United States Patent

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[54] RAPID MIXER
9 Claims, 3 Drawing Figs.

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[51] Int. Cl. B01f 5/18
[50] Field of Search 137/604, 559; 239/419, 419.3, 424.5, 426, 430, 431; 259/4

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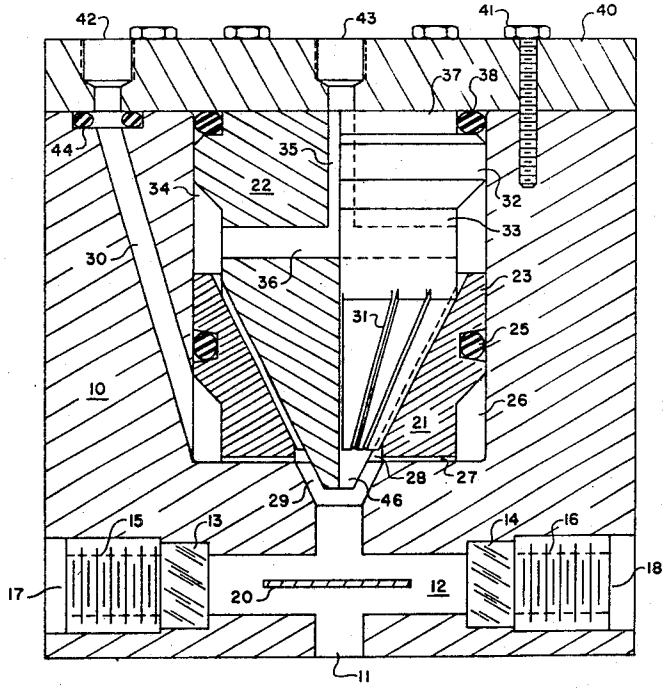
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ABSTRACT: A mixer of the type comprising two sets of jets discharging into a small mixing chamber, one set being disposed to discharge at points adjacent discharge points of the other set, the one set being formed by radial grooves on the end of a cylindrical body placed inside a smooth counterbore in a main body concentric with a bore which leads to a cuvette formed as an integral part thereof. The second set is formed by grooves on a frustum of a cone inserted into a smooth conical counterbore in the cylindrical body concentric with a bore therein which forms the mixing chamber.



