Dec. 9, 1947. G. G. SCHMIDT 2,432,175

APPARATUS FOR MIXING AND BLENDING FLUIDS

Filed Oct. 16, 1944 2 Sheets-Sheet 1

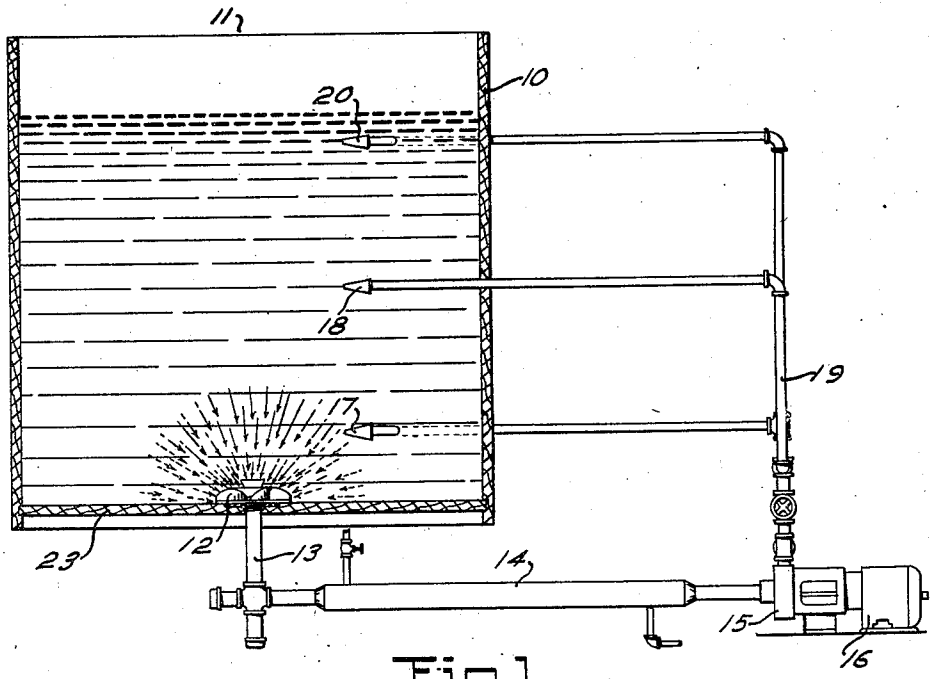


Fig. 1.

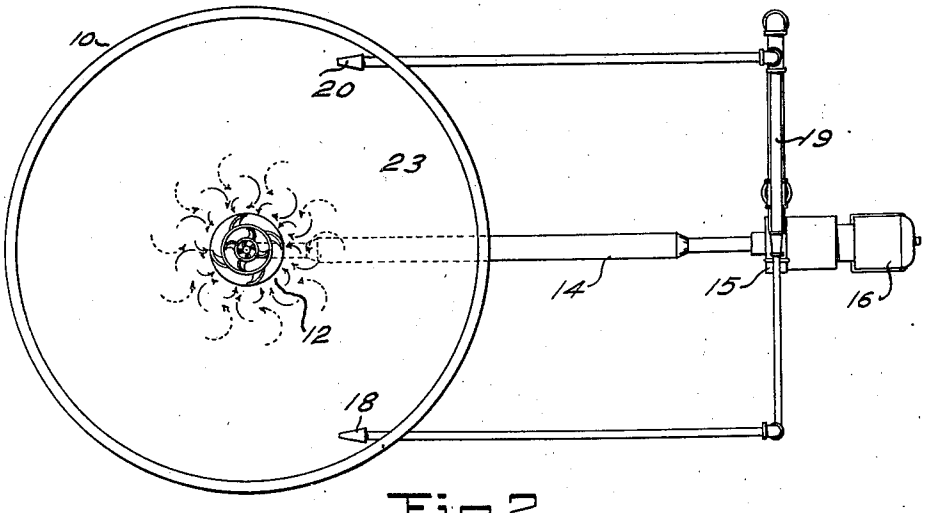


Fig. 2.

