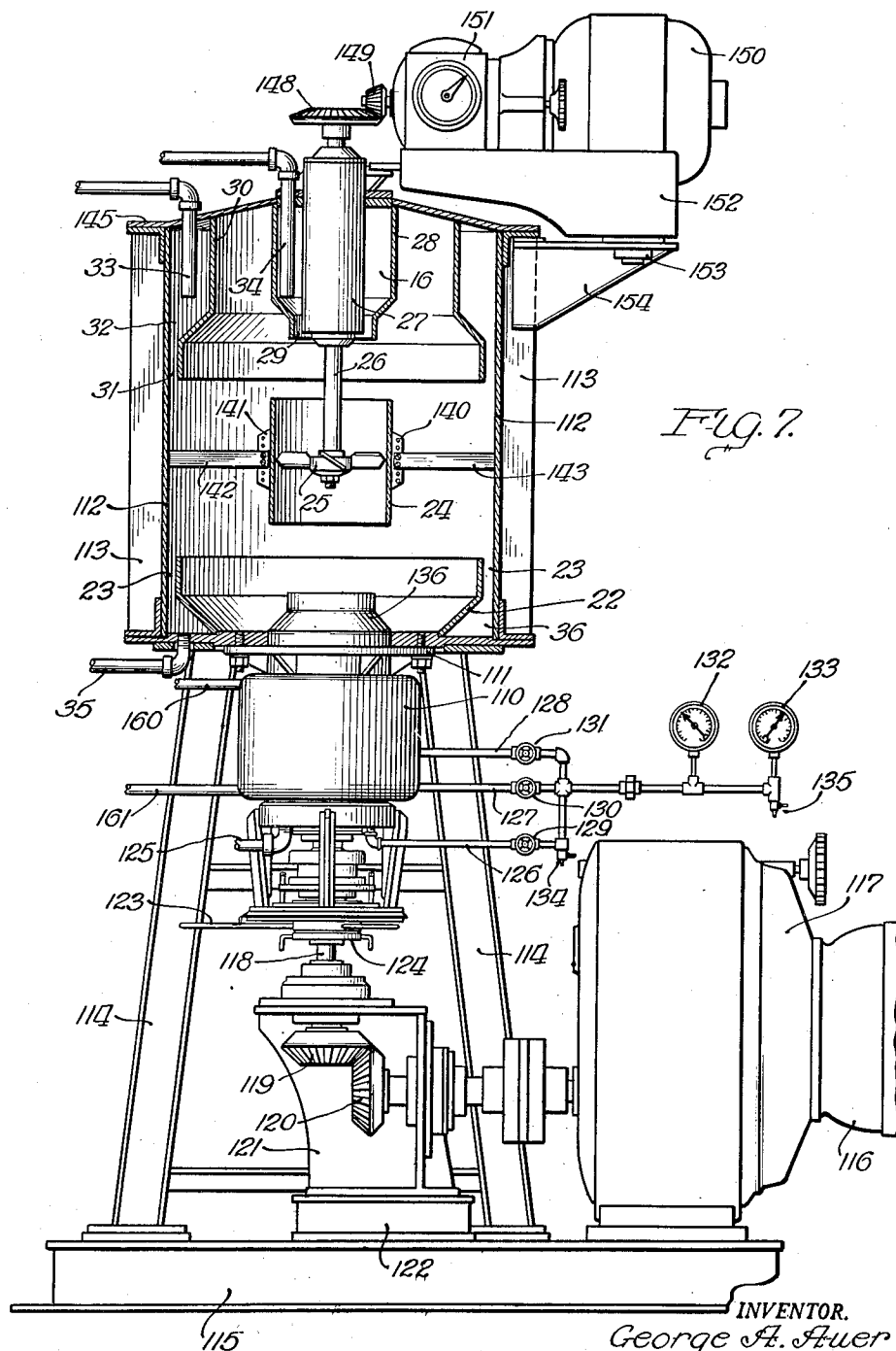


FIG. 7

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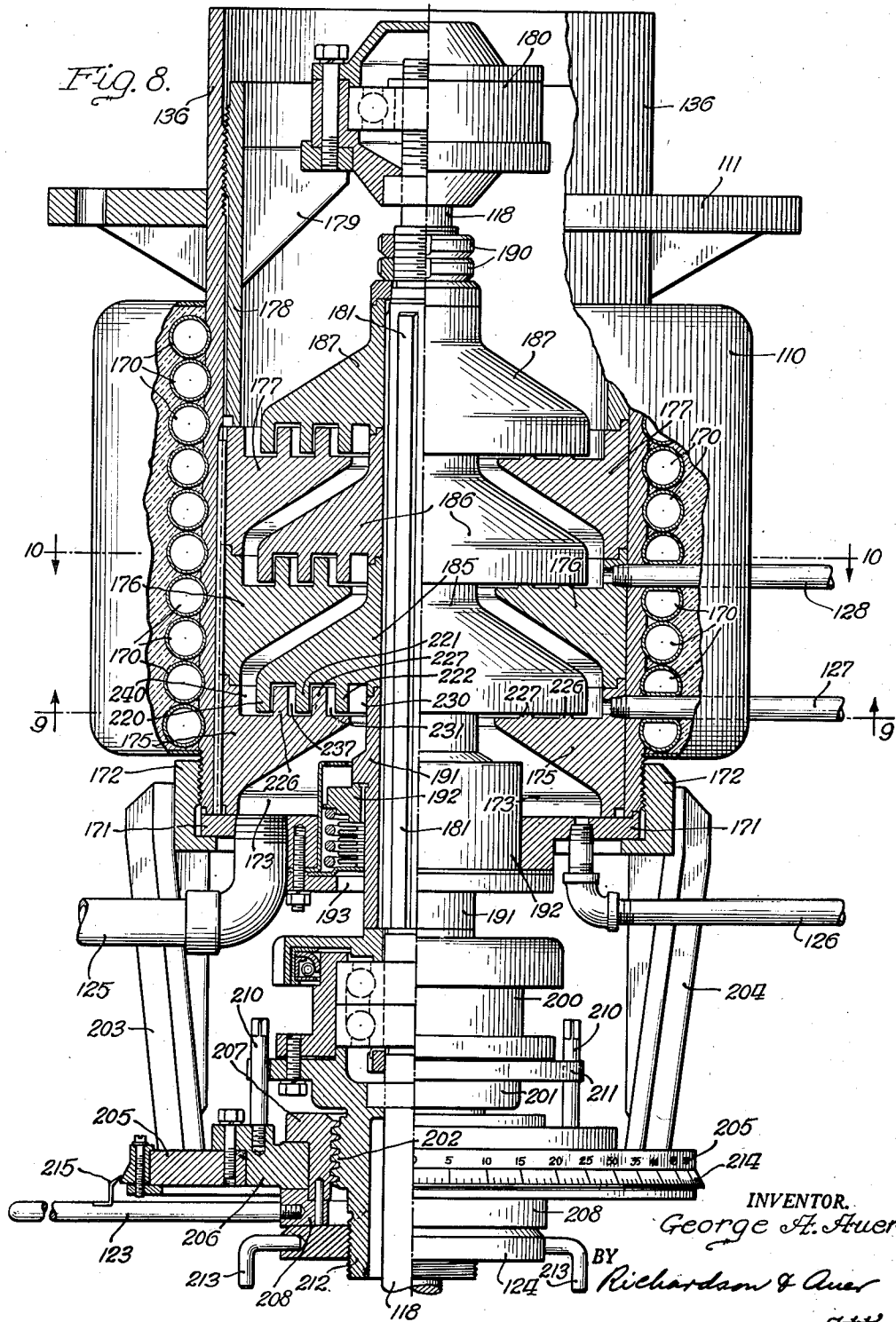
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STREAMCURRENT APPARATUS FOR MIXING MATERIALS

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6 Sheets-Sheet 4



Jan. 1, 1946.

