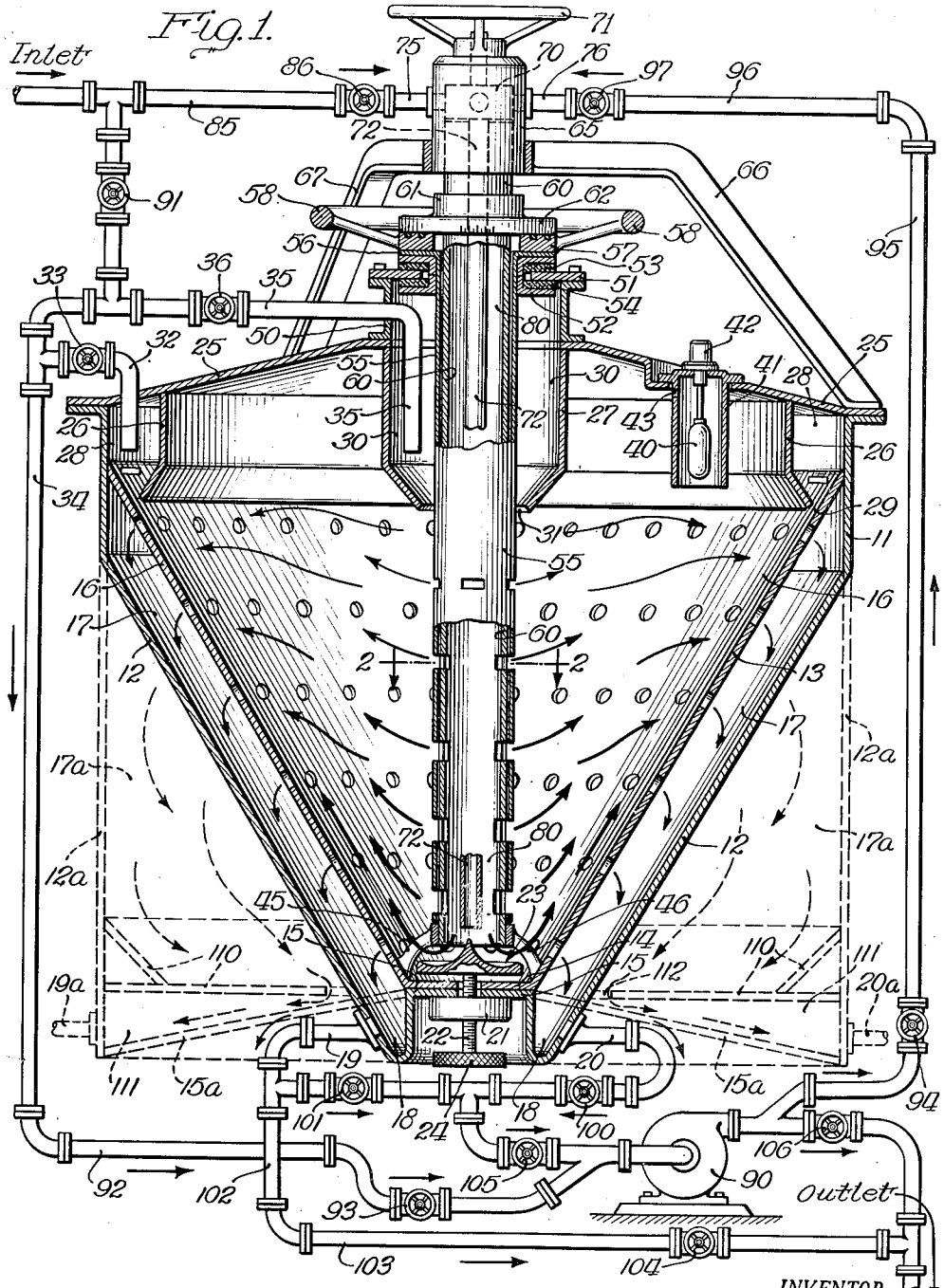
Oct. 9, 1945. G. A. AUER 2,386,419

STREAMCURRENT APPARATUS FOR HANDLING SOLUTIONS AND SUSPENSIONS

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Fig. 1.




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STREAMCURRENT APPARATUS FOR HANDLING SOLUTIONS AND SUSPENSIONS

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Fig. 2.

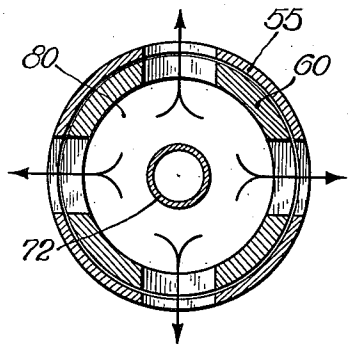



Fig. 3.