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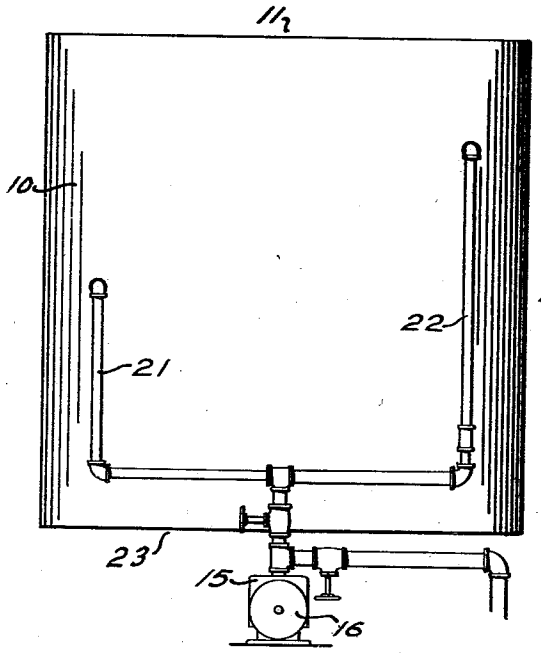


Fig. 3.

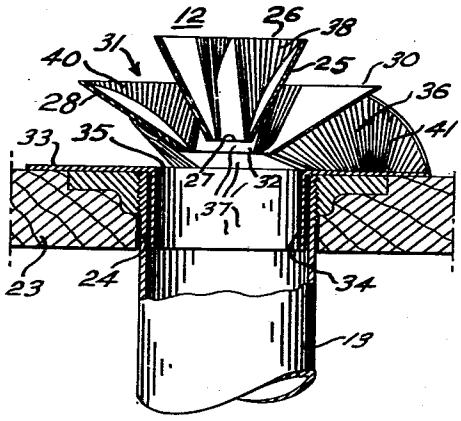


Fig. 4.

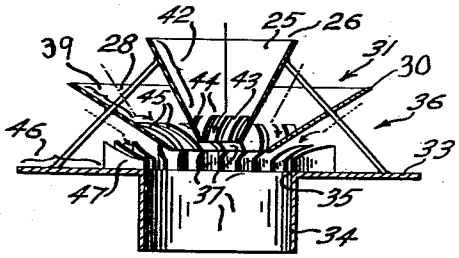


Fig. 7.

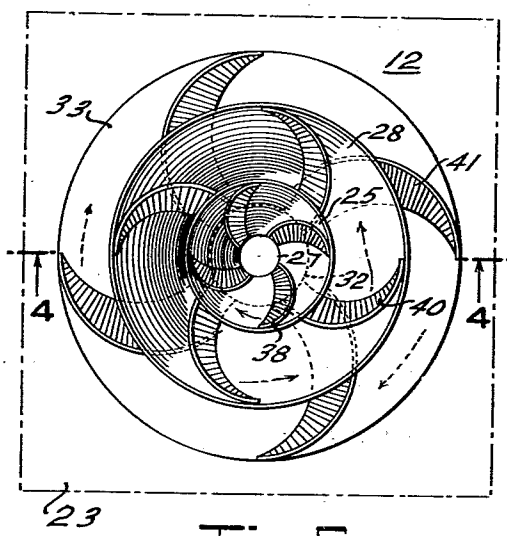


Fig. 5.

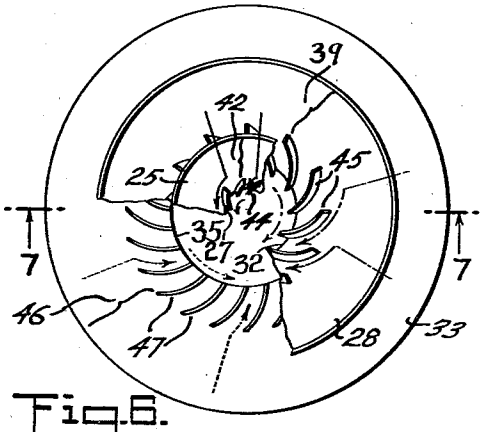


Fig. 6.