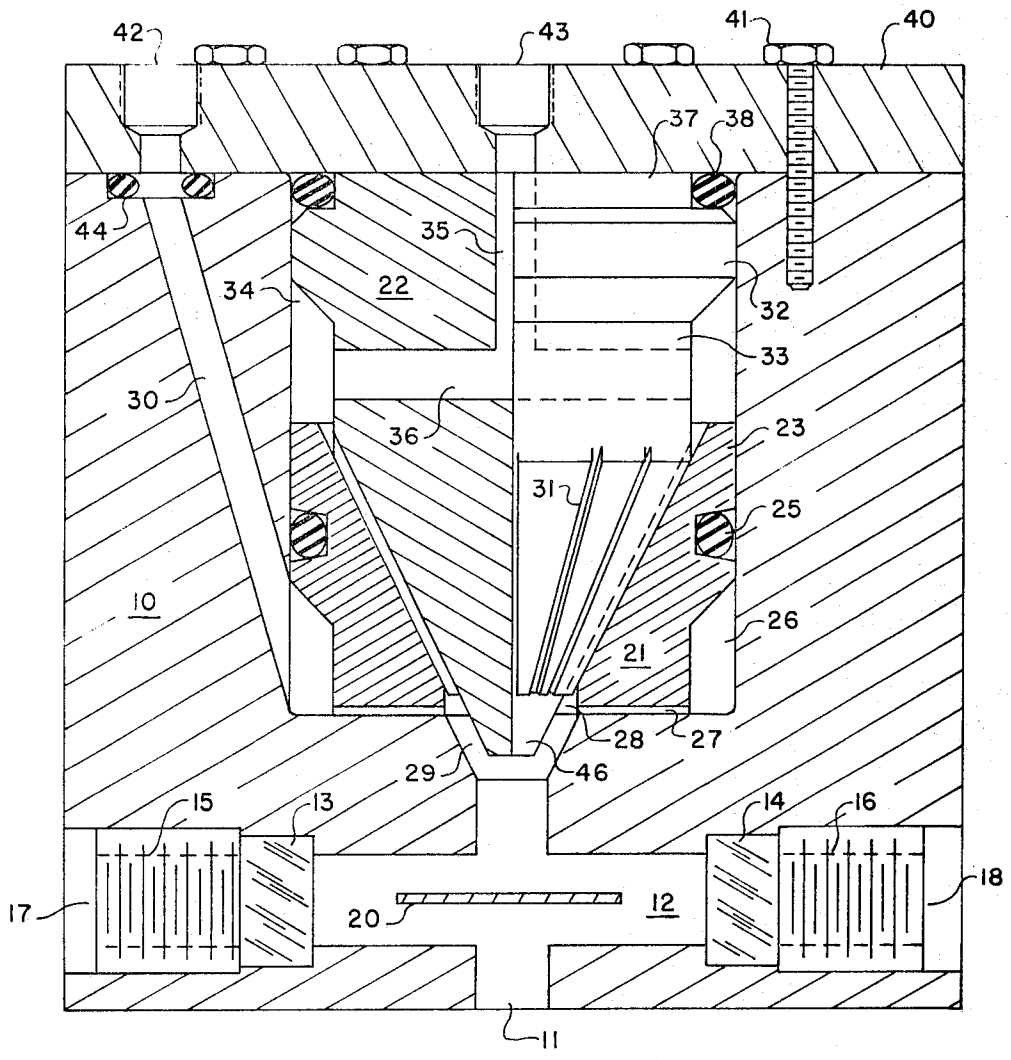


FIG 1

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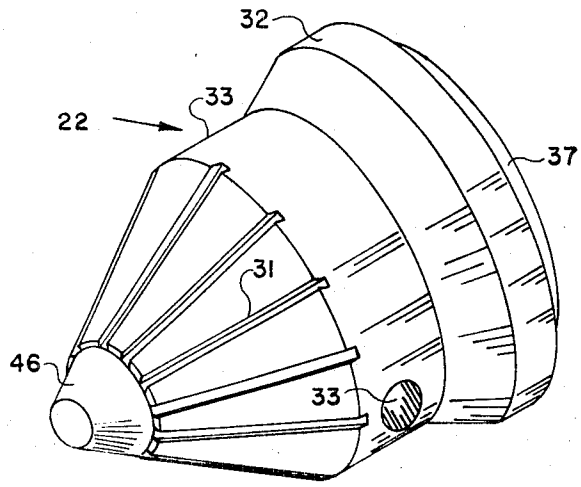


FIG 3

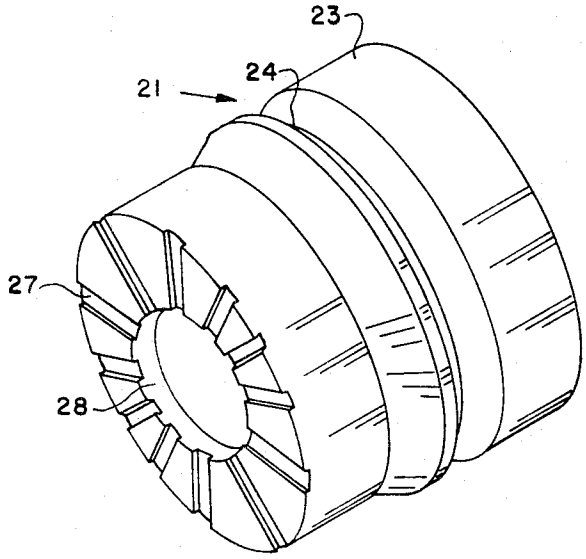


FIG 2

RAPID MIXER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a rapid mixer for a stop flow reaction kinetic system of the type disclosed in U.S. application Ser. No. 706,351 filed Feb. 19, 1968, by Harry A. Penhasi and assigned to the assignee of the present invention.

