July 14, 1953 R. F. STEARNS 2,645,463

METHOD AND APPARATUS FOR CONTINUOUS FLOW MIXING

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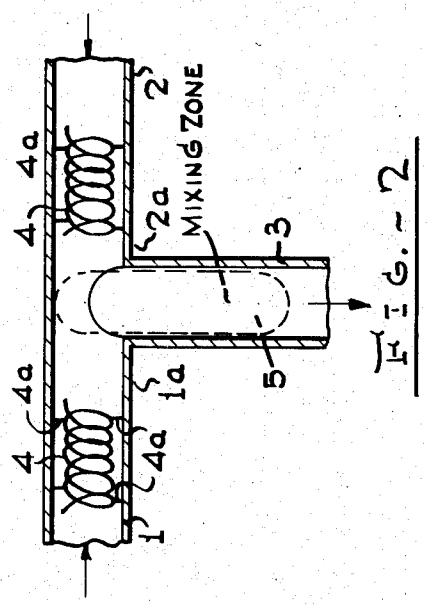

Fig. - 2

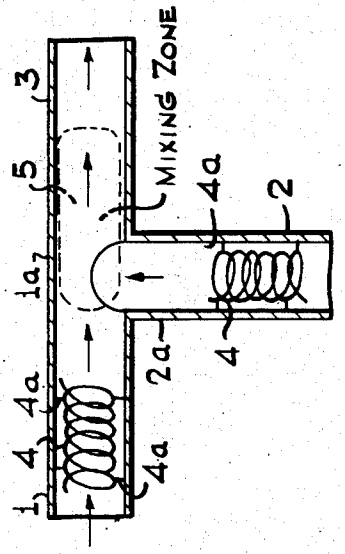

Fig. - 1

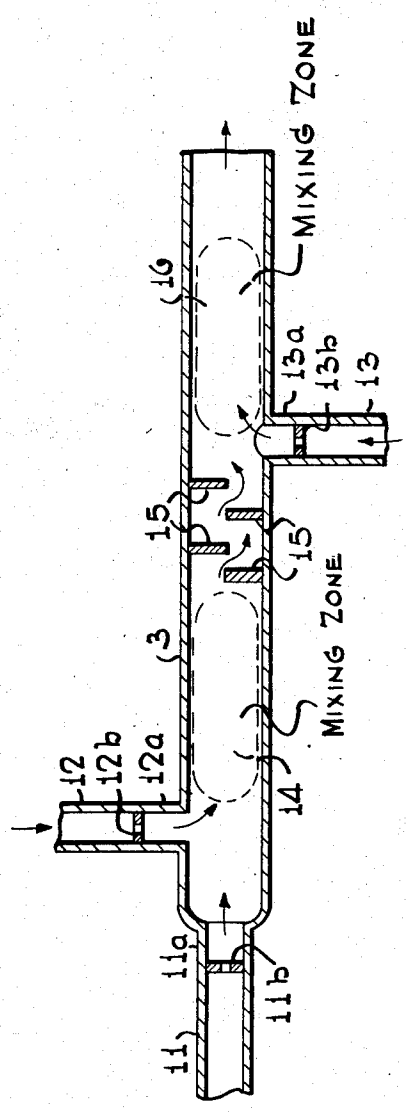

Fig. - 3

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METHOD AND APPARATUS FOR CONTINUOUS FLOW MIXING

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The present invention relates to a method and apparatus for continuous flow mixing, and, more particularly, to such method and apparatus in which mixing or blending is accomplished primarily by inducing turbulent flow in each of a plurality of streams of fluids immediately prior to the union of such streams in a common conduit.

In any mixing operation, the mixing action may be conceived of as taking place in two phases. The first phase consists of the rough inter-dispersion of the two components or rough distribution of one component in another, followed by a second phase in which the remaining concentration differences of the primary rough mixture are completely erased or "homogenized." In conventional mixing apparatus, mechanical means for accomplishing mixing action are normally utilized without regard for the dual nature of the operation, the initial distribution and subsequent "homogenization" being effected concurrently. The fluids to be mixed are brought together in the presence of mechanical mixing aids such as orifice plates, baffles, stirrers, and the like, and subjected to intensive churning and agitation as they are passed through the mixing apparatus. Ordinarily, little or no distinction in the method of operation is made between the handling of readily miscible materials and difficultly miscible materials, and, in fact, readily miscible materials may frequently be processed by means primarily suitable for creating dispersions of immiscible materials. Under such circumstances, it has been found that when immiscible fluids are being handled, the use of conventional methods and apparatus may result in problems of emulsion formation or inefficient and incomplete combination of the fluids. When miscible fluids are being handled, the conventional systems may result in inefficient application of power when mechanical mixing aids are used, or in slow blending rates in the absence of such mechanical aids.

It is an object of the present invention to provide a method and means for improving the characteristics of any system for mixing fluids with or without the utilization of secondary mixing means. Particular objects of the invention are to provide for better initial dispersion of difficultly miscible or immiscible liquids prior to a subsequent mechanical mixing step and to avoid overmixing of easily miscible materials with possible elimination or modification of secondary mixing devices.

The invention and its objects may be more fully understood from the following specification

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when read in conjunction with the accompanying drawings, in which

Figure 1 is a cross-sectional view through a line flow mixing apparatus according to the invention;

Figure 2 is a similar view through another form of the apparatus used; and

Figure 3 is a similar view through a modified form of apparatus.