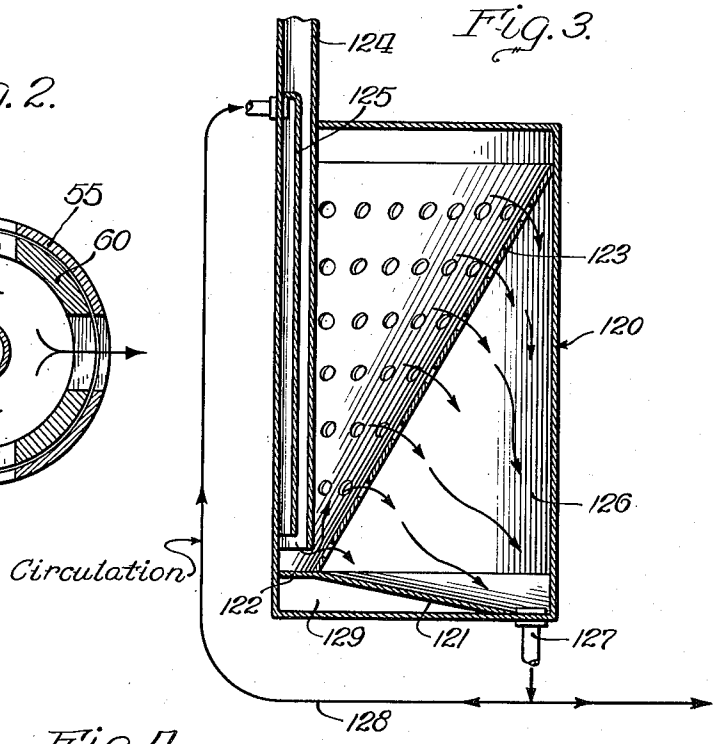
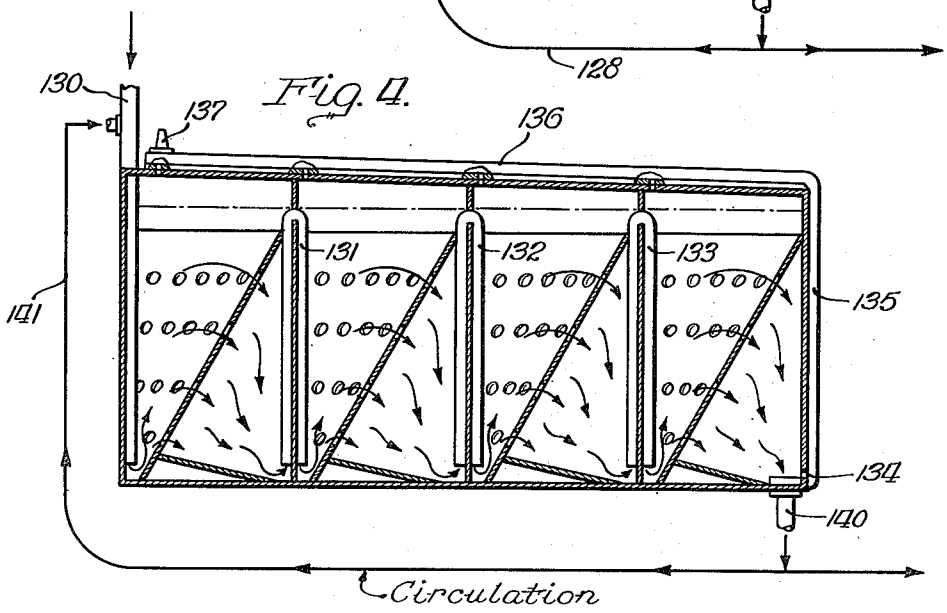



Fig. 4.




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# UNITED STATES PATENT OFFICE

2,386,419

## STREAMCURRENT APPARATUS FOR HANDLING SOLUTIONS AND SUSPENSIONS

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Application August 12, 1943, Serial No. 498,330

22 Claims. (Cl. 259—95)

This invention is concerned with a streamcurrent method and apparatus for handling solutions and suspensions for the purpose of effecting and maintaining uniform and homogeneous intermixture thereof.

The term "streamcurrent" has been adopted and is being used as a supplement and in contradistinction to the term "streamline." While the old term refers to the path of an individual fluid particle in fluid motion, and hence to the shaping of objects in such a manner that their movement through a fluid medium is facilitated, the new concept as expressed by the term "streamcurrent" is intended to refer to the control of a body of a fluid or liquid in motion for the purpose of producing a hydraulically stable agitation wherein fluid and solid particles will exhibit a predictable behavior.

The term "stable" as used in this concept with reference to hydraulic agitation means a condition of balance, symmetry, equilibrium (the terms may be interchangeably used), resulting from substantially uniform, symmetrical and controlled displacement or agitation of the fluid medium.

The term "handling" is intended to cover operations including the mixing, e. g., the blending of liquids; the sustaining of previously processed, mixed or blended liquids; and also the sustaining or maintaining of solutions, mixtures, and suspensions.

The term "solution" refers to true solutions, including liquids containing solids in a colloidal state of subdivision, that is to say, solids of microscopic or ultra-miscroscopic particle size; and the term "suspension" refers to liquids containing in dispersion solids of a mechanically determinable particle size.

As an example of mixing liquids or solutions may be mentioned the blending of crude petroleum oils, petroleum products, and gasolines of different specific gravities. As an example of sustaining solutions may be mentioned the storing of blended products in such a manner as to avoid stratification into layers of different specific gravities. As an example of sustaining or maintaining suspensions may be mentioned the handling, in storage, transport or use, of so-called colloidal fuel composed of comminuted coal particles in suspension in fuel oil.

The problem in each of the above noted instances is one of agitation for the purpose of either accomplishing the mixing (blending) of several liquids so as to form a uniform and homogeneous composite liquid, or for the purpose of preventing separation of a composite liquid or mixture into its constituent parts.

The prior art provides for these purposes the so-called "turnover" pumping, and agitation by the use of impellers, propellers, paddles, spiral blades and the like. Examples, referring to the use of propeller or similar agitators and to turnover pumping, in connection with the maintenance of colloidal fuel, may be found in the article "Emergency use of coal-oil suspensions as colloidal fuel," by W. L. Faith and H. W. Zabel, January 1943 issue, vol. 22, No. 1, page 70 (10) of "Petroleum Refinery," and on page 33, in a publication entitled "Colloidal Fuel Program," paper No. 57430–10, released February-March 1943 by the Marketing Division, Petroleum Administration for War.

The turnover pumping consists of withdrawing liquid from one point of a tank and returning it to a point usually farthest removed from the take-off point. Such procedure is ineffective because it merely creates irrational turbulence at the suction and at the discharge points without affecting the entire liquid body. In the case of blending petroleum liquids the p cedure, though widely used, is inefficient, requiring frequently up to 48 hours and more to obtain somewhat satisfactory and marketable products. In the case of sustaining liquids containing in dispersion comminuted solids, the procedure does more harm than good, actually contributing toward destroying the equilibrium of the suspensions.

Mechanical agitation by the use of devices of the propeller, paddle, spiral blade and similar types is likewise inadequate. Such agitators consume a great deal of power and can be used with some assurance only in very small tank units. An inquiry into the obscure subject of the behavior of solids in liquids revealed that such devices produce in the liquid isolated fields of turbulence, meandering vortices and eddies, non-uniform currents, dead pockets, and isolated variable fields of stagnation. The use of multiple propeller or paddle devices increases, in addition, installation, operation and maintenance costs, and multiplies the sources of mechanical troubles.