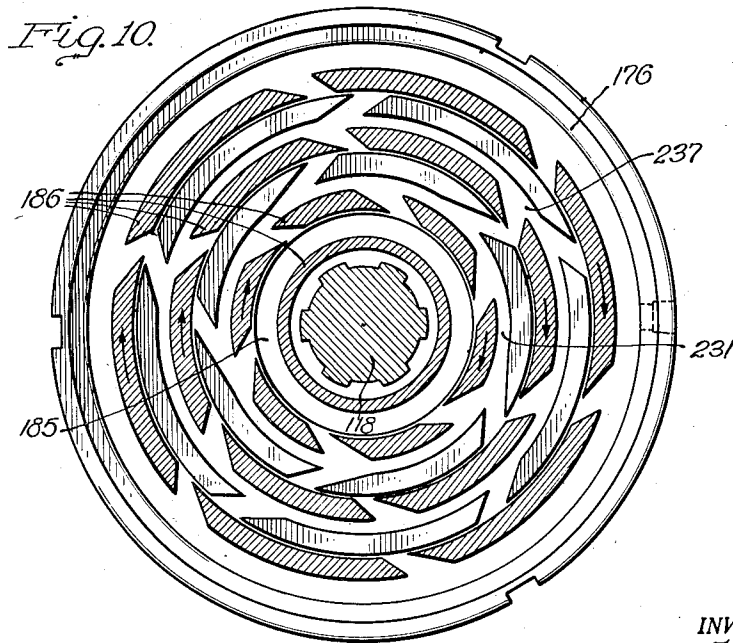
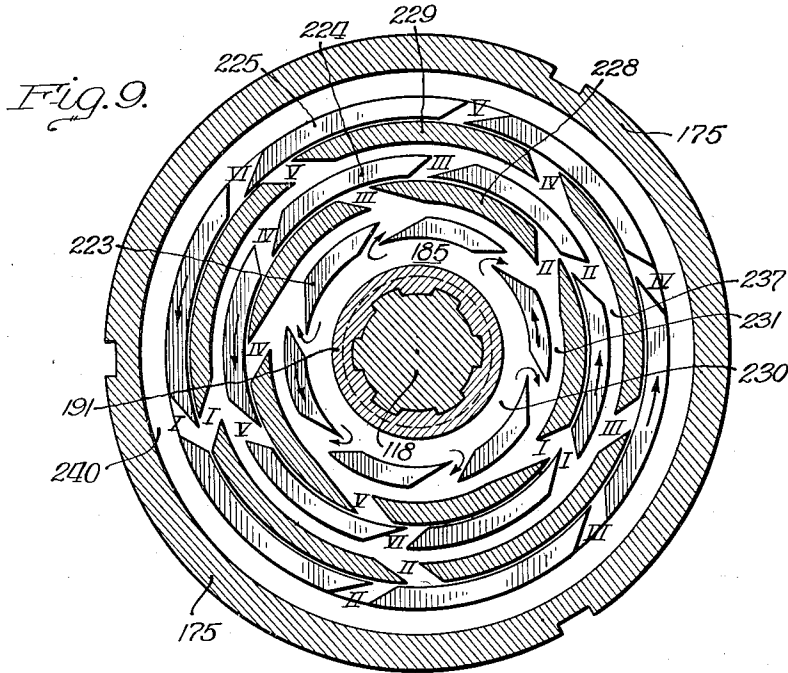
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STREAMCURRENT APPARATUS FOR MIXING MATERIALS

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6 Sheets-Sheet 5



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STREAMCURRENT APPARATUS FOR MIXING MATERIALS

Filed July 31, 1943

6 Sheets-Sheet 6

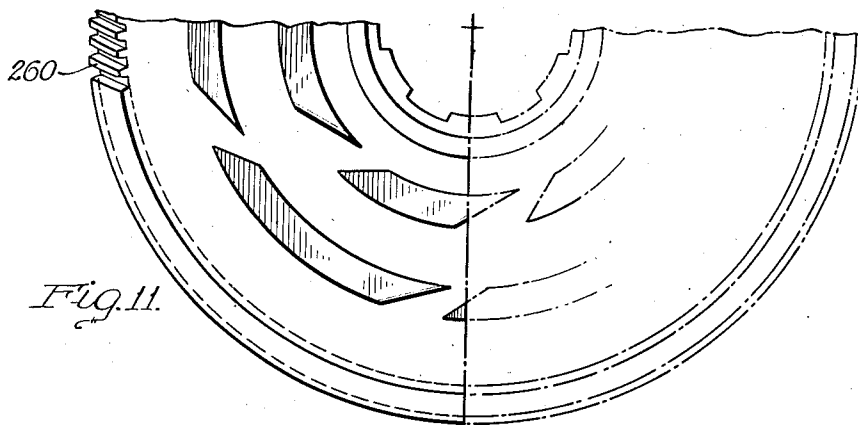


Fig. 11.

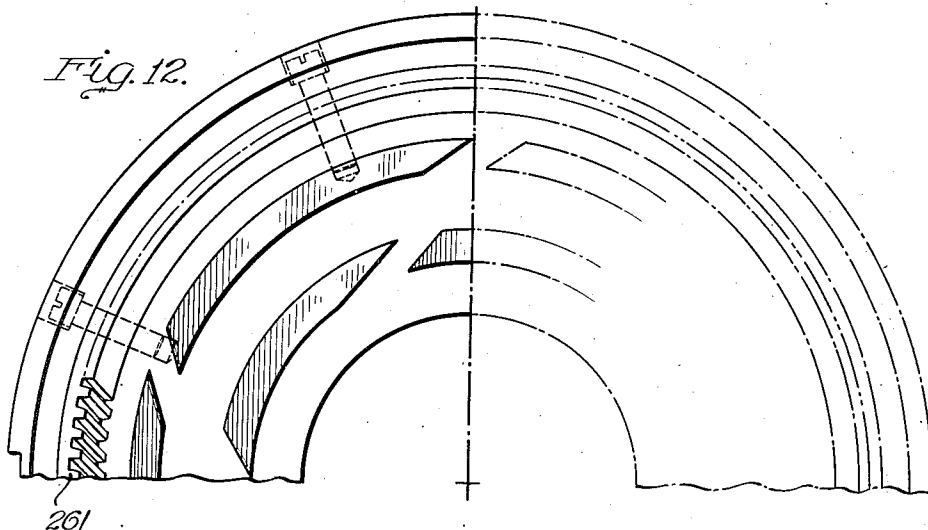


Fig. 12.