Referring more specifically to the drawings, in Figures 1 and 2, the apparatus is illustrated at a T-branch conduit connection, in which the T-branch arm portions 1 and 2 are provided for introduction of the respective fluids to be mixed, and the T-branch arm portion 3 is a common conduit for said fluids, in which the mixing action takes place. As shown, each of the arm portions 1 and 2 is provided with a means for inducing turbulence in the stream of fluid passing through thhe respective arm portions. A means for inducing turbulence in the respective streams of fluid may be any conventional means such as baffles, orifice plates, spirals, or the like. As shown, such means consists of a spiral member 4 supported within each conduit in spaced relation to the conduit walls as by rods, arms, or link members 4a. The elements 4 are disposed in the conduits in spaced relation to their discharge end portions 1a and 2a, so that, upon entering the mixing zone, the flow of fluid from the conduits will have an optimum degree of turbulence. Preferably, the introduction of one stream of fluid into the other stream is accomplished as shown, at right angles to the line of flow of the other stream, and to the line of flow through the common conduit, but other methods or means for combining the streams may be employed. For example, the one turbulent stream may be fed into the other in substantially opposed or countercurrent relation, as through one arm of a Y-connection, or even in directly opposed relation, as illustrated in Figure 2. Mixing of the fluids takes place in the common conduit for said fluids. While such mixing may be substantially continued for the total length of such common conduit, particularly where difficultly miscible materials are being handled, in general, substantially complete mixing of the materials will take place in a zone extending from about the point of original contact of the turbulent streams discharged through conduits 1 and 2, to a point immediately beyond such contact point in the common conduit 3. This general mixing zone is indicated in Figures 1 and 2 by dotted lines and the numeral 5. A particular characteristic of

the apparatus as shown is the disposition of turbulence-inducing means in each individual conduit for fluids to be mixed at a point upstream from the point of contact of said fluids in a common conduit therefor, and immediately adjacent to such point of contact.

In the modified form of apparatus illustrated in Figure 3, the common conduit for fluids **3** is shown as provided for connection with three individual conduit elements **11**, **12** and **13**, having discharge end portions **11***a*, **12***a* and **13***a* respectively, opening into the conduit **3**. In the discharge end of each of the individual conduit elements is provided a means for inducing turbulent flow in the fluid stream passed through the respective elements. In the modification shown, such means for inducing turbulent flow is in the form of orifice plate members **11***b*, **12***b* and **13***b* respectively. In this modification, two fluid streams are first introduced into the common conduit **3** by way of conduit means **11** and **12** to be mixed in the zone **14**. Subsequent to mixing, the combined stream is passed through a means for inducing turbulent flow therein, as provided by baffle members **15** in the conduit **3** immediately prior to the point of introduction of a third fluid by way of line **13**. In effect, the baffle members **15** tend not only to induce turbulent flow in the combined stream passing through the conduit **3** immediately prior to the introduction of the third fluid through the line **13**, but also serve as a means for homogenizing the mixture of fluids produced in the mixing zone **14**, so that the fluid introduced by way of conduit **13** is combined in the conduit **3** with a substantially homogeneous fluid mixture rather than being added to a partially formed mixture of fluids previously introduced into the conduit. Additional fluids to be included in a final mixture may be introduced beyond the mixing zone **16** by provision of suitable conduit connections and turbulence-inducing elements comparable to those indicated by the numeral **15**. In either the apparatus, as shown by Figure 3, or that illustrated in Figures 1 and 2, the common conduit **3** may discharge either directly into a receiver for the mixed fluids, where readily miscible materials are being handled, or may be connected to a secondary mixing device for final homogenization of the fluid mixture, where substantially immiscible or difficultly miscible materials are being handled.

What is claimed is:

1. A method of continuous flow mixing, comprising passing each stream of a plurality of fluid streams to be mixed through a confined flow path for said stream, inducing turbulence in each of said streams during passage through said confined flow path therefor, producing a plurality of individual turbulent flow streams, and immediately thereafter combining said turbulent flow streams in a common, confined flow path as a single turbulent stream of fluid.

2. A method according to claim 1, in which said turbulent flow streams are combined by introducing one of said streams into another in a substantially opposed flow relationship.

3. A method according to claim 1, in which said turbulent flow streams are combined by introducing one of said streams into another substantially at right angles to the line of flow of said other stream.

4. Apparatus for continuous flow mixing of fluids, comprising a conduit for one of said fluids, a conduit for another of said fluids, said conduits each having a discharge end opening into a common conduit for said fluids, and turbulent flow inducing means in each of the conduits for the respective fluids to be mixed, said means disposed in substantially closely spaced relation to the discharge ends of said conduits opening into said common conduit for said fluids.

5. Apparatus according to claim 4, in which the conduit for one of said fluids is one arm of a T-branch conduit connection, the common conduit for said fluids is an opposite arm of said connection, and the conduit for another of said fluids is the third arm of said connection, having a discharge end opening at right angles into said first-mentioned T-branch arms at their juncture.

6. Apparatus for continuous flow mixing of fluids, comprising a common conduit for combined flow of a plurality of fluids, conduit means for introducing each of a plurality of fluids to be mixed into said common conduit, each of such conduit means having a discharge end portion opening into said common conduit, and turbulent flow inducing means in each of said conduit means for the respective fluids, disposed in the discharge end portions of said conduits immediately upstream from the opening of said discharge ends into said common conduit.

7. Apparatus for continuous flow mixing of fluids, comprising a common conduit for combined flow of a plurality of fluids to be mixed, individual conduit means for each of said plurality of fluids, each having a discharge end opening into said common conduit in spaced relation along the line of fluid flow therethrough, turbulent flow inducing means in each of said individual conduit means for said fluids to be mixed immediately adjacent and upstream from each conduit discharge end, and turbulent flow inducing means in said common conduit for the combined fluids disposed upstream from and immediately adjacent to the opening into said common conduit of the discharge end of an individual conduit means for one of the respective fluids to be mixed.

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