

[54] **STATIC MIXING DEVICE**

[75] Inventors: **Charles Edward Nelson**, White Bear Lake; **Clifford L. Jewett**, Minneapolis, both of Minn.

[73] Assignee: **Minnesota Mining and Manufacturing Co.**, St. Paul, Minn.

[22] Filed: **Nov. 16, 1973**

[21] Appl. No.: **416,604**

[52] U.S. Cl. .... **259/4, 138/42**  
 [51] Int. Cl. .... **B01f 5/00**  
 [58] Field of Search ..... 259/4, DIG. 30; 138/42, 138/43; 48/180 R, 180 B, 180 M; 239/432

[56] **References Cited**  
**UNITED STATES PATENTS**

2,894,732 7/1959 Taber..... 259/4

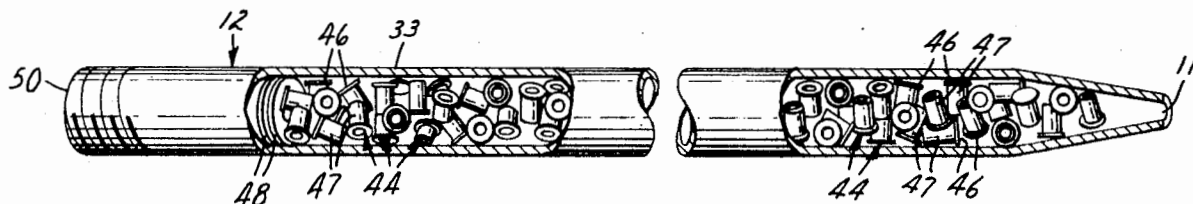
3,378,234 4/1968 Svec..... 259/4  
 3,468,637 9/1969 Hammond ..... 289/4 X

*Primary Examiner*—Harvey C. Hornsby  
*Assistant Examiner*—Alan Cantor  
*Attorney, Agent, or Firm*—Alexander, Sell, Steldt & DeLaHunt

[57] **ABSTRACT**

A static in-line mixing tube for mixing a plurality of fluids during their passage through the tube comprises a hollow tube packed with shaped pieces, each comprising a disc having at least one projection perpendicularly attached thereto.

**4 Claims, 3 Drawing Figures**



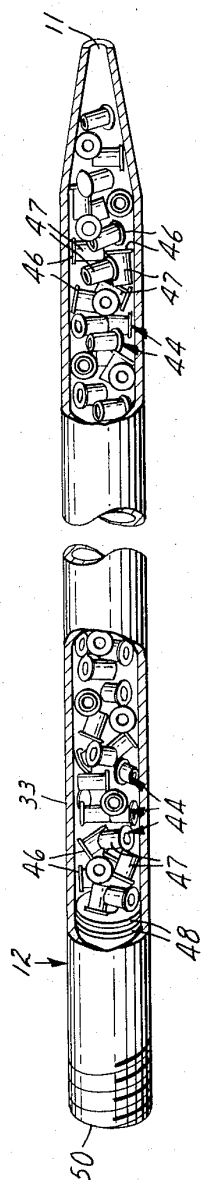


**FIG. 2**