2. Description of the Prior Art

Performance of a stop flow reaction kinetic system is dependent upon both the efficiency with which reactants are rapidly mixed and the reproducibility of the system as a whole, including the mixing of the reactants. In the past, mixers of many types have been employed, the most simple of which consists of a T connection into which the reactants are driven at high velocity. A more complex type includes means for developing turbulence downstream from a T connection. Even more complex mixers have employed T's with multiple jets and T's provided with offset nozzles. Other mixers have been made with concentric annular nozzles, and more recently with a bundle of plastic tubes through which one liquid is passed while the second solution is introduced through the interstices of the tubes in the bundle, almost perfect mixing taking place at the immediate outlet of the tubes. A mixer of that more recent type is most difficult to fabricate from plastic such as Kel-F because it is most difficult to draw such tubes into a bundle of closely spaced small orifices. Fabricating one with glass tubes is more practicable but systems for mounting and connecting to it would be complex and expensive to manufacture. Moreover, sometimes it would be desirable to fabricate the mixer with metal tubes because of the nature of the reactants to be used, and such metal tubes would be as impracticable as tubes made from plastic, such as Kel-F.

SUMMARY

The subject of the present invention is a mixer of the type in which two sets of jets for two reactants to be mixed are brought into a small mixing chamber at high velocity. One set of jets is formed by radial grooves in a first body placed against a smooth mating surface of a second or main body (or vice versa) such that a first fluid is discharged into a bore through the center of the first body. That bore forms the mixing chamber. The other set of jets is formed by radial grooves in a third body so placed against a smooth mating surface of a counterbore in the first body (or vice versa) that a second reactant is discharged through the second set of grooves directly into the bore or mixing chamber. In a preferred embodiment, the first body consists of a cylinder with the first set of radial grooves at one end thereof and the second or main body consists of a block with a bore leading away from the mixing chamber and a concentric smooth counterbore into which the first body is inserted. The first body is provided with a diameter just under the diameter of the counterbore in the main body and with an O-ring in an annular groove for sealing the first body in the counterbore. An annular space is provided between the sealed end of the first body and the counterbore of the main body by a portion of the first body (at the end with the radial grooves which is first inserted into the counterbore) having a reduced diameter. Access to that annular space is provided by a passage through the main body. The third cylindrical body has a diameter just under the diameter of the counterbore in the main body so that it may be inserted into the counterbore of the main body just behind the first body. The counterbore in the first body is in the form of a frustum of a cone. Thus, when the third body is inserted into the counterbore of the main body with its conical end in the counterbore of the first body, jets are formed by the grooves of the third body against the mating smooth surface of the first body which discharge directly into the mixing chamber at an angle with the first set of jets which are formed by grooves on a flat surface on the end of the first cylindrical body. The third body is further provided with a tip in the form of a frustum of a cone having a base with a radius equal to the radius at the end of the third body to which it is attached. That tip protrudes into the mixing chamber in order to reduce the volume thereof. The bore in the main body leading away from the mixing chamber connects directly with a cuvette formed as an integral part of the main body in order to reduce to a minimum the distance (time) the mixed reactants must travel before their reaction can be observed. The second reactant is introduced into an annular space between a reduced diameter portion of the third body and the wall of the counterbore in the main body into which the first and third bodies are sequentially inserted. A passage through the third body to that annular space is provided to introduce the second reactant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of the assembled component parts of the preferred embodiment of the present invention.

FIG. 2 is an isometric view of a first principal part of the assembly shown in FIG. 1.

FIG. 3 is an isometric view of a second principal part of the assembly disclosed in FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 discloses in a sectional view an assembled mixer and cuvette assembly comprising a main body **10** having an exit bore **11** and a cross-drilled bore **12** the ends of which are sealed by quartz windows **13** and **14** secured in place by hollow nuts **15** and **16** threaded into counterbores **17** and **18**. Mixed reactants enter the lateral cuvette bore from a mixing chamber above and flow around a baffle **20** placed in the lateral cuvette bore in order that the mixed reactants will more readily fill the lateral bore **12** for observation, although it should be understood that the mixer and cuvette assembly is intended for use in a stopped flow reaction kinetic system so that once reactants of sufficient volume to fill the c uvette have been introduced into the mixer, flow through the bore **11** is stopped by means (not shown) connected thereto. Following the observation, the spent mixture is drained from the cuvette through the lower end of the bore **11**.