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APPARATUS FOR MIXING AND BLENDING FLUIDS

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13 Claims. (Cl. 259—95)

1

This invention relates to apparatus for mixing and blending fluids, and particularly to such apparatus as, for purely illustrative purposes, are particularly adapted to mixing and blending paints and the like.

In the prior art of mixing, it has been common to provide a tank as a mixing receptacle into which the ingredients are poured or otherwise disposed or placed, with a frequent stratification of materials into layers of different materials or densities which require intimate mixing to convert the heterogeneity of the mass into useable homogeneity. In one class of mixing devices a closed circulation of the fluid has been provided sucking the liquid into an open-mouthed delivery pipe at and generally flush with the bottom of the tank, forcing it through the pipe to a pump, and discharging the output of the pump into the tank at the top thereof. This system establishes a vortex appreciably smaller in diameter than the tank and with poor and incomplete mixing.

In another form of mixing device the tank has been provided with a rotary or otherwise moving power-actuated mechanical agitator. This is in the form of impellers, propellers, or paddles, or the like. This power agitator has been used alone in some cases and in others has been coupled with and superposed upon the closed circulation through the return flow device mentioned. In many cases, areas or zones of the materials are found to remain in the tanks without being mixed, and the intimacy of ultimate mixing is sometimes somewhat lacking. Moreover, the frictional effects produced introduce excessive heat into the mass which must be controlled, and, of even greater import, such heat conversion represents a direct loss of power that is expensive and undesirable. The fluid circulation with the open pipe intake is marked by a rapid acceleration of the fluid adjacent to but outside of the actual intake pipe, resulting in a vortex in the body of liquid in the tank which limits the area or total zone of materials being mixed. Both the recited circulation and the mechanical agitation introduce such factors of rapid acceleration in the main body or mass of the material in the tank that eddy formation and turbulence creation are inevitable, with losses of energy and improper ultimate mixing. Moreover, the turbulence created in the tanks is such as to keep the upper surface of the materials in a state of such unrest as to necessitate a cover as a splash receiver, which complicates

2

the tank manipulations and increases its cost as well as the processing cost.

It is among the objects of this invention: to reduce the power requirements for mixing apparatus; to provide a mixing system which obviates the necessity for a mechanical agitator in a tank; to provide a circulating system for tanks with means for securing rapid acceleration of the fluids in the intake pipe and means while maintaining slow velocities in the body of liquid; to provide a hydraulic agitating system by which the intake portion of the system exerts an attraction to particles at remote portions of the mass in the tank unrelated to a vortex attraction; to provide a mixing hydraulic circulating system by which movement of the particles in the mass relative to adjacent particles is at such a slow rate as to preclude such shearing action as would establish eddies and such similar manifestations of turbulence; to provide a mixing system for fluids in which the entire mass of liquids is guided into an intake pipe through convergent means by which slow flow movements in the tank are converted into accelerated flow within the guiding means and intake whereby intimacy of scrubbing contact is established without having any appreciable turbulence appear in the tank itself; to provide a plurality of frustums of cones in nested convergent relation with means for drawing liquids into the spaces between the cones in an accelerating flow to delivery into an intake pipe; to provide a plurality of such truncated cones in nested spaced convergent relation to intermediate quasi-helical vanes and with means for drawing liquids through the cones and spaces between the cones whereby the liquid accelerating in its flow through one cone is given a whirl in one direction while the liquid passing through and accelerating in its flow adjacent thereto is given a whirl in the opposite direction so as to force intimate mixing swirling turbulent flow through the common delivery of the cones to enhance the intimacy of mixing of the constituents to increase the efficiency of the mixing process; to provide in a mixing apparatus a critical arrangement of cones for intake of fluid for re-circulation whereby to effect a reaching out into heterogeneous regions in a body of fluid by means of controlled velocity vectors within the body of the fluid; to provide a hydraulic mixing system for liquids whereby a selection of heterogeneous zones of liquid for flow into the circulating stream is controlled so that turbulent flow in the body

of the fluid is substantially prevented; and to provide other improvements and advantages as will be apparent as the description proceeds.