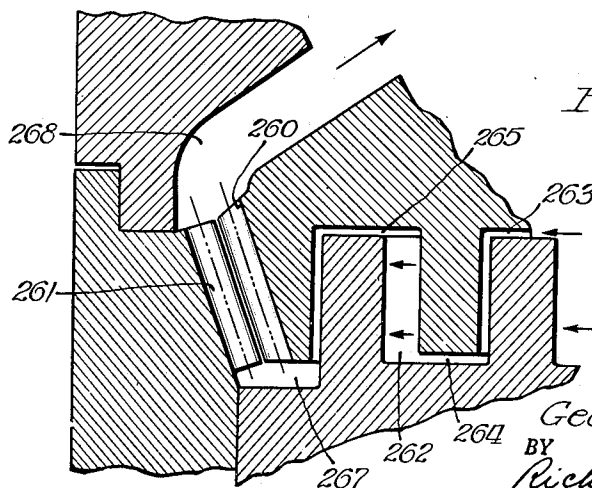


Fig. 13.

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UNITED STATES PATENT OFFICE

2,391,858

STREAMCURRENT APPARATUS FOR
MIXING MATERIALS

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Application July 31, 1943, Serial No. 496,920

8 Claims. (Cl. 259—95)

This invention relates to streamcurrent processing and is particularly concerned with a streamcurrent method and apparatus for mixing materials.

The term—streamcurrent—as defined and explained in U. S. Patent No. 2,386,419, is intended to refer to the control of a body of a fluid in motion, in such a manner that the flow thereof is hydraulically stable and rationally predictable, thereby producing conditions wherein fluid and solid particles contained in the medium or passing through or moved by the medium will exhibit a predictable behavior.

The term—mixing—, as used herein, unless otherwise qualified, is intended to mean mixing as generally understood, also homogenizing, emulsifying, agitating, processing, and like operations, including the mixing of normally miscible and normally immiscible liquids, the mixing of substances of different specific gravities, and the dispersion of comminuted solids in liquids.

Prior mixers, including devices employing single or multiple propellers, paddles, spiral blades, also the so-called colloid mills wherein the material is subjected to shearing and centrifugal forces between coating stator and rotor elements, operate with an obscure element of uncertainty which is apparently recognized in the art. For example, Chemical Engineer's Handbook (1934); p. 1267, records the following observation: "At the present time the subject of mixing probably has the least scientific foundation of all the unit processes of chemical engineering. There is no formula or equation which can be used to calculate the degree or speed of mixing under a given set of conditions. The reason is that the conditions are so varied that to date they have escaped a mathematical analysis. It is to be hoped that in time order may be obtained from the chaos now existing." Another authority, who also discusses some of the above intimated mixing devices, may be quoted to indicate that the handicaps continue to exist up to the present day. H. Bennett, in a book published May 1943, (Practical Emulsions; Chemical Publishing Co., Inc.), says: "The hydrodynamics of emulsification, i. e., the mechanical forces used to produce emulsions, is exceedingly complex and is not thoroughly understood. Since these forces are applied most un-uniformly it can be readily seen that such variables will give variable results. It is exceedingly important, in attempting to duplicate known emulsions, that all forces be duplicated as closely as possible."

The literature does not give explanations that would furnish conclusive reasons for the uncer-

tain performance of prior mixers or would offer practically useful suggestions for remedial steps. The situation is summed up, for example, by Hixson and Wilkens (Performance of Agitators in Liquid-Solid Chemical Systems; Indus. and Engin. Chem.; Indus. Ed. 25; p. 1196-1203; November, 1933) who state that the purposes for which mixing operations are used are exceedingly numerous, but that the literature contains little of fundamental importance on the subject.

The invention contemplates improvements designed to contribute toward overcoming the drawbacks and handicaps of prior mixers. It proposes structures which operate with a greater degree of certainty and accuracy, rendering more accurate and more uniform mixtures in less time and at less expenditure of energy than prior devices. The structures made in accordance with the invention also contribute toward more accurate duplication of desired operating conditions. Some of the salient objects and features of the invention are briefly stated below.

The invention provides a mixer comprising an improved mechanical mixing device of the colloid mill type for subjecting successive material increments to a controlled processing action, and a new hydraulic mixing device for receiving the processed or partially processed material increments and for subjecting a mass formed of such increments to a definitely controlled hydraulic intermixing and final processing operation.

Another feature resides in the provision of means for imparting to the material stream a directional flow, termed stream-current flow, whereby the feed of the material into, through and from the mixer is kept under definite control during all phases of the mixing operation.

Still another feature is concerned with the provision of means for dividing the directional flow of material through and within the mixing device for the purpose of effecting a controlled intermixing of successively processed material portions.

A further object utilizes the feature noted in the preceding paragraph, for the purpose of subjecting partially processed material to a re-processing treatment by re-grouping its component parts so as to accelerate the mixing treatment and the intermixing of the final product.

Additional objects and features relate to structural and functional improvements in the mechanical as well as in the hydraulic aspects of the new mixer.

The invention will be better understood from the detailed description which is rendered below

with reference to the accompanying drawings. In these drawings,

Fig. 1 represents a diagram which illustrates an example of the present practice;

Figs. 2 and 3 illustrate an embodiment of the invention in diagrammatic form and the flow conditions resulting therein;

Figs. 4 and 5 represent another embodiment of the invention showing structure and flow conditions, in diagrammatic manner, analogous to the showing of Figs. 2 and 3;

Fig. 6 is a detail, on a larger scale, of a valve employed in connection with the embodiment Figs. 4 and 5;

Fig. 7 represents a view, partially in section, of a structural embodiment of a mixer such as diagrammatically shown in Figs. 2 and 3;

Fig. 8 illustrates a mechanical mixer unit, partially in section, as used in the structure shown in Fig. 7;

Figs. 9 and 10 are sectional diagrammatic views taken along lines 9—9 and 10—10 in Fig. 8; and

Figs. 11, 12 and 13 illustrate details in connection with a modification of a mixer element such as employed in the mixer unit shown in Fig. 8.

Like parts are numbered alike throughout the drawings. Known elements and details will be described only to the extent required for an understanding of the invention.

The present practice is apparent from Fig. 1. The raw materials are fed in a stream 12 to a mechanical mixer 11, e. g., of the colloid mill type and are discharged therefrom in a stream 13. Re-circulation may be provided for by directing the discharge for re-treatment through the mechanical mixer in a stream indicated in dotted lines 14. Such practice results in the previously explained detriments. The diagram is included herein so as to afford comparison with the operations resulting from the new structures.

An embodiment of the invention is described below with reference to Figs. 2 and 3.