The irrational and unpredictable agitation (mixing) forces produced by such devices cannot deliver a uniformly intermixed (blended) product with any degree of certainty, and it follows, therefore, that such operation cannot maintain the uniformity of a composite product, whether such product is a composite solution or a suspension. In the case of suspensions having properties similar to those of colloidal fuel, the

prior devices actually tend to hasten rather than to impede the separation of the dispersed phase from the dispersion medium.

Uniformity of a mixture can result with certainty only from uniformity in the mixing operation. It is, therefore, considered in the nature of an axiom that devices which cannot produce uniform agitation for mixing are, for this very reason, incapable of producing the uniform agitation that is required for the blending of liquids and for maintaining liquid substances in uniform condition.

The inadequacy of the above discussed equipment led to the development of so-called "eductor" type mixers mainly employed in the oil industry for the blending of petroleum products and gasolines. These mixers use an incoming or a circulating (turnover) stream of oil in an injector nozzle or Venturi tube to entrain oil from within the tank. Such mixers, while more efficient than the previously discussed apparatus, do not provide adequate high capacities of entrained oil for mixing, and produce, in common with the propeller agitation and simple turnover pumping, localized irrational and unpredictable turbulence conditions which are inimical to efficient and accurate operation. The eductor effect is operative in a restricted tank area. It does not produce uniform agitation for the entire liquid. As a consequence, the eductor mixers also require long pumping times and large power expenditures.

The results accomplished by the use of the above mentioned and other prior art devices are obtained mainly by force of turbulence input which defies rational analysis. Hence the uncertainty of operation and the long blending or mixing times. The detriments increase with the size of the tank units. The importance of the matter will be realized when it is considered that mixing for blending purposes, and agitating for sustaining purposes represent major problems in connection with quite small tank units, in industrial processes which use tank units with capacities ranging from 5 to 50 thousand barrels and more.

The condition operates as a serious detriment in innumerable chemical and industrial processes of which the blending and sustaining of petroleum products and the maintaining of colloidal fuel are only examples.

The invention proposes handling equipment designed with the object of contributing toward the problem of remedying these shortcomings. Some of the salient objects and features of the invention are briefly stated below.

The principal object resides in the provision of a tank equipped with means for creating in a fluid medium fed thereinto or withdrawn therefrom, solely as a result of such feeding or withdrawal, and without the use of any mechanical forces, hydraulic agitation affecting the entire body of the fluid medium throughout its entire extent, for the purpose of effecting uniform blending thereof or for effecting maintenance of its uniformly blended homogeneous condition. The magnitude of the hydraulic agitation can be obtained for any given set of conditions with calculable certainty.

The hydraulic agitation of the fluid medium, as noted in the preceding paragraph, is obtained regardless of the amount or quantity of fluid medium contained at any time within the tank. The agitation is a by-product of the injection or feeding of the fluid medium into the tank and likewise a by-product of the withdrawal thereof from the tank. Complete withdrawal of fluid medium can be effected without leaving in the tank any residue except the inevitable film that will adhere to the tank walls.

The displacement of the body of the fluid medium for blending or for sustaining purposes proceeds from the point of injection, at or near the tank bottom, upwardly and laterally outwardly and thence downwardly to the point of withdrawal of the medium from the tank, the point of withdrawal being arranged at the tank bottom adjacent to the point of injection of the medium.

Increments of fluid or liquid to be blended may be injected in a top level of the fluid body in the path of the upward and laterally outward displacement thereof and for entrainment therein.

Another object is concerned with the provision of means for adjusting the displacement of the body of the fluid medium in accordance with the inflow and withdrawal capacity and in accordance with the physical properties of the fluid medium to be handled.

The adjusting means noted in the foregoing paragraph include means for determining the magnitude of inflow of the fluid medium differentially along a plurality of levels centrally of the body of fluid medium in the tank, and controlled withdrawal thereof differentially from a plurality of levels peripherally of the fluid body, thereby creating laterally effective differential upward displacement, entrainment and re-grouping of the constituent parts of the fluid body for blending or for sustaining purposes, as stated before.

The re-grouping of constituent parts or portions of the fluid body may also be carried out by controlled turnover circulation which effects the hydraulic entraining agitation of the entire fluid body by withdrawal and re-injection of a circulating stream regardless of the tank contents.

The turnover circulation may be accomplished by withdrawing controlled portions of fluid from a plurality of levels, and reinjecting such portions in a common stream into the fluid body at a common point or at a plurality of points arranged in such a manner that controlled re-grouping of the constituent parts of the fluid body is effected in a plurality of levels without creating irrational turbulence.

These and additional objects and features will appear from the detailed description of the invention which is presented below with reference to the drawings. In these drawings,

Fig. 1 is a diagrammatic sectional view of a blending or storage tank made in accordance with the invention;

Fig. 2 shows a section, on a larger scale, through the adjustable feed or injection column of the structure Fig. 1 along lines 2—2 thereof; and

Figs. 3 and 4 are diagrammatic views of additional embodiments of the invention showing single- and multiple-cell blending or storage tank structures for industrial, commercial and domestic use and, as in the case of Fig. 4, for use in tank cars or ship bunkers and the like.

The drawings are not to scale. The dimensions of certain parts are distorted at the expense of other parts so as to show details more clearly than would be otherwise possible.

The structure shown in Fig. 1 in full lines comprises a circular tank having a cylindrical

upper section 11 and an inwardly and downwardly extending section 12. Within this tank is disposed a partition 13 in the shape of an inverted cone. The bottom section 14 of this partition is joined with the bottom section 15 of the outer tank 12 and forms a well for the introduction of the fluid. The partition 13 forms an inner tank area or primary mixing chamber 16 and an outer tank area or fluid collecting chamber 17. The bottom of the outer tank 12 forms an annular area or discharge well 18 which connects with the outlet conduits 19 and 20. The recessed bottom 15 of the outer tank 12 is provided with a fitting 21 which is in fluid-tight connection with the tank and is internally threaded for the threaded shaft 22 of an adjusting or flow control member 23. The shaft 22 is operable from the outside by suitable means, for example, a hand wheel or knob 24. Therefore, the flow control member 23 can be moved up and down within certain limits toward and away from the well 14 of the inner tank 13. In the case of large structures which are sunk in the ground, the inflow adjustment member 23 may be operated by remote control in any one of several well known and approved ways.