In the accompanying drawings forming part of this description:

Fig. 1 represents an elevation, partially in section, of a circulating system for hydraulic agitation and mixing of liquids in a tank according to an illustrative form of my invention; showing by respectively dotted, dashed and dotted, and full lined arrows, the flows into the mixing unit at different levels.

Fig. 2 represents a plan of the tank and hydraulic system of Fig. 1 showing by concentric series of arrows of different visual aspects surrounding the intake unit the direction of substantially helical flows into the several mouths when guide vanes are provided in association with the cones in one embodiment thereof.

Fig. 3 represents an elevation of a tank with a modified form of discharge assembly for returning the flow to the tank.

Fig. 4 represents a vertical transverse section through the assembly of truncated cones of the intake unit and the intake connector of the hydraulic system, according to one form of the invention.

Fig. 5 represents a plan of the cone assembly discharge or intake of Fig. 4, showing by respective dotted, dashed and dotted, and full lined arrows the direction of opposing substantially helical flows leading into the common discharge chamber of the unit in different mouths at different levels.

Fig. 6 represents a fragmentary plan of a modified form of intake unit in which the initial flows into the respective convergent mouths are radial of the unit with short blades or vanes within the unit spaced from the mouths thereof to impart respectively clockwise or counterclockwise whirls to the flows entering the respective mouths for enhancing mixing within the unit.

Fig. 7 represents a transverse vertical section through the unit of Fig. 6.

Referring to Figs. 1 and 2, it will be observed that the tank 10 has preferably an open top 11, and is provided, preferably, substantially centrally of the tank 10, with a compound cone intake unit 12, to be described in detail hereinafter. The intake unit leads to an intake pipe 13, which, purely illustratively, will or may be of approximately 2'' diameter when the tank is of the order of 1000 gallons capacity. The intake pipe 13 leads through a heat exchange unit 14 for either heating or cooling the materials flowing through intake pipe 13, and delivers into a pump unit 15, including or having a power source such as a motor 16. The discharge from the pump 15 leads through suitable connections 19 to preferably three jet discharges respectively 17, 18 and 20 suitably disposed within the tank 10, preferably at different levels below the level of the upper surface of the liquid mass in the tank and with two at least entering the tank at respectively different angles relative to the vertical axis thereof, so as to assist in generally agitating the mass in the tank. The discharge pipes for the discharge jets are, illustratively, for the tank capacity and intake pipe size used as an illustrative case, of the order of approximately 1'' in diameter.

As shown in Fig. 3, the discharge jets for the system may comprise merely two in number, on the ends of the respective discharge pipes 21 and 22 as shown. For illustrative purposes, these also may be of the order of approximately 1'' in diameter. Obviously, if desired, the discharge may comprise a single nozzle, or any desired number greater than the three shown in Fig. 1.