The new unit shown in Fig. 2 comprises a mechanical mixer 20, which may be of a suitable known colloid mill type, and a hydraulic control device comprising a tank 21 which receives the material processed in the mechanical mixer. An improved type of mechanical mixer that may be used in place of the device 20 will presently be described. The tank 21 is equipped at its bottom with a circular insert or baffle 22 forming an annular suction inlet 23 which communicates with the suction chamber 36. The latter is connected with a valved outlet pipe 35. Centrally within the tank 21 is disposed a cylindrical insert 24 secured to the inside walls of the tank 21 by suitable brackets. The lid or cover of the machine is provided with a central tubular member 27 in which may be mounted the bearings for the shaft 26 projecting downwardly and carrying a propeller indicated at 25. The latter is positioned within the cylindrical insert 24. Depending from the lid or cover is a circular insert or baffle 28 forming with the central mounting 27 an annular suction inlet 29 which communicates with the suction chamber 16. An outlet pipe 34 communicates with this suction chamber. Another peripherally disposed insert 30 forms with the inner wall of the tank 21 an annular suction inlet 31 communicating with the suction chamber 32 which is provided with an outlet 33. On top of the lid or cover may be disposed a pressure gauge 41 and a vent valve 42. This valve is controlled by a float 43 and is closed by the float when a desired liquid level is reached within the tank 21. Gas pressure

then developing on top of the liquid in the tank may be drawn off by way of the pipe 44, valve 45, to the gas outlet, as indicated in Fig. 2.

The unit furnishes several operating possibilities including, first, batch operation involving the preparation of a rough mix within the hydraulic mixer device 21 and subsequent processing of the rough mix through the mechanical mixer; second, batch operation by feeding to the unit a rough mix previously prepared in a separate mixer; and third, continuous operation involving continuous supply of a rough mix and continuous withdrawal of the finished product from selected levels of the hydraulic control device.

It will be assumed that it is desired to use the machine as a self-contained unit which receives materials to be mixed and prepares, first, a rough mix which is then processed in the mechanical mixer. The lid or cover of the machine, Fig. 2, is provided with a manhole or hand-hole (not shown). One phase, for example, the liquid phase, of the product is introduced into the machine by way of valve 46, pump 40, valve 47, mechanical mixer 20. The mixer unit may be provided with temperature control means so as to heat or to cool the liquid as may be desired. The other ingredients, for example, solids to be dispersed in the liquid, may be introduced through the above-mentioned manhole. The propeller 25 is rotated at a desired speed by a suitable drive so as to set up agitation within the tank 21 sufficient to produce a rough mixture of the materials. The principal circulating currents are indicated in Fig. 2 by flow lines. Upon completion of the rough mix, which for most cases may be very incomplete and accomplished very quickly, the processing may be started.

For this purpose, the rotary speed of the propeller 25 is adjusted to a point where it has no mixing function proper, but only a flow control function. The fluid material has flooded the suction chambers 16, 32 and 36. Rough mix may now be selectively withdrawn from any one or in adjusted amounts in common from all of these suction chambers by way of the valves 50, 51, 52, pump 40, and may be introduced for processing into the mechanical mixer 20 by way of valve 47. The processed or partially processed material leaves the mechanical mixer in upward direction in a central stream indicated in Fig. 3. The hydraulic displacement of the material is upwardly, laterally outwardly, downwardly and laterally inwardly again for intermixture with the stream rising from the mechanical mixer. This controlled flow of the material effects a re-grouping of its component parts and thereby accelerates the mixing operation. A further regrouping is effected by the withdrawal of material from one or from all of the selected levels, namely, from the suction chambers 16, 32 and 36. The final product may be discharged for use or for storage from the lowermost suction chamber 36 by way of pipe 35, valve 52, pump 40, valves 53 and 54. The discharge may also proceed from the bottom of the mechanical mixer by way of pipe 60, valve 61, pump 40 and valves 53 and 54.

The pump may be used for circulating the fluid mass as described, or it may be used only for starting the circulation, in the nature of a primer for the mechanical mixer, and the latter will take care of the circulating by way of the by-pass shown in dotted lines. The use of the pump may be dispensed with in the case of certain materials.

It is assumed next that a previously prepared

rough mix is fed to the machine for homogenizing. The feed may proceed by way of valve 46, pump 40, valve 47, through the mechanical mixer 20. As in the former case, the mechanical mixer may be used as a means of pumping the materials into the machine by way of the by-pass. Gas is displaced within the tank 21 as the liquid level therein rises and is discharged through the vent valve 42. When a desired top level is reached the float 43 closes the vent valve 42 and any further gas discharge in connection with processes that evolve gases or vapors will then proceed by way of pipe 44 and valve 45. The propeller 25 is operated at such speed as to produce a flow control operation directing the liquid mass within the tank 21 in accordance with the flow lines shown in Fig. 2. It should be noted at this point that processed material discharged from the mechanical mixer 20 is not haphazardly added to previously discharged material, but that the discharged mass is subjected to a controlled streamcurrent flow which permits orientation of the processed or partially processed mass and intermixing thereof in accordance with controlled and predictable conditions.

Depending on the material, the final product may be obtained in a single pass through the mill. In this case, when the tank 21 is filled, the processing of the batch is completed, and discharge may proceed as previously outlined, either from the lowermost suction chamber 36 or from the bottom of the mechanical mixer by way of valve 61. The discharge may be forced by using the pump 40, or may be by gravity by way of valves 64, 65, 54.

If re-treatment of the partially processed mass is required or desired, such re-treatment may proceed from one or more or from all of the suction chambers 16, 32 and 36, the material withdrawn from each chamber being re-circulated through the mechanical mixer 21 in the manner already described. During re-treatment the processed material discharged from the mechanical mixer is again subjected to the controlled streamcurrent flow in the hydraulic control device. No irrational forces come into play, and intermixing is therefore under controlled conditions. The operation is accelerated due to the continuous regrouping of the component parts of the material by virtue of the controlled flow within the tank 21 and also by virtue of withdrawal of controlled amounts of partially processed liquid from one or more of the various liquid levels. It should be observed that the inlets 29, 31 and 23 communicating with the various control chambers 16, 32 and 36 are arranged in such a manner that suction forces applied to these inlets will assist the directional streamcurrent displacement of the material within the tank 21. The sloping walls of the inserts 28 and 30 form a symmetrical tank structure at the top, and the sloping walls of the insert 22 form with the outlet of the mixer 20 a similar structure at the bottom. The space defined by these elements therefore provides for a symmetric, that is to say, for a stable hydraulic displacement of the fluid within the tank. The sloping portion of the insert 28 may be disposed in horizontal alignment with the sloping wall of insert 30.