The structure is provided with a cover 25 carrying a peripheral cylindrical baffle or insert partition 26 and a centrally disposed cylindrical baffle or insert partition 27. The insert 26 forms with the wall 11 of the tank a peripheral top chamber 28 which communicates with the inner tank 16 through the annular space 29. The insert 27 forms with the centrally disposed feed or injection column a chamber 30 which communicates with the interior 16 of the tank through the annular space 31. The centrally disposed feed or injection column will presently be described in detail. The chamber 28 is provided with a pipe 32 connected with the valve 33 and the latter communicates with the conduit 34. The chamber 30 is provided with a pipe 35 which communicates with the valve 36 and the latter also connects with the conduit 34. Several pipes such as 32 and 35 may be provided within the corresponding annular chambers 28 and 30, in accordance with the size of the unit and the needs of the material to be handled. The inlets 29 and 31 may be arranged as shown or may be extended downwardly or upwardly as desired. Material may be withdrawn from the chambers 28 and 30, or may be injected thereinto for intermixing with the liquid in the tank, as may be desired or required for any given set of conditions.

A float 40 disposed within a guide shell 41 is arranged for the control of the vent valve 42. This valve is normally open for the escape of gases, but when the liquid in the tank rises to a certain level it will lift the float and the float will close the valve 42. The guide shell 41 is provided with an opening 43 for the escape of gases from the upper part of the tank chamber. The opening 43 may be connected with a pipe extension leading to the highest point within the tank for the escape of gases therefrom. The valve 42 may be of the pressure controlled type which permits certain pressure within the tank as a counter-balance for the liquid stream introduced thereinto.

On top of the cover 25 and centrally thereof is disposed a tubular support 50 carrying an annular ring-like member 51. The latter is mounted in an assembled cross-sectionally U-shaped journal member 52. This member is in frictional and rotatable engagement with the fixed ring-shaped member 51 through the medium of suitable washers 53, 54 which may be of leather or other suitable material. Roller bearings or any other suitable and approved journal structure may be substituted for the washers 53 and 54. The journal assembly is made fluid-tight and pressure-tight in any desirable and approved manner.

Attached to the assembled U-shaped journal 52 is a downwardly depending pipe 55 carrying a flange 56 at the top thereof. Connected with the flange 56 and pipe 55 is the hub 57 of an operating member shown in the form of a hand-wheel 58. Therefore, the hub 57 of the hand-wheel 58 is attached through the medium of the flange 56 to the cross-sectionally U-shaped rotatable journal 52, and when the hand-wheel is rotated, it will rotate the pipe 55 around the stationary pipe 60. Keyed to the stationary pipe 60 is a member 61 having a flange 62 which maintains the journal assembly of the rotatably mounted pipe 55 by engagement with the hub 57 of the hand-wheel 58. The connection may be made fluid- and pressure-tight by means of a suitable labyrinth gland including packed annular grooves as diagrammatically indicated in the drawings. The flange 62 may be provided with suitable calibrations coacting with index fingers on the hub 57 of the hand-wheel 58. The outer pipe 55 is shown rotatable by means of the hand-wheel solely for the sake of convenience. In large structures the adjustments may be made by remote control in any desired and suitable manner.

Attached to the stationary pipe 60 is a top casting or fitting 65 supported in central position by means of brackets 66, 67 attached to the mounted tank cover, as shown. The pipe 60 extends downwardly within the rotatable pipe 55 and carries at its bottom end a ring from which extend brackets 45, 46, and the latter are attached to the inner tank 13 at the bottom thereof so as to center the stationary pipe 60 in proper position. The brackets or legs 45, 46 are preferably streamlined.

The stationary inner pipe 60 and the rotatable outer pipe 55 are each provided with openings the size of which increases upwardly from the bottom. The edges of these openings are preferably rounded. The rotatable pipe 55 operates in the nature of a valve for adjusting the size of these openings. When the assembly is in the position shown in Fig. 2 the openings in the stationary and rotatable pipes are in alignment for maximum lateral outflow from the feed or injection column. When the rotatable pipe is radially displaced by means of the hand-wheel 58, or by equivalent means, the sectors intermediate the openings will more or less restrict the outflow to the extent of adjustment of the rotatable valve pipe. The openings in these pipes may cover arcuate sections of approximately 20°. Thus only a 20° rotation is required to bring about a complete closure of the outlets in the feed or injection column. Leakage radially around the solid sectors of the stationary pipe 60 can be neglected in the operation of the structure.

The valve member 23 at the bottom of the tank is adapted to control the outflow from the stationary pipe 60. If in fully closed position, the downward inflow from the pipe 60 will be blocked. It is thus possible to control the inflow from the injection or feed column downwardly, and, by means of the valve pipe 55, also laterally through

the valved openings disposed at various levels of the column. It is likewise possible to operate the structure with the valved openings around the column entirely closed so that the column functions as a fixed inlet which conducts the fluid medium to the bottom inflow well of the tank, or to operate with the bottom inflow entirely closed and to permit the fluid to enter the tank laterally only through the valved openings provided at the various levels of the feed column.

The casting or fitting 65 at the top of the structure is equipped with a valve 70 operable by means of a hand-wheel 71 or by suitable remote control. Depending from the valve 70 downwardly is a central inlet pipe 72 which reaches near to the bottom inflow of the stationary pipe 60. This centrally disposed pipe 72 may be centered within the stationary pipe 60 by means of suitable spiders. The fitting 65 is provided with inlets 75 and 76 leading to the valve 70. The function of this valve is to admit liquid into the structure selectively from the inlets 75, 76 either by way of the centrally disposed pipe 72 or around this pipe through the annular space 80 formed thereby within the stationary inlet pipe 60. The valve may be of the rotary type as indicated. A plunger or other suitable valve structure may be substituted.