The fundamental structural feature by which the highly efficient mixing and blending derivable from the invention herein is obtained, is an intake device or unit formed illustratively of sheet metal or plastics or the like, of the general character illustrated in one embodiment in Figs. 4 and 5. The floor of the tank 10 is indicated at 23 with an orifice 24 within which the intake unit liquid mixer to be described is sealed in any conventional or suitable manner. Essentially, the liquid mixing and blending unit comprises at least two open ended truncated conical members and a common delivery conduit associated therewith. In the illustrative form of unit under discussion, a hollow open ended small truncated cone 25 is provided having a vertical axis with which the entire unit is concentric. Cone 25 is preferably formed with a wall leading from the upper entrance or intake mouth 26 to a lower discharge outlet 27 at a relatively acute angle to the vertical axis of the cone compared to other cones of the unit. The cone 25 is directed upwardly toward a central zone of influence in the tank and is held in spaced relation to the next truncated open-ended obtuse cone member 28 in any suitable way, and preferably, although not necessarily essentially, by a series of whirl-inducing vanes to be described. The vertical axis of the cone 28 as noted is coincident with the axis of the cone 25, but the upper end or mouth 30 thereof is below the level of the mouth 26 of cone 25, but being of appreciably greater diameter than cone 25 extends laterally therebeyond throughout the periphery of the latter to define between the mouths 26 and 30 a convergent entrance or intake passage 31; the median line or cone line of which projects upwardly into a second zone of influence concentric with and spaced from the central zone of influence of cone 25. The second cone 28 has a lower discharge mouth 32 of much greater diameter than and spaced slightly below the smaller mouth 27 of the upper cone. The cone 28 in turn is supported in any desired manner, as by whirl-inducing vanes to be described, relative to a lower plate 33. Plate 33 is arranged to overlie the floor 23 in such close relation preferably as to interpose no appreciable restraint to flow along the floor of the tank, and merges into the discharge pipe 34 by a mouth 35 arranged slightly below mouth 32 of the second cone and of greater diameter than said last mentioned mouth. It will be observed that plate 33 and second cone 28 establish an inwardly convergent entrance passage 36 leading into the unit. The median cone line of passage 36 projects upwardly laterally into a third zone of influence concentric with and spaced from both the central and second zones. The discharge pipe 34 and its mouth 35, the spaced mouth 32 and the spaced mouth 27 all are located in and define a common mixing passage 37 into which all of the conical passages discharge or deliver liquid entering the respective entrances or mouths in an accelerated high velocity discharge.

The broad cone arrangements of intake unit 12 are identical in Figs. 4, 5, 6 and 7 and the following description of their operations will be understood to be directed to all four figures. This is because under the broadest aspects of the invention the "whirl-inducing" blades may be omitted while still attaining a useable efficiency

of mixing. As each of the passages through the unit are convergent from the large entrance to the smaller delivery opening located in the common internal mixing chamber, it will be clear that the flows in and about or adjacent to the mouths in the tank and flows along the median cone lines of the zones of influence in the tank spaced from but directed toward the intake unit are at relatively slow velocities compared with the accelerated rate of flow at the discharge from each passage into the common mixing passage **37** and into the pipe **13**. It is probable that the pressure drop at the several mouths **27**, **32** and **35** relative to the pressures at the entrances to the several converging passages mutually conduce toward the acceleration of the flows through the several passages.

Assuming that the tank is at the proper level with liquids to be mixed, such, illustratively only, as paint, for example, and with the entire hydraulic system properly filled and with the intake unit comprised of mere cones, apart from blades or vanes, the motor **16** is started and the pump **15** begins to move the liquid from intake pipe **13** through the pump and into the connecting system **19** for jet discharge from the nozzles **17**, **18** and **20**, back into the tank **10**. This circulatory movement causes such differential pressures on the liquid in the tank and that in the discharge pipe **13** that there is forthwith a flow from and relative to the several zones disposed in concentric spaced relation in the liquid in the tank as "focal" centers of attraction on one side at least of zones of less attraction with which varying differential flows are to be established into the several mouths of the unit. These flows are marked by relatively slow velocities in the tank so that while with reference to the material in the tank on each side of the "focal" line or cone line of the passages into the unit, differential flows toward unit **12** are secured, to enhance mixing in the tank, account is taken of the high viscosity of the materials to establish such small or low differentials in flow rates that shearing stresses between contiguous particles traveling toward the cone mouths at different velocity rates is reduced to such a negligible point that practically no eddies or turbulences appear in the liquid in the tank itself. At the same time that more or less gentle but thorough mixing is occurring in the tank, however, the slowly moving materials entering the respective mouths of the unit **12**, are, within the mixing unit, given a rapid acceleration and pass into the common discharge outlet, and the intake pipe **13** at very high velocity. It will be apparent that there will be three initially at least relatively independent relatively concentric columns of liquid passing into the common chamber **37**, and due to impingement and contact they will rapidly be transformed into a common merging mixed single stream entering pipe **13**, as a function of which, and of the passage through the pump, the materials are placed under high turbulence and intimate scrubbing action which establishes a most intimate mixing and blending. The eventual projection through jets **17**, **18** and **20**, removes the turbulence effects of the scrubbing by projecting high velocity discharge into the slow velocities in the tank, with components which are already highly mixed. It will be obvious that it takes but a comparatively short time for this hydraulic circulation alone to accomplish a most efficient and intimate blending and mixing of even very diverse materials of

appreciably different densities and of degrees of viscosity or fluidity.

In further explanation of the energetic mixing that occurs in the common chamber **37** of unit **12**, it will be apparent that there will be initially a solid column of high velocity discharge from mouths **27** and **32** and possibly **35**, but of these the only one which is directly vertical is the center one passing through cone **25**. The flow from passage **31** through mouth **32** has a lateral component causing transverse impingement against and intimate mixing with the vertical column from mouth **27**. Similarly, the flow through passage **36** is possessed of a much greater lateral component to impinge against and thoroughly mix with the compound stream from mouths **27** and **32**. The ultimate result is complete scrubbing and intermixing in a common single stream emerging from spout **34** into pipe **13**.

Mention has been made of the fact that the means for supporting the cones relative to each other in Figs. 4 and 5 may, if desired, be by means of "whirl-inducing" vanes or blades, and one form of these is shown in these figures. The blades need not be actual supports, of course, as it is merely necessary within the contemplation of the invention that liquid flowing through one or more of the several passages in the unit be given such rotative component as to assist and enhance the intimacy of mixing in the common chamber **37**. Thus, as shown in the noted figures, the cone **25** may be provided with a series, say, illustratively, of four sloping generally arcuate blades **38** arranged generally in the form of a helix so that liquid flowing axially downwardly will be given a rotative component, which, illustratively, will be clockwise, so that liquid flowing at high velocity from the delivery mouth **27** of the cone **25** will have a clockwise component as indicated by the arrow in full lines in all figures. Cone **25** and cone **28** will have a series, say, also illustratively, of four inclined blades or vanes **40** arranged to impart a rotative component to the accelerated flow passing out of the lower mouth **32** thereof as indicated by the dot and dash arrow in all figures. Preferably, the helical disposition of the blades **40** is such as to impart a counterclockwise component of rotation to the liquid flowing through passage **36** provided that the flow from cone **25** was clockwise. Finally, extending between the floor-disposed element **33** and the cone **28** is the series of arcuate inclined blades or vanes **41**, illustratively also, four in number, and which impart a clockwise whirl or component to the flow descending into the pipe **34** over the edge of mouth **35** as indicated in dotted arrows in all figures. It is preferable with this form of the invention that the helical blades be so disposed as to work on the entire body of liquid in the convergent spaces, starting at or adjacent to the mouth of the respective openings or entrances, and the effect of this is to start a helical whirl in the body of liquid in the tank adjacent to but external of the intake unit. This has the advantage of setting the liquid adjacent to one level of the intake unit to whirling in one direction in a small simulation of a vortex in a counter direction so as to start a further intimate admixture of the liquid in the tank itself adjacent to the unit by supplemental differential flows. While this is desirable under certain conditions of materials and times, in certain cases it is undesirable that there be any angular relative flows in the tank itself nor any other than those occasioned by establishment of a mul-

tiplicity of streams of varying velocities flowing toward and into the unit, as this latter is more gentle and less conducive to the formation of eddies and the like within the tank itself.