Continuous feed and continuous discharge of proportionate processed amounts of material may also be accomplished with this machine. The feed of materials in the form, for example, of a rough mix, may be again by way of valve 46, pump 40 and valve 47, or by the action of the

mixer unit over the valved by-pass, as previously described. Depending on the materials to be mixed, it may be found that as soon as a certain level within the tank 21 is reached, discharge from one or the other of the suction chambers may proceed. For example, material may be continuously discharged from the chamber 16 by way of pipe 34, valves 62 and 54, the amount of material discharged from this chamber being replaced with the raw feed supplied to the machine. Material may also be discharged in this manner from the peripheral top suction chamber 32 by way of pipe 33 and valves 63 and 54. Finally, material may be discharged from the suction chamber 36 by way of pipe 35, valves 52, 64, 65 and 54. The operation accomplishes not a haphazard and irrational discharge from the mechanical mixer 20, but a final processing within the tank 21 and controlled discharge of adjusted amounts of selected processed material from selected levels of the liquid body in the tank. The discharged material is composed of portions which are subjected to processing treatment for variable times.

The embodiment shown in Figs. 4-6, inclusive, comprises again a mechanical mixer unit which may be of any suitable type or may be made in accordance with the structure to be presently described. This mechanical mixer unit is mounted on top of the hydraulic control device comprising the tank 74. Disposed within this tank is a perforated partition or insert 75. At the bottom of the device is a valve 77 (see also Fig. 6) which is operable by suitable means, e. g., a knob or hand-wheel 78. The valve permits adjustment of the flow of material discharged from the mechanical mixer downwardly through the pipe 76. Around the perforated partition 75 is a space 79. Within the tank 74 on top thereof is a circular partition 82 forming with the pipe 76 a suction chamber 83. A peripherally disposed insert or partition 80 forms with the tank wall and with the perforated insert 75 a suction chamber 81. Baffle or partition means 84 at the bottom of the tank form a suction chamber 85. Control means, such as the pressure gauge, as well as the float-controlled vent valve mentioned in connection with the previous embodiment, are omitted in Fig. 4. They may be provided if desired. The operation is as follows:

A rough mix may, for example, be supplied to the machine by way of valve 90, pump 91, valve 95. As in the former case, the pump may be used for obtaining only the initial feed and priming of the mechanical mixer, or its use may be entirely dispensed with and the feed carried on by means of the pumping action of the mechanical mixer over the by-pass. The stream is processed in the mechanical mixer and discharged downwardly through the pipe 76, to the annular opening controlled by the valve 77 which is suitably adjusted. The material leaving the mechanical mixer through the pipe 76 takes an upward, laterally outward, downward and laterally inward course as in the previous case. In the present instance, the streamcurrent displacement of the material within the hydraulic control device is regulated by the perforations in the partition 75 which increase in number and therefore in outflow capacity upwardly from the bottom. The material takes an upward course, as indicated by the flow lines and is discharged into the tank 79 through the perforations in the partition of the tank 75. The flow of the liquid mass is diagrammatically indicated in Fig. 5. Again,

as in the former case, various modes of operation are possible.

Material may be processed through the mechanical mixer so as to fill the hydraulic control tank and may then be discharged in a batch. In this case the successive discharge of the material from the mechanical mixer through and from the pipe 76 sets up the currents generally indicated in Figs. 4 and 5 by flow lines, permitting a re-orientation of the material and intermixing or final processing of the component parts thereof substantially without creating irrational hydraulic forces. This re-orientation or re-grouping of the component parts of the processed materials accelerates the final intermixing. The discharge may proceed either by gravity by way of valve 100 or may be forced by way of pipe 92, valves 93, 94, pump 91 and valve 101.

Re-processing of the material may be carried out by withdrawing controlled amounts of material from selected levels (suction chambers 83, 81, 85) and returning such material by way of valve 94, pump 91, valve 95 (or by way of the bypass around the pump) to and through the mechanical mixer for retreatment.

A continuous process may likewise be carried out with this embodiment by continually discharging material from one or several of the suction chambers 81, 83, 85 by way of valves 105, 106 and 100, the amounts discharged being continually supplied by raw mix.

Simultaneous discharge as well as partial re-circulation may also be practiced with this unit. For example, discharge may be carried on from one or the other of the upper suction chambers 83 and 81, while re-circulation of part of the mixture is carried on through pipe 92, valves 93, 94, the re-circulated amount being added to the raw mix fed to the machine by way of valve 90.

The embodiment shown in Figs. 4 and 5, and also the previously described embodiment may also be used for the mixing of materials mainly in the hydraulic control device 21 (Fig. 2) or 74 (Fig. 4). The mixing action will be accomplished in both cases in controlled manner, in the first case by the hydraulic currents resulting from the upward flow of the material introduced from below, reinforced and controlled, if desired, by the action of the propeller, and in the second case solely by hydraulic currents which always affect the entire tank contents, subjecting the entire mass of material to uniform mixing conditions. The mechanical mixer may in such case be either disconnected or may serve merely as a feeder for the material stream.

Fig. 7 shows a structural embodiment of the machine made in accordance with the principles discussed in connection with Figs. 2 and 3. The machine comprises a mechanical mixer indicated by numeral 110. Details of this mixer will be explained later on. The mechanical mixer is built as a unit and is attached by means of the flange 111 to the bottom of the tank 112 of the hydraulic control device. The tank 112 is reinforced by means of vertically extending ribs 113. The machine is provided with legs or standards 114 and is mounted on a base 115. Also mounted on this base is the motor 116 with its speed control device 117. The motor operates the shaft 118 of the mechanical mixer unit 110 through suitable gears 119, 120 which may be bevel gears or spiral gears as desired or necessary. The gears are secured in a mounting 121 attached to the base 115 at 122.

The mechanical mixer unit 110 is of the turbine

mixer type, as will be explained later on more in detail, and is provided with a number of stators and coating rotors, the latter being removably mounted in splined connection with and on the shaft 118. The space between the rotor and stator faces is adjustable within certain limits, by means of a hand lever 123 and can be fixed in any adjusted position by means of the member 124. For this purpose the shaft 118 is in splined connection with the gear 119.

The material to be processed may be fed to the mechanical mixer 110 at 125. Lines 126, 127 and 128 connect with various critical points within the mixer 110 and with valves 129, 130, 131, for selectively connecting these points with the pressure gauge 132 and with the temperature gauge 133 so as to measure and to check the pressure and temperature condition at these points during the operation of the machine. Drain valves for facilitating the checking and measuring operation are indicated at 134 and 135. These valves may also be employed as sampling valves.

The mechanical mixer is mounted in such a manner that its upper cylindrical outlet portion 136 projects through the bottom of the upper tank 112 and part way into the tank. At the bottom of the hydraulic control tank 112 is mounted the cylindrical insert or baffle 22 forming the annular suction chamber 36 which is flooded by fluid through the annular space 23. The corresponding parts are designated in Fig. 2 by identical reference numerals. The suction chamber 36 connects with the suction line 35, also shown in Fig. 2.

At a central point of the tank 112 is mounted the cylindrical insert 24 which is provided with ears 140, 141 for attachment to brackets 142, 143 secured to the inside wall of the tank 112. The provision of the ears 140 and 141 permits vertical adjustment of the insert or baffle 24 within the tank.