The mixer assembly comprises a counterbore in the body **10** concentric with the bore **11**, a first cylindrical body **21** more clearly shown in an isometric view in FIG. **2**, and a second cylindrical body **22** more fully shown in an isometric view in FIG. **3**. The first cylindrical body **21** has a portion **23** of a diameter just under the diameter of the counterbore in the body **10** into which it is inserted as shown in FIG. **1**. That portion of the cylindrical body **21** is provided with an annular groove **24** (FIG. **2**) for an O-ring **25** (FIG. **1**) to seal a space **26** between the cylindrical body **21** and the bottom of the counterbore in the body **10**. That space is provided by reducing the diameter of the cylindrical body **21** at the end thereof which mates with a smooth surface at the bottom of the counterbore as shown in FIG. **1**.

The cylindrical body **21** is provided with a plurality of radial grooves **27** only a few of which have been shown in FIG. **2** for clarity. When cylindrical body **21** is inserted into the counterbore of the body **10** as shown in FIG. **1**, the radial grooves **27** form a set of jets through which a reactant is introduced into the mixing chamber comprising a bore **28** in the body **21** connected to the bore **11** by a conical-shaped counterbore **29** in the body **10**. The annular space **26** between the conical body **21** and the main body **10** serves as a manifold for supplying a reactant to the radial jets formed by the grooves **27** against the smooth mating surface of the counterbore in the main body **10**. The reactant is introduced into that space **26** under high pressure through a bore **30** in the main body **10**.

The cylindrical body **21** is provided with a conical counterbore concentric with the bore **28** (mixing chamber), and the cylindrical body **22** is formed at the lower end thereof in the shape of a frustum of a cone which exactly mates with the conical counterbore in the cylindrical body **21**. Grooves **31** are provided on the surface of that conical end of the cylindrical body **22** so that when it is inserted into the smooth conical

counterbore of the cylindrical body 21, radial jets discharging into the mixing chamber (bore 28 in the body 21) are provided.

The cylindrical body 22 is provided with a portion 32 having a diameter just under the diameter of the counterbore in the main body 10. A portion 33 of lesser diameter is then provided between the grooves 31 and the portion 32 to leave an annular space 34 to serve as a manifold for the radial jets formed by the grooves 31. A second reactant is introduced into space 34 under high pressure through a bore 35 and a lateral bore 36 in the body 22. Another portion 37 of reduced diameter is provided on the cylindrical body 22 above the portion 32 in order to provide an O-ring 38 as shown in FIG. 1 to seal the space 34 in the counterbore of the main body 10.

A retaining block 40 is fastened to the main body 10 as by screws 41 to so apply sufficient pressure on the cylindrical bodies 21 and 22 that their respective grooved surfaces will seat tightly against the mating smooth surfaces of the main body 10 and the cylindrical body 21, respectively. The retaining block 40 is provided with bores 42 and 43 communicating with respective bores 30 and 35. Each of the bores 42 and 43 are threaded to receive high pressure fittings for tubes conveying reactants thereto. A counterbore is provided for the bore 30 to receive an O-ring 44. A corresponding counterbore and O-ring is not necessary for the bore 35 since the O-ring 38 will provide an adequate seal not only for the space 34 but also for the bore 43.

It should be noted that although particular geometry has been illustrated for the surfaces on which radial jet forming grooves are provided, other geometries may be selected for one or both surfaces such as spheres, parabaloids, and the like. The geometry for the grooves themselves is also selectable over a wide range such as straight and radial as illustrated, straight and tangential, or curved. The grooves may also be of various length rather than of uniform lengths as illustrated; and of nonuniform cross sections rather than of uniform cross sections as illustrated. In addition, it should be appreciated that the mixer for more than two reactants may be provided in accordance with the teachings of the present invention such as by providing additional concentric bodies. For instance, instead of introducing the reactant into space 34 through the center of the cylindrical body 22, a second bore through the main body 10 may be provided to that space, leaving the center of the cylindrical body 22 available for providing a cylindrical bore therethrough with a cylindrical body having axial grooves to provide a third set of jets discharging directly into the mixing chamber 28.