In a further modification, all flows within the tank are radial of the unit in the floor, while still obtaining the benefits of the enhanced scrubbing action of the impinging intersecting counter flows within the common chamber 37 of the unit, and this is shown in Figs. 6 and 7. In this form of the invention, as noted, the constriction of cones, and the mouths for entrance and discharge are the same as and bear the same reference characters as the analogous cones of the Figs. 4 and 5. In this case, however, the inner surface of the top central cone 25 has an entrance area of conducting surface 42 into which the liquid flows radially of the unit symmetrically about the periphery of the mouth 26 of the cone. Then the lower internal surface of the cone 25, in a relatively short bottom area 43, adjacent to mouth 27, has a plurality of short inclined blades or vanes 44 arranged to impart a rotational component to the flowing stream moving axially through the cone 25. This has the advantage of reducing the friction developed in the flow, and permitting straight radial flows into the central cone, while still imparting the desired whirl to the descending flow. Similarly, the next more obtuse cone 28 carries on its inner lower surface below a bare area 39 a plurality of inclined short vanes or blades 45, by which, after a straight untwisting radial entrance into passage 31, a rotational component is imparted to the flow. Blades 45 are preferably reversely inclined so that the imparted rotational component is preferably counter to that from cone 25. Finally, a similar bare area inducing radial flow is provided on surface 33, as at 46, while adjacent to the exit or discharge opening 35 thereof there are the respective inclined vanes or blades 47 of a series arranged to impart a rotational component to the liquid passing into the common discharge passage 37 through the entrance or passage 36.

It will be clear that if desired the blades or vanes of any length can be equally well attached to the under side of any cone as well as on the inner surface. Furthermore, it will be appreciated that the flow through the central cone 25 can be a straight vertical flow without a rotational component while the flow through the other channels or passages can be given rotational flows in relative opposition. Further, it will be apparent that if one descending column in chamber 37 only is given a rotational component enhanced mixing will ensue.

In conclusion, it will be evident that an improved mixing apparatus and process has been created herein by which agitation within the tank as by differential flows is kept within the bounds of safety consonant with Reynold's numbers for such viscous fluids as are contemplated herein to utilize most efficiently the mixing and blending characteristics of such differential flows within the tank or container, while the added high accelerations and intimate scrubbing, mixing and blending occurring within the unit and within the confines of the hydraulic system without undue accelerations within the body of liquid, will be appreciated. Furthermore, the advantages of the enhancement of the intimate mixing within the unit by having rotational components imparted to the flows, and especially those imparted in relative opposition within the unit will be appreciated. The fact that many modifications

and changes can be made within the teachings of the invention without departing from the spirit thereof and within the scope of the appended claims will also be appreciated, and such changes are to be construed as within the scope of the said invention.

Having thus described my invention, I claim:

1. A mixing device for liquids comprising a plurality of substantially concentric angularly divergent open-ended axially spaced nested truncated cones arranged to be relatively immersed in a body of liquid, with the large ends thereof arranged to receive slowly flowing streams of liquid in the said body thereof, and the small ends thereof delivering rapidly flowing streams of liquid into a common delivery conduit leading from the said body of liquid.

2. A mixing device for liquids in a tank comprising a hydraulic circulating system having an intake in the tank and having an outlet discharging into the tank, said intake comprising a stationary plurality of open-ended outwardly relatively divergent axially spaced truncated cones leading to a common mixing chamber substantially concentric with the cones, and means establishing communication between the chamber and the hydraulic system.

3. A mixing device for liquids in a tank comprising the intake for a stationary hydraulic system, comprising a plurality of substantially concentric axially spaced nested outwardly relatively divergent open-ended truncated cones each having one end comprising an entrance and the other end comprising a discharge outlet and, the discharge outlets of which are directed into a common fixed discharge outlet.

4. A mixing device for liquids in a tank comprising the intake for a hydraulic system, comprising a plurality of nested open-ended non-parallel truncated cones the discharge outlets of which are directed into a common discharge outlet, and means associated with the space between adjacent cones for imparting a rotational component to liquids passing between said cones.

5. A mixing device for liquids in a tank comprising a stationary intake unit for a circulatory system for the tank comprised of a pair of open-ended non-parallel truncated substantially concentric cones in spaced relation with the open upper ends at different levels and having different sizes of non-divergent entrances forming a plurality of passages into a relatively fixed common mixing chamber, and means defining such mixing chamber.

6. A mixing device for liquids in a tank comprising an intake unit for a circulatory system for the tank comprised of a pair of open-ended non-parallel truncated cones in spaced relation with the open upper ends at different levels and having different sizes of entrances forming a plurality of passages into a common mixing chamber, means defining such mixing chamber, and blades for imparting a whirl to liquids passing into the mixing chamber adjacent one of said cones.

7. A mixing device for liquids in a tank comprising an intake unit for a circulatory system for the tank comprised of a pair of open-ended truncated cones in spaced relation with the open upper ends at different levels and having different sizes of entrances forming a plurality of passages into a common mixing chamber, means defining such mixing chamber, and blades for imparting counter whirls to the streams passing adjacent each of two of the said cones respectively

to generate mixing turbulence in said mixing chamber.

8. A mixing device for liquids in a tank comprising a plurality of substantially concentric axially spaced guiding devices, the spacing of the guiding devices forming a plurality of inwardly convergent substantially conical passageways, the entrances to the several passageways being respectively of different sizes and located at different levels, means fixed relative to the guiding device and such tank defining a common passage for all of the passageways into which they each discharge fluids flowing into the entrances thereof.

9. A mixing device for liquids in a tank comprising a plurality of guiding devices, the guiding devices having a plurality of inwardly convergent substantially conical passageways, the entrances to the several passageways being respectively of different sizes and located at different levels, means defining a common passage for all of the passageways into which they each discharge fluids flowing into the entrances thereof, and means associated with one of the passageways for imparting a rotational component to fluid passing through it.

10. A mixing device for liquids in a tank comprising a plurality of guiding devices, the guiding devices having a plurality of inwardly convergent substantially conical passageways, the entrances to the several passageways being respectively of different sizes and located at different levels, means defining a common passage for all of the passageways into which they each discharge fluids flowing into the entrances thereof, means associated with one of the passageways for imparting a rotational component to fluid passing through it, and means associated with another of the passageways for imparting a rotational component to the fluid passing through it.

11. A mixing device for liquids in a tank comprising a plurality of guiding devices, the guiding devices having a plurality of inwardly convergent substantially conical passageways, the entrances to the several passageways being respectively of different sizes and located at different levels, means defining a common passage for all of the passageways into which they each discharge fluids flowing into the entrances thereof, means associated with one of the passageways for imparting a rotational component to fluid passing through it, and means associated with another of the passageways for imparting a rotational component to the fluid passing through it counter to the rotational component imparted to the first mentioned fluid stream.

12. A mixing system for liquids which comprises a receptacle for the liquids, means for circulating liquid at a high rate of flow from an entrance at one part of the receptacle to discharge into another part thereof, and means for securing relatively slow differential flows in the liquids in the tank passing toward said entrance to the circulating means whereby shearing stresses between contiguous particles are so minimized as to preclude the formation of eddies in the liquid in the tank, said last mentioned means comprising a plurality of angularly divergent and non-parallel substantially concentric axially spaced nested truncated conical guiding members discharging into a common concentric angular conduit comprising said entrance and communicating with the means for circulating the liquid.

13. A mixing system for liquids which comprises a receptacle for the liquids, means for circulating liquid at a high rate of flow from an entrance at one part of the receptacle to discharge into another part thereof, means for securing relatively slow differential flows in the liquids in the tank passing toward said entrance to the circulating means whereby shearing stresses between contiguous particles are so minimized as to preclude the formation of eddies in the liquid in the tank, and means in the entrance for converting the slow velocities of flow in the receptacle into high velocity flow in the circulating means only, said last mentioned means comprising a plurality of angularly divergent and non-parallel substantially concentric axially spaced nested truncated conical guiding members discharging into a common concentric angular conduit comprising said entrance and communicating with the means for circulating the liquid.

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