The inner tank 13 is perforated as indicated, to provide for upwardly increasing outflow capacity of liquid from the inner primary mixing chamber 16 into the outer collecting chamber 17. The liquid collects in the annular outlet well 18 for withdrawal through the pipes 19 and 20. These pipes are, of course, attached to the structure in such a manner as to effect complete drainage of liquid from the well 18.

The additional equipment shown in Fig. 1, comprising various valves and a pump, is best described in connection with the operation of the structure.

The nature of the liquids to be blended or of the solution or suspension to be maintained in the structure is known. The inlet capacity, that is to say, the capacity of the inflowing stream of a given liquid, is likewise known. The valve provisions, namely, the bottom valve 23 and the valved outlets along the feed column are suitably adjusted to the properties of the liquid to be handled and to the inflow capacity thereof. It is thus possible to provide for relatively mild agitation by operating with completely opened bottom valve and completely opened inlets along the feed column, in the presence of a liquid stream injected without force or only with moderate force, or to restrict the inlet openings as compared with the amount of liquid to be injected in a time unit so as to obtain a more or less intense agitation as desired. The hydraulic displacement which constitutes such agitation will, however, always proceed as explained below and as indicated by the flow lines in Fig. 1.

It is assumed first that it is desired to blend products of high fluidity such as gasolines or light oils of different specific gravities. The stream of gasolines to be introduced into the tank may be injected through the pipe 85, valve 86, with the valve 70 adjusted so that the supply stream is directed downwardly through the annular space 80 around the central pipe 72. The valve 23 is set in accordance with the capacity of the supply stream so as to provide a bottom outflow and a stream of desired and calculable magnitude annularly outwardly from the bottom of the stationary pipe 60 and laterally upwardly and outwardly in the direction of the arrows. The rotatable valved pipe 65 is preferably set for medium adjustment (according to the properties of the liquids to be handled) restricting the size of the openings along the feed column. Nevertheless these openings decrease in size from the bottom upwardly. Therefore, the liquid injected has more chance to escape from the feed column near and at the bottom thereof, producing lateral upwardly diminishing inlet streams or jets for entrainment with the liquid in the tank.

An escape of the liquid from the inner tank area 16 into the outer tank area 17 is only possible through the perforations in the partition 13, the outflow capacity of which increases from the bottom upwardly. The partition thus forms a part of the outlet means and constitutes a flow distributing wall. The result is that the fluid injected takes an upward and laterally outward course, as indicated by the flow lines. This flow produces a mixing action for blending purposes for the entire duration of the inflow of the liquid. It should be noted that the magnitude of the hydraulic displacement diminishes from the bottom upwardly, which is indicated by flow lines of upwardly decreasing prominence. Gas escapes through the vent valve 42. When a certain liquid level is reached the float 40 will close the valve and the liquid can now be discharged or turnover circulation can be started for effecting further blending and homogenizing of the fluid body in the tank.

The increments of liquids to be blended may also be introduced by way of valve 91, conduits 34, 92, valve 93, pump 90, conduits 95, 96, valve 97, into the fitting 65 and thence exactly as previously described, through the valve 70 set so as to admit the liquid into the tank through the annular space 80 formed within the stationary pipe 60 by the centrally disposed pipe 72.

It may be desirable in connection with certain liquids to inject increments thereof in a stream to the bottom well in the inner tank 13, and also through one or the other or through both of the upper chambers 28 and 30, for intermixture with the hydraulically displaced liquid body in the tank.

The discharging of liquid may be started either after the tank is completely filled or, at such time as may be convenient, before the full tank capacity is reached. The discharge may proceed either by gravity through the valves 100, 101, pipe connections 102, 103 and valve 104, or may be forced by the pump 90, and in the latter case it will proceed by way of valves 100, 101, 105, pump 90 and valve 106.

The outflow capacity, that is to say, the amount of liquid withdrawn from the tank unit, is a function, in gravity discharge, of the dimensioning of the outlets or, in forced discharge, of the capacity of the pump. It can be adjusted in either case in accordance with the requirements of the liquid so as to produce the desired agitation within the mixing tank. In other words, the outflow capacity may be so adjusted as to exceed the outlet capacity of the lowermost rows of perforations in the partition 13. Therefore, in order to satisfy the adjusted and desired outflow, liquid will be drawn from the inner tank 16 from various levels thereof, and from each level progressively increasing amounts due to the progressively upwardly increasing outflow capacity of the partition 13. The result, purely as a function of the withdrawal of liquid, is again hydraulic displace-

ment of the liquid body in the tank along the flow lines indicated in the drawings.

In case turnover circulation is desired, such circulation may be carried out either incident to and simultaneous with feeding fresh liquid into the tank or after the tank is completely filled with liquid. In the first case liquid is withdrawn by means of the pump from the bottom well 18 and reinjected by way of valve 94, conduits 95, 96, valve 97, to the top of the column while fresh liquid is at the same time fed into the column through valve 86. Turnover circulation after the tank is entirely filled may be carried on by means of the pump 90 from the bottom discharge well 18 of the structure, valves 100, 101, 105, pump 90, valve 94, conduits 95, 96 and valve 97. The intermixing, agitating or blending flow within the tank caused by such turnover circulation proceeds along the same lines as previously discussed.

Additional re-grouping of the component parts of the mixture for the purpose of thorough blending is provided for and may be carried out by withdrawing liquid by means of the pump simultaneously from the discharge well 18 at the bottom of the structure and also from one or the other or from both of the chambers 28 and 30 by way of the valves 33 and 36 which connect over valve 93 with the intake side of the pump. Adjusted amounts can thus be withdrawn from the top of the liquid through the annular inlet spaces 31 and 29, and the portions withdrawn from the chambers 28, 30 and well 18 can be re-injected into the feed column in common through the valve 97.

The mixing of liquids difficult to blend can be accelerated by employing the controlled re-grouping turnover circulation in conjunction with certain valve settings. For example, the bottom valve 23 may be closed so as to prevent inflow of returned re-grouped liquid directly from the bottom of the stationary feed pipe 60. Inflow from the pipe 72 is not blocked in such a case. The rotatable valve pipe 55 may be adjusted so as to restrict the laterally directed outlet openings along the injection column. The result is that liquid returned by way of the pipe 72 rises under pressure within the space 80 of the feed column and is forcibly injected into the liquid body in the tank in the form of forced streams or jets in differentially upwardly calculably decreasing amounts along a plurality of levels of the liquid body. Consequently upwardly and outwardly laterally directed currents of calculable magnitude are again created in the liquid body. The agitation is more intense. This controlled mixing agitation is assisted by the withdrawal of quantities of liquid differentially from various levels of the liquid body, the amounts withdrawn increasing from the bottom upwardly.

The action affects the entire liquid and yet can be adjusted so as to avoid any undesirable surface agitation or ebullition which may be detrimental to the condition of a given product. The agitation may be adjusted so that the surface of the liquid in the tank remains substantially quiet.

It should be observed that the tank can be drained completely, leaving within the structure only the film of liquid that naturally will always adhere to the tank walls. The agitation as described is operative regardless of the amount of liquid which may be in the tank at any time.

The structure is also adapted to serve as a storage tank for solutions, blended liquids, and the like which display a tendency to separate or deteriorate when subjected to quiescent conditions. The required agitation will then be furnished purely as a by-product of the withdrawal of liquid for use. Turnover circulation may be employed periodically during prolonged intervals of inactivity, that is, when no liquid isi normally withdrawn for use.

The structure described above accelerates the blending of liquids and solutions as compared with the operation of prior devices, cutting down the cost of blending, and keeps such liquids in uniform homogeneous condition in storage, due to the fact that the agitation is effected solely hydraulically without using any mechanical force except, of course, the usual pump that is required in any case for introducing liquid into a tank and for withdrawing it from the tank.

Any desirable hydraulic condition may be produced with calculable certainty. This will be understood when it is considered that all of the factors required for calculating the magnitude and force of displacement of the fluid at any point within the tank are known and can be adjusted at will to accommodate any given set of conditions.

It is believed that this is the first instance of a mixer structure which furnishes hydraulic agitation suitable for blending and sustaining purposes, without the use of any mechanical forces, other than required for feeding and for withdrawing liquid, and purely as a result of feeding and of withdrawing the liquid. It is also believed that the present disclosure is the first example of a hydraulic mixer in which the hydraulic agitation is calculable, permitting adjustment or dimensioning of details so as to produce desired agitation for many materials and many purposes.

The outer tank 12 of the structure Fig. 1 may be made cylindrical, as indicated in dotted lines marked by the numeral 12*a*. The outer tank space 17 will then be enlarged as indicated by the numeral 17*a*. The structure is in such a case provided with an upwardly sloping tank bottom 15*a* which is joined with the bottom well 14 of the inner tank 13 in the same manner as the bottom 15 of the inverted cone-shaped tank 12 is joined with the bottom of the perforated inner tank 13. Bottom inserts 110 are provided in such structure, forming a bottom well or discharge chamber 111 which communicates with the fluid body in the tank space 17*a* through an annular inlet 112. Outlet conduits 19*a* and 20*a* corresponding to the outlet conduits 19 and 20 in the first described structure are connected to the various valves in the same manner as described in connection with the full line structure Fig. 1. These conduits are placed so as to effect complete drainage from the tank.

Temperature control means, e. g., heating coils or jackets may be provided where needed or desired.

The operation of the device, when used for storage or other handling of liquids containing in dispersion solids, such as colloidal fuel, proceeds substantially along the lines discussed above. The composite liquid is introduced through the feed or injection column and floods the perforated inner tank from the bottom upwardly along the flow lines shown in the drawings. The upward and laterally outwardly directed components of the hydraulic displacement constitute agitation of calculable magnitude which effects the intermixture of the dispersed phase with the dispersion medium and main-

tenance of the dispersed phase in proper dispersion in the medium. The settling of the solid particles from the liquid is prevented. The agitation required for such action is adjustable in accordance with calculable requirements of the composite liquid to be handled in the tank. Withdrawal of liquid from the tank effects hydraulic displacement agitation in the same manner purely as a by-product of the action of discharging liquid. Periodic turnover circulation may be applied during prolonged intervals of inactivity.

The exacting and far-reaching adjustment provisions shown in Fig. 1, while desirable in an all-purpose machine and in connection with certain fluids to be blended or stored, are not necessary in every instance where the use of the structure is desired. For example, in connection with the handling of a predetermined solution or suspension whose properties are definitely established, and in the presence of definitely predetermined inflow and outflow capacities, it will not be necessary to provide for adjustment of the injection or feed column but to provide instead a feed column having fixed inflow provisions which are adapted to produce, in conjunction with the outlet means comprising the fixed perforated inner tank, or flow distributing wall and in the presence of predetermined inlet and discharge capacities a definite hydraulic displacement which is required for producing the desired agitation. Therefore, the structure may be made very simple for any given set of conditions which invariably remain and it is possible in the presence of such predetermined conditions to dispense with the valved inlet fitting on top of the structure as well as with the adjusting provisions for the injection or feed column. A simple inlet pipe may then be used. The outlet of this pipe may be properly spaced from the bottom of the perforated insert tank so as to deliver the upward currents for agitation in the presence of a definite inflow without the use of a valve such as 23. The inserts 26 and 27 may or may not be provided, depending on whether or not the liquid to be treated or stored requires entrainment of fluid into or from the top levels incident to feed or turnover circulation as described. The feed column may be provided with fixed outlets of upwardly decreasing size, or such outlets may be omitted, depending on the fixed conditions under which the structure is to operate.

The unit may be furnished to provide for practically all current capacities that may be desired in industrial operation in connection with blending or sustaining of many materials.

Fig. 3 shows in diagrammatic manner a modified unit for industrial, commercial or domestic use, for example, in connection with the storage of suspensions including colloidal fuel. The unit is in a sense one-half of the one shown in Fig. 1. It comprises a preferably semi-circular outer tank 120 with a sloping bottom 121 forming an outlet well provided with the discharge pipe 127. The left end 122 of the bottom forms the inlet well for the semi-circular perforated inner tank or out-flow distributing wall 123. The inlet pipe 124 extends downwardly to the bottom inlet well 122. This pipe may be provided with perforations such as shown in connection with the injection or feed column in Fig. 1. An interior pipe 125 extends within the pipe 124 downwardly. The liquid, e. g., a composite oil-coal fuel, is introduced through the pipe 124. The properties of the liquid are known, and the structure can therefore be so dimensioned in all its details as to produce the agitation that is required for sustaining the liquid. Incident to introduction of the liquid are produced the upwardly and outwardly directed hydraulic sustaining currents within the perforated inner tank or on the inside of the flow distributing wall 123, as indicated by the flow lines. The liquid passes through the holes in the flow distributing wall 123 and gradually floods the outer tank chamber 126. The liquid may be withdrawn for use from the outlet well through the pipe 127 or may be re-circulated along the line 128 through the pipe 125 for producing the required sustaining or blending agitation. The outlet 127 may also be arranged directly beneath the inlet well 122 so as to draw liquid from the chamber 129. For this purpose the tank bottom 121 should be suitably perforated. The structure is simple and may be fixed for any predetermined condition of operation. Control means such as a float-regulated vent valve, also gauges and the like, may be provided if desired.

Fig. 4 shows in a diagrammatic manner a multi-cell structure for large capacity industrial use or for use in tank cars, tankers or ship bunkers and the like. A four-cell structure is shown, but their number may be as desired.

The operation of the multi-cell structure shown in Fig. 4 is merely multiplication of the operation of the structure Fig. 3. The perforated inserts or flow distributing walls and the cell walls may take any suitable specific form, square or rectangular, if desired, so long as the general shape indicated in the drawings, and the operation resulting therefrom, is preserved. It is possible, for example, to make the perforated inserts of sheet metal, welded at the edges, to furnish an inner tank of cross-sectionally upwardly increasing area fitted into a square or rectangular outer tank. The liquid is initially introduced through the pipe 130, flooding the first cell from the bottom upwardly along the flow lines indicated in the drawings. When the top level is reached liquid moves into the second cell through the interconnecting centrally disposed siphon pipe 131 and floods the second cell in the same manner.

The operation is repeated by way of the interconnecting siphon pipe 132 moving the liquid into the third cell and from there in the same manner by way of interconnecting pipe 133 to the fourth cell. The last cell is equipped with an outlet port 134 communicating with the standpipe 135. This pipe communicates with an inclined conduit 136 which carries a vent valve 137. Gas outlets connect the various cells with the vent conduit 136 and therefore with the vent valve 137. Separate vent valves may be used in connection with the various cells. The liquid is withdrawn for use or desired disposal by way of conduit 140. Turnover circulation may be obtained by withdrawing liquid from the conduit 140 and circulating it back to the inlet by way of line 141 through an inner pipe disposed in the pipe 130, as shown in connection with previously discussed embodiments. The dimensioning of details will be determined by the operating conditions that are to be satisfied. As previously discussed, adjusting means may, of course, be provided.

Temperature control means, heating coils or jackets and the like may be employed in the structures Figs. 3 and 4 as desired or necessary.

The invention is not limited for use in systems for blending oil or gasoline products, or for

sustaining such products in storage, as described herein, or for use in connection with the handling of suspensions such as colloidal fuel. It may be used in many industrial and chemical processes, including coal and ore separation processes; also in connection with digesters, purifiers for liquid, agitators and the like, and in general, wherever it is desired to blend liquids or to sustain in bulk storage quantities of complex, compounded or composite liquids, artificial dispersions or the like, indeed, for the handling of almost any liquid material in which the assured maintenance of homogeneity is important. Among additional and diversified purposes to which the invention can be applied may be mentioned its use as a blending device in connection with a mechanical mixer, as disclosed in the copending application Ser. No. 496,920, filed July 31, 1943.

What is believed to be new and desired to have protected by Letters Patent is pointed out in the following claims.

I claim:

1. Apparatus for handling liquids comprising a tank, a downwardly and uniformly inwardly tapering partition disposed in said tank substantially throughout its axial extent and forming an inner and an outer chamber therein, a tubular liquid supply conduit disposed in said inner chamber and having an outlet at the bottom thereof for introducing liquid into said inner chamber, said conduit and said partition being so constructed and arranged that hydraulic stream-current agitation is produced within the liquid in the inner chamber, responsive to the introduction of said liquid, which affects the entire liquid body in said inner chamber regardless of the amount thereof and displaces such liquid body in such inner chamber solely upwardly and radially symmetrically outwardly, and discharge means for removing liquid from the outer chamber at the bottom thereof, said discharge means being so constructed and arranged relative to said partition that the hydraulic agitation as noted is produced incident to discharge of liquid from the device.

2. The structure and combination defined in claim 1, together with valve means for adjusting the inflow of liquid from the bottom of said conduit into said inner chamber.

3. The structure and combination defined in claim 1, wherein said tubular conduit is provided with an axially successive series of inflow ports of upwardly decreasing size for the purpose of introducing liquid into the inner chamber in a plurality of vertically successive radially directed streams.

4. The structure and combination defined in claim 1, wherein said tubular conduit is provided with a vertically successive series of ports of upwardly decreasing size for the purpose of introducing liquid into the inner chamber in a plurality of vertically successive radially directed streams, and valve means for adjusting the outflow from the ports in said tubular member.

5. The structure and combination defined in claim 1, together with a tubular conduit disposed within and coaxial with said first noted conduit, and valve means for adjustably introducing liquid to the bottom of the inner chamber alternatively through either one of said conduits.

6. The structure and combination defined in claim 1, wherein said tubular conduit is provided with a vertically successive series of outlet ports of upwardly diminishing size, means for adjusting the inflow of liquid from said ports and the inflow of liquid from the bottom of said conduit, a second tubular conduit disposed within and coaxial with said first noted conduit, and valve means for introducing liquid into the tank either through said first or said second noted conduit.

7. The structure and combination defined in claim 1, together with means in said tank forming annular chambers at the top thereof, and means for providing hydraulic communication between the tank chambers and said annular top chambers.

8. In the art of handling composite liquids, a tank, an inlet well at the bottom of said tank, a conduit for introducing liquid into said inlet well, a partition rising upwardly and outwardly from the inlet well at the bottom of said tank substantially to the top thereof and forming an inner mixing chamber and an outer liquid collecting chamber which surrounds said mixing chamber substantially from top to bottom thereof, and ports in said partition providing for upwardly increasing outflow capacity from said mixing into said collecting chamber, said partition and the ports therein being so constructed and arranged that liquid introduced into said inlet well is displaced within said mixing chamber solely upwardly and radially outwardly with upwardly diminishing calculable magnitude for the purpose of inducing uniform intermixture of the component parts of the liquid and of maintaining such uniform intermixture thereof.

9. The combination and structure defined in claim 8, together with an outlet well at the bottom of said liquid collecting chamber, and an outlet for withdrawing liquid therefrom, said outlet well and said outlet being so constructed and arranged that the liquid in said mixing chamber is displaced as stated incident to and as a result of withdrawal of liquid through said outlet.

10. In the art of handling in storage liquids which display a tendency to deteriorate in the absence of agitation thereof, a reservoir structure comprising a plurality of successive cells, inlet means for introducing liquid into the first cell at the bottom thereof, outlet means for discharging liquid from the last cell at the bottom thereof, siphon-like means for interconnecting the bottoms of the successive cells, and means in each cell for imparting to the liquid moving therethrough an upward and laterally directed outward flow for the purpose of agitating the liquid body in each cell solely as a result of the movement of the liquid through the cells incident to feeding the liquid thereinto and withdrawing the liquid therefrom.

11. The structure and combination defined in claim 10, wherein a perforated partition providing for increased capacity of liquid flow from the bottom upwardly constitutes the means in each cell for imparting to the liquid the displacement for agitation as noted.

12. In combination, an upright tank, a partition in said tank forming therein an inner chamber and an outer chamber extending substantially throughout the vertical extent of said tank, a conduit comprising coaxial tubes extending into said inner chamber, valve means for directing a fluid medium into said coaxial tubes, said tubes being so constructed and arranged that the fluid medium directed thereinto is introduced into said inner chamber in upwardly diminishing adjustable amounts, and outlet ports in said partition which are so arranged that fluid medium is

drained from said inner chamber into the outer chamber in upwardly increasing amounts.

13. The combination and structure defined in claim 12, together with means for confining amounts of fluid medium in the upper strata of said inner tank, and means for entraining quantities of such confined amounts with the fluid medium directed into said coaxial tubes for introduction into said inner tank.

14. The combination and structure defined in claim 13, together with additional valve means for controlling the outflow of fluid medium from said coaxial tubes.

15. A device for handling composite liquids for the purpose of effecting and maintaining uniform intermixture of their component parts having a tank, an inlet well near the bottom of said tank, injection means for introducing a stream of liquid into said tank comprising an outer tubular conduit adapted to discharge liquid radially outwardly from a plurality of levels, an inner conduit disposed within said outer conduit adapted to discharge liquid in downward direction into said inlet well, means for regulating the in-flow of liquid into either of said conduits, means for regulating the downwardly directed out-flow of liquid from either of said conduits, means for regulating the radially directed discharge from said outer conduit, a partition extending upwardly and outwardly from the inlet well and forming an inner and an outer chamber in said tank; said partition being so constructed and arranged that the body of liquid formed in said inner chamber is subjected within the inner chamber to hydraulic displacement which proceeds upwardly and radially symmetrically outwardly with upwardly diminishing magnitude affecting the entire liquid within the inner chamber regardless of the vertical extent thereof, and an outlet well at the bottom of the outer chamber for discharging liquid therefrom.

16. Apparatus of the class described for intermixing fluid media, having a mixing device which comprises an upright mixing vessel, a tubular fluid supply conduit extending into said vessel, control means for directing a fluid medium into said supply conduit, a plurality of outlet ports in said supply conduit, said outlet ports being so constructed and arranged that the fluid medium directed into said supply conduit is injected into said mixing vessel in upwardly diminishing amounts forming a plurality of vertically spaced radially directed streams of upwardly diminishing magnitude, and a separate tubular conduit for supplying fluid medium directly to the bottom of said mixing vessel.

17. A device for handling fluid media having a vertically disposed tank, inlet means extending into said tank for downwardly directing fluid material thereinto, and a flow distributing wall disposed within said tank and extending in generally vertical direction substantially for the full distance thereof, said flow distributing wall forming in said tank an inner chamber for receiving material from said inlet means and having holes for draining material from said inner chamber in upwardly increasing amounts.

18. The structure defined in claim 17, wherein the flow distributing wall extends transversely of the tank.

19. The structure defined in claim 17, wherein the flow distributing wall is a conical wall concentric with the vertical axis of the tank.

20. The structure and combination defined in claim 17, together with means for selectively withdrawing material from a plurality of levels of the fluid body in the tank.

21. The structure and combination defined in claim 17, together with means for selectively withdrawing material from a plurality of levels of the fluid body in the tank, and means for selectively directing withdrawn material for discharge and/or re-injection through said inlet.

22. A device for handling materials composed of a fluid medium and solid particles dispersed therein, said device comprising an upright tank, an inlet for downwardly injecting material into said tank, flow-distributing means disposed within said tank and extending therein in generally vertical direction substantially for the full distance thereof, said flow-distributing means forming in said tank an inner chamber for receiving the material from said inlet and being so constructed and arranged that the entire body of fluid medium reposing therein is hydraulically symmetrically and uniformly displaced in upward and radially outward direction, responsive to the injection of material through said inlet, means for selectively withdrawing material from a plurality of levels of the fluid body in the tank, and means for selectively directing withdrawn material for discharge from and/or re-injection into said tank.

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