Although mixing takes place primarily in the bore 28 of the cylindrical member 21, it should be noted that mixing may not be completed immediately even though mixing is more instantaneous than in some of the prior art designs employing T junctions or tangential jets into a round chamber. Accordingly, some delay is purposely introduced for the delivery of the mixed reactant into the cuvette bore 12 by the conical counterbore 29 leading into the bore 11. A tip section 46 in the shape of a frustum of a cone is provided on the cylindrical body 22 to extend through the mixing chamber 28 in order to not only reduce the volume of the mixing chamber but also direct the mixed reactants through the conical counterbore in the body 10 and the bore 11 through which the mixture is introduced into the cuvette bore 12. However, it should be recognized that such a tip section is not essential to the present invention in its broadest aspects and that the conical counterbore 29 is also not essential. Instead, the bore 11 extending through the cuvette bore 12 in the body 10 may be further extended with a uniform diameter to the counterbore in the body 10 holding the cylindrical bodies 21 and 22, in which case the mixed reactants will be confined to the mixing chamber 28 for a longer period of time before entering the bore 11 leading into the cuvette bore 12. The delay in introducing the reactants into the cuvette bore 12 by confining the mixed reactants to the mixing chamber 28 for a slightly greater period will allow placing the cuvette bore 12 slightly closer to the mixing chamber 28.

Although the principles of the invention have been disclosed with reference to a preferred embodiment in which the smooth mating surfaces are on the body containing a counterbore, it should be obvious to those skilled in the art that the grooves may be provided on the opposing body instead, or that some grooves may be provided on one body and other grooves, such as alternate ones, on the other body.

I claim:

1. A mixer of the type comprising first and second sets of jets for two liquids to be mixed discharging into a small mixing chamber defined by a first bore in a generally cylindrical first body, said first set of jets being formed by a first set of radial grooves in said cylindrical first body placed against the smooth mating surface of a first counterbore in a second body such that a first fluid is discharged at the center thereof through the first set of grooves into said mixing chamber, the diameter of the first cylindrical body at one end thereof being less than the remainder thereof with the greater diameter being just under the diameter of said first counterbore and the grooves of the first set of jets at the lower diameter end thereof being juxtaposed to the bottom of the first counterbore, a passageway in said second body and communicating with the outside thereof, a first annular space between said counterbore wall and the lesser diameter portion of said first cylindrical body connected to said passageway, said passageway and said annular space forming a conduit through which said first fluid is introduced simultaneously into said first set of grooves, a second set of jets being formed by a second set of radial grooves in a third body placed against a smooth mating surface of said first body, a second annular space between said first and third bodies through which said second fluid is introduced simultaneously into said second set of grooves, and a second bore in said second body concentric with the first bore in said first body forming an exit passageway from said mixing chamber.

2. A mixer as defined in claim 1 wherein there is provided a second counterbore in said first cylindrical body concentric with the bore therein forming said mixing chamber and said smooth mating surface of said third body forming said second set of jets is formed by one of a pair of opposing surfaces in said second counterbore.

3. A mixer as defined in claim 2 wherein the portion of said first cylindrical body having the greater diameter includes an annular groove with an O-ring therein to seal said first annular space between said first counterbore wall and a portion of said first cylindrical body of less diameter.

4. A mixer as defined in claim 3 wherein said third body is cylindrical with the grooves formed therein at the bottom thereof and cooperating with said second counterbore in said first body to form said second set of jets, the diameter of said third body at the one end thereof being less than the remainder thereof, the greater diameter being just under the diameter of said first counterbore into which said third body is inserted, the portion of greater dimension having an annular groove and an O-ring therein to seal a second annular space between the wall of said first counterbore and the portion of lesser diameter of said third body, and wherein there is provided a passage from the outside of said first and third bodies to said second annular space.

5. A mixer as defined in claim 4 wherein the bottom of said first counterbore forms a flat surface in a plane normal to the axis of the bore which comprises the mixing chamber, and the grooves in said first body lie in a plane normal to said axis of the bore comprising the mixing chamber.

6. A mixer as defined in claim 5 wherein said second counterbore is in the shape of a frustum of a cone, and the end of said third cylindrical body inserted therein to form said second set of jets is also in the shape of a frustum of a cone.

7. A mixer as defined in claim 6 wherein said end of said third body inserted into said second counterbore is provided with an extension thereof in the shape of a frustum of a cone protruding into said bore comprising said mixing chamber whereby the volume of said mixing chamber is substantially reduced.

8. A mixer as defined in claim 7 wherein said second body includes a cuvette in direct communication with said mixing chamber through said bore therein concentric with the bore forming said mixing chamber.

9. A mixer as defined in claim 3 wherein said second body includes a cuvette in direct communication with said mixing chamber through said bore therein concentric with the bore forming said mixing chamber.