The cover or lid 145 is centrally provided with the journal member 27 mounting the shaft 26 which carries the propeller 25. The propeller or agitator may be of a type providing for adjustment of the pitch of the blades. The shaft 26 also carries a suitable gear 148 which intermeshes with gear 149 and the latter is operated by a motor 150 provided with an adjustable speed control 151. Bevel gears are shown, but any suitable type of gears, for example, spiral gears or the like, may be used. The motor 150 with its speed control 151 is secured to a mounting 152 which is rotatable in a journal 153, and the latter is secured on a bracket 154 carried by the tank 112. It is thus possible to swing the motor with its speed control and gear 149 out of position away from the tank when it is desired to remove the tank cover to gain entrance into the interior. Suitable means are provided for locking the motor assembly in operating position with the gear 149 meshing with gear 148.

Depending from the tank cover 145 is the circular baffle or insert 28 forming the annular suction inlet 29. The annular inlet 29 communicates with the suction chamber 16 in which is disposed the suction line 34 and the latter is connected, as shown in Fig. 2, with the valves 50 and 62.

Also depending from the cover 145 is the circular insert or baffle 30 forming the annular suction inlet 31 which communicates with the suction chamber 32, the latter communicating with the suction line 33. Line 33, as shown in Fig. 2, connects with the valves 51 and 63.

The sloping walls of the inserts 28 and 30 may be arranged in horizontal concentric alignment, as previously discussed. It should be noted that the diameters of the inlet 136, from the mechanical mixer, and of the annular inlet 29, into the chamber 16, are less than the inner diameter of the insert 24 and that these elements are symmetrically arranged with respect to the insert 24.

Control devices such as the float 43, vent valve 42, gas outlet 44, pressure gauge 41, shown in Fig. 2, and the previously mentioned man-hole or hand-hole are not shown in Fig. 7, but may be provided. In addition, if desired, provisions may be made for a sight opening either in the tank cover or at any convenient point of the tank, and for auxiliary devices such as level gauges and the like.

The operation of the machine shown in Fig. 7 is the same as explained in connection with Figs. 2 and 3. The material to be processed may be introduced into the mechanical mixer unit at 125. The mixer unit may also be provided with a heating or cooling jacket to be employed as desired, and the latter may be supplied with heating or cooling fluid by way of lines 160—161. The material stream is successively processed in a controlled manner within the mechanical mixer and is discharged upwardly into the tank 112. As the liquid rises within the tank 112 it floods first the chamber 36 through the annular inlet 23. When the liquid level rises upwardly beyond the propeller 25, the motor 150 may be started, to impart to the liquid a controlled flow so as to circulate it within the tank 112 along the flow lines indicated in Figs. 2 and 3. When the liquid reaches near the top level it floods the chambers 16 and 32 through the annular inlets 29 and 31. The propeller 25 in such operation of the machine has primarily a flow control function. Whatever mixing action will result is incidental. There may, of course, be occasion for adjusting the pitch of the blades of the propeller 25 and rotating it at such speed as to provide for agitating turbulence going beyond the flow control proceeding along the flow lines shown in Figs. 2 and 3. Such operation may be carried out, for example, when the hydraulic control device is initially used as a rough mixer tank, as previously explained. The mixing may also be accomplished mainly within the tank 112, the mechanical mixer furnishing the supply and circulation of the material. Rough mixing, with the agitator 25 adjusted so as to furnish agitating rough turbulence, may be followed by fine streamcurrent controlled final processing, with the agitator functioning as a flow control element. It should be observed that the suction inlets 29, 31, 23 are disposed at points, along the symmetrically designed tank chamber, which will assist the stable hydraulic circulation flow of the liquid in accordance with the flow lines explained before.

The mechanical mixer used in this embodiment is shown on a larger scale in Fig. 8. It comprises the tubular shell 136 carrying the flange 111 for attachment to the bottom of the tank as shown in Fig. 7. The upper end of the shell 136 is shown cylindrical in Fig. 8 but may be shaped as indicated in Fig. 7, or may be provided with a suitable attachment. The shell carries coils 170 covered by an insulating jacket, the coils connecting with the lines 160 and 161 shown in Fig. 7, for circulating heating or cooling fluid as may be required. A coil is shown for the sake of convenience, but the heating or cooling provisions, respectively, may be different. A member

171 forms the bottom of the shell 136 and is attached thereto by means of a bushing 172. Attached to the bottom 171 is the material inlet 125 which empties into the inlet chamber 173. The pipe 126 is connected by a suitable coupling to the bottom member 171, as shown, so as to permit withdrawal of liquid from the inlet chamber 173, during the operation of the machine, through the valve 129 shown in Fig. 7 to the pressure and temperature gauges 132 and 133.

Stators 175, 176, 177 are mounted within the tubular shell 136 by means of the tubular member 178. This member carries brackets 179 to which is secured the upper bearing 180. The upper end of the shaft 118 is journaled in this bearing 180 in splined connection therewith. The shaft is splined as indicated at 181 for the removable attachment thereto of the rotors 185, 186 and 187 which are secured by nuts 190. If it is desired to use only one or two of these rotors instead of all three, the rotor or rotors to be eliminated from a given operation can be removed and suitable sleeves can be inserted in their place. A sleeve 191 is keyed to the shaft 181 at the lower end thereof. This sleeve 191 coacts with the seal 192. The assembly is closed at the bottom by means of the plate 193, the seal 192 providing a pressure-tight connection. The shaft 118 with its rotors 185—187, inclusive, is thus vertically movable within the structure.

Attached to the shaft 118 at its lower end adjacent the sleeve 191 is the bearing 200. This bearing is secured to an adjusting member 201 which is provided with a tubular sleeve carrying a thread 202. Arms 203 and 204 are secured at their upper ends to the bushing member 172 and at their lower ends carry a ring 205. Attached to this ring is the member 206 and rotatably secured with respect thereto is the ring 208 by means of which a nut 207 can be rotated, this nut being in threaded engagement with the thread 202 carried by the member 201. The ring 208 may be rotated by means of the lever 123, and if it is rotated, it will lift the member 201 by means of thread 202 upwardly or downwardly and therefore will lift the shaft with its bearing 200 and its rotors 185—187, inclusive. The members 210 are guide pins for the upper plate 211 of the adjusting member 201 and keep the bearing stationary during rotation of the ring 208. Any position of adjustment can be set and fixed by means of the locking member 124 which is in threaded engagement with the tubular sleeve 212 depending from the adjustment member 201. The ring 124 may be operated by levers 213. The inclined surface 214 on the fixed ring 205 is provided with calibrations for coaction with the index finger 215 which is attached to the lever 123. The adjustment provided for in this particular machine takes care of moving the rotors with respect to the stators from a close position of a few microns up to a maximum distance of $\frac{1}{4}$ ".

The stators carry a plurality of annular axially extending rings and the rotors carry coacting annular rings which interlace with the stator rings in the manner of turbine blades. The stator as well as the rotor rings are tangentially slotted in a manner to be described later, so as to provide a laterally outwardly effective propulsion and mixing force for the liquid to be treated. Such rotor-stator structures are broadly known. Improvements in details of this particular structure will now be described with reference jointly to Figs. 8, 9 and 10.

Fig. 9 is a section through the first turbine

mixer stage formed by stator 175 and rotor 185, taken along lines 9—9 in Fig. 8, looking upwardly at the rotor 185. The rotor is keyed to the shaft 118 in splined connection therewith, above the sleeve 191, which is shown in section. The rotor is provided with three annular rings 220, 221, 222 (see Fig. 8), each ring being tangentially slotted in the manner shown in Fig. 9 to provide blades or sectors indicated by the numerals 223, 224, 225, these blades being shown in elevation and vertically shaded. The number of blades or sectors formed by each annular rotor ring is alike. In this case each ring carries six blades or sectors such as 223, 224, 225, the tangential slots between adjacent blades in blade rings 224 and 225 being marked by numerals I—VI.

The stator 175, as shown in Fig. 8, carries two annular rings 226 and 227. These annular rings are likewise tangentially slotted as indicated in Fig. 9, to provide stationary blades or sectors indicated by numerals 228 and 229, shown in section and diagonally cross-hatched. These stator rings 226 and 227 are slotted in such a manner as to carry equal numbers of blades such as 228 and 229 (Fig. 9), and in this case there are formed by each stator ring five such blades. The tangential slots between the stator blades in each ring form stationary gates marked by I—V.

The direction of rotation of the rotor blades is indicated in Fig. 9 by the arrows. The shell 136, in which the mechanism is mounted, is omitted in Fig. 9.

The liquid is introduced for processing through the pipe 125 into the inlet chamber 173 shown in Fig. 8. It may be stated at this point that this chamber may be enlarged if desired, and that separate blades may be attached to the rotor shaft so as to propel the liquid through the upwardly and inwardly sloping space of the chamber 173 in the direction of the interlacing rotor faces of the first turbine mixing stage formed by the stator 175 and the rotor 185. The liquid emerges upwardly (downwardly perpendicularly to the plane of the drawings as viewed in Fig. 9) in the annular space marked in Figs. 8 and 9 by the numeral 230. The liquid is scooped up by the six innermost blades 223 of the rotor blade ring 22, which act in the manner of an impeller, disposed at the top of chamber 173, drawing liquid from the chamber, and the liquid is then propelled laterally outwardly into the annular space 231 which connects with the inside face of the innermost stator blade ring 227 forming the stationary blades 228 and the inner gates I—V indicated in Fig. 9. Each turbine stage is thus provided with its own impeller which controls transfer of the liquid from the inlet to and through the corresponding processing level. Escape of the liquid from chamber 231 is possible only over definite channels. The arrangement provides for escape of liquid successively through the gates I—V of the stationary blade rings 228.

Assuming, for example, that the mechanism is in the position shown in Fig. 9, it will be seen that liquid is scooped up by the tips of the innermost rotor blade rings 223 in the manner indicated by the arrows. Now, following circularly around the space 231 in back of the blade rings 223, in the direction of rotation of the rotor, it will be seen that the liquid has no chance to escape laterally from the space 231 except through the stationary gate space I between the stationary blades 228 which is now aligned with the rotatable gate space I between the rotor

blades of blade ring 224. The liquid thus enters the second chamber 237 of the rotor-stator assembly. The next escape of liquid from chamber 231 into chamber 237 will be upon alignment of the movable gate II between rotor blades 224 with the stationary gate space II of the stator blades 228.

In short, the liquid escapes from chamber 231 into chamber 237 successively by successive alignment, in the direction of rotation of the rotor, of the rotor gates I—VI with the stator gates I—V. The five stator gates I—V eject liquid successively in numerical order during each revolution of the rotor.

Following the chamber 237 annularly around in the direction of rotation of the rotor, as shown in Fig. 9, it will be seen that the liquid can escape laterally from this chamber in the assumed initial position of the mechanism only through the gate space I of the outermost stator blades 229, all other spaces being closed by the overlapping relation of the stator and rotor blades. This gate space is now in alignment with the space I of the rotor blades 225 which connects with the channel 240 leading to the second turbine stage of the structure formed by the stator 176 and the rotor 186 in Fig. 8. The successive movement of the liquid from the chamber 237 into the space 240 follows the same pattern as outlined before in connection with the movement of the liquid from chamber 231 into chamber 237.

The action resulting from the operation described above maintains continuity of the liquid, at the same time subjecting the liquid to centrifugal and maximum shearing forces which are believed to be beneficial for the mixing operation, and cutting down chopping forces which would result in a different arrangement of the rotor-stator blades, for example, in an arrangement providing for equal division of the tangential slots in the rotor as well as in the stator rings. Another point to be considered in connection with this structure resides in the provision of the chambers 231 and 237 between the rotor blade rings and the adjacent stator blade rings. These chambers equalize the pressure resulting from the operation of the rotor blades and thus contribute toward maintaining the continuity, and therewith the control, over the fluid stream. The configuration of the rotor-stator blades, and the resulting coaction, provides likewise for continuous and even propulsion of the liquid.

The above described operation applies when the rotor faces are in close attachment with respect to the stator faces. The material will then be subjected to a combination of centrifugal, shearing, and pressure forces. The mechanism will also act to propel the liquid laterally outwardly in a steady controlled stream which is constantly subjected to the shearing and pressure forces. The innermost rotor blade rings operate in the nature of a centrifugal pump and adapt the structure for use as a self-contained unit which after initial priming, as previously described, performs a pumping action and takes care of the feed of the material stream to be processed. With many materials priming will be unnecessary.

The combination of forces as outlined above is desirable in connection with the treatment of many materials and is not necessary with other materials. The present unit has been designed as an all-purpose machine suitable for the treatment of different materials. Therefore, a large

latitude of adjustment in the relation of the rotor-stator faces is provided, measuring from a very close adjustment of a few microns up to about $\frac{1}{4}$ ", as previously mentioned. As the distance between the rotor-stator faces is increased, the shearing and pressure forces described above are lessened and the outwardly effective centrifugal forces are increased. The impeller action of the rotor blades 224 is increasingly added to that of the innermost rotor blades 223. Therefore, the amount of material that can be moved through the turbine stage is greater with increased spacing between the rotor-stator faces, but the pressure and shearing forces may be increased with close adjustment. A medium adjustment will provide for a churning turbulence due to the coaction with the stator blades. Very wide adjustment will mainly furnish a turbulent continuous flow.

For the reasons outlined above, the mechanism can be used to provide a processing treatment similar to that known from ordinary colloid mills, with such improvements that result from the new structure, and also to provide mixing agitation for large amounts of material moved therethrough, and, finally, a turbulent flow for feeding material into the upper tank.

The pipe 127 shown in Fig. 8 connects with the valve 130 shown in Fig. 7 which in turn is connected with the pressure and temperature measurement instruments 132 and 133. The pressure and temperature conditions at this critical point, namely, the first turbine mixing stage, can thus be checked during operation.

Fig. 10, which is a section through the mixer unit shown in Fig. 8 along lines 10—10 thereof, shows the various parts in substantially the same relationship as explained in connection with Fig. 9, except that these parts apply to stator 176 and rotor 186. The view is looking down on the stator 176, the stator blades being shown in elevation, vertically shaded, and the rotor blades appearing in section and cross-hatched. The flow of liquid to be processed in this mixer stage proceeds perpendicularly upwardly from the plane of the drawing Fig. 10 on the top of the rotor 185 which is underneath this stage. The liquid is scooped up by the innermost rotor blades, and is subjected to the action of the laterally outwardly successive rotor-stator blades exactly in the same way as explained in connection with Fig. 9. The flow of the liquid does not need to be repeated here in detail.

This mixer stage is provided with a pipe 128 (see Fig. 8) connecting with the instruments 132 and 133 shown in Fig. 7, so as to permit checking of temperature and pressure conditions during operation.

Fig. 11 is a sectional view of a modified rotor conforming to the view shown in Fig. 9. Fig. 12 is a view of a stator coacting with the rotor in Fig. 11 conforming to the view of the stator shown in Fig. 10. Fig. 13 is a sectional view showing the essential parts of this modified embodiment of rotor and stator and the coaction thereof.

Referring now to these figures, it will be seen that the rotor is equipped in this case with two blade rings corresponding to the innermost blade rings in the previous embodiment. The outermost blade ring, however, is omitted, and instead there is provided an annular peripheral toothed or suitably serrated portion indicated at 260. The stator, Fig. 12, is provided with a peripheral toothed or serrated portion 261 for coaction with the portion 260 of the rotor. The teeth or serrations may be of any desired type, in the form of gear teeth, spiral teeth, or preferably spiral serrations of the general type as used in flour mills.

The processing by the use of the modified rotor-stator assembly shown in Figs. 11-13 proceeds substantially along the same lines as explained in connection with the description of the previous embodiment. The provision of intermediate laterally successive chambers between the rotor-stator blades is particularly apparent from Fig. 13, an intermediate chamber in this figure being indicated by the numeral 262. The material flows during processing along the lines of the spaces 263, 264, 265, providing shearing by-passes, and the liquid being propelled as previously explained, by the rotor blades coacting with the stator blades. The liquid finally arrives at the chamber 267 and is then subjected to a final processing step between the coacting serrations 260 and 261 of the rotors and stators. The liquid moves from the final processing step of this turbine mixer stage upwardly through the channel 268 in the direction of the arrow.

The mixer unit shown in Fig. 8 may be mounted for up-flow operation in connection with the embodiment Figs. 2 and 3, or for down-flow operation in accordance with the embodiment shown in Figs. 4 and 5.

The machine disclosed herein will be found useful for many purposes including, for example, homogenizing of milk, the processing of numerous food products, preparation of bituminous emulsions, chemical and pharmaceutical preparations, and also in the mixing of colloidal fuel consisting of coal particles dispersed in fuel oil. Certain features of the invention may be found useful in apparatus other than mixers of the types specifically mentioned herein. Modifications may be made with regard to structure as well as to function. Attention may be called, e. g., to the fact that one or the other of the chambers through which liquid is withdrawn may be employed, if desired, for adding substances for intermixing with the circulating fluid body. The machine made in accordance with the invention is a versatile unit and its usefulness will increase with the ingenuity of the operator.

The invention may be used, and changes may be made, within the scope and spirit of the following claims which define what is considered new and desired to have protected by Letters Patent of the United States.

It is understood, however, that the scope of claims which define a combination, first, of means for subjecting material to irrational turbulence and, second, of means for then subjecting the material to hydraulic displacement or agitation without creating irrational turbulence therein, or equivalent language, is limited to arrangements wherein said first and said second means form a machine unit which permits transfer of the irrationally intermixed turbulent material from said first means directly and immediately to said second means without incurring segregation or agglomeration of the material components incident to such transfer of the material. Arrangements comprising separate mixers or the like, which are separately disposed and are interconnected by pipes or the like wherein segregation or agglomeration of material would occur incident to transfer of material therethrough are, accordingly, disclaimed from the scope of such claims.

I claim:

1. Apparatus for mixing and blending fluid materials having a tank for receiving material and for subjecting the material therein to a circulatory mixing displacement which includes material flow generally centrally axially of the tank followed by lateral outward deflection near one end of the tank to circulate the material generally peripherally in reverse direction toward the opposite end of the tank where the material is laterally inwardly deflected for intermixture with the generally axially directed flow, the improvement which consists in the provision of tubular baffle means disposed within the tank centrally at one end thereof to guide the lateral outward deflection of the material, baffle means disposed within the tank peripherally at the identical end thereof for guiding the laterally outwardly deflected material to flow peripherally toward the opposite end of the tank, and baffle means disposed within the tank at the opposite end thereof for guiding the lateral inward deflection of the material, said baffle means being so constructed and arranged that the material is displaced in its circulatory motion substantially without creating irrational turbulence therein.

2. The structure defined in claim 1, together with means for applying suction to the circulating material body peripherally thereof for the purpose of sustaining its circulatory motion.

3. The structure defined in claim 1, wherein each of said baffle means forms a chamber for confining an amount of material, and means in each of said chambers for withdrawing material therefrom to create suction areas peripherally of the circulating fluid body for the purpose of sustaining the circulation thereof.

4. The structure defined in claim 1, wherein said baffle means forms chambers for confining amounts of material peripherally of said circulating material body, means for selectively withdrawing material from said chambers to create suction peripherally of the circulating fluid body for the purpose of sustaining the circulatory displacement thereof, and means for intermixing withdrawn amounts of material with the main flow of material in said tank.

5. In a machine having a tank for receiving a fluid medium and material for dispersion therein by intermixture therewith and having means for injecting such fluid medium into said tank for upflow therein, the improvement which consists in the provision of flow-controlling means comprising a tubular downwardly and inwardly directed member disposed within said tank centrally axially at the top thereof and extending into the upper strata of the fluid medium therein, and a tubular downwardly and outwardly directed member disposed within said tank peripherally annularly at the top thereof in concentric relation with respect to said first-named member and substantially at the same horizontal level therewith, said members forming in the upper strata of said fluid medium an annular symmetrically constricted area of upwardly symmetrically decreasing dimension for the purpose of symmetrically and uniformly deflecting the upflow of said fluid medium to obtain hydraulic displacement thereof without creating irrational turbulence therein.

6. Apparatus for handling fluid materials comprising an upright tank, means forming an inlet disposed centrally axially of said tank at one end thereof for injecting a stream of fluid material thereinto to form a fluid body therein, a plurality of baffle means disposed in said tank adjacent the wall thereof and forming a plurality of separate confined chambers each of which communicates hydraulically with said fluid body solely peripherally thereof, and means for selectively withdrawing fluid material from said chambers and for selectively directing such withdrawn material to discharge and/or for re-injection through said inlet.

7. The structure and combination defined in claim 6, together with means in said inlet for regulating the flow of material therethrough.

8. The structure and combination defined in claim 6, together with means forming a tubular extension which projects from said inlet into the tank centrally axially thereof for guiding the flow of the stream of fluid material thereinto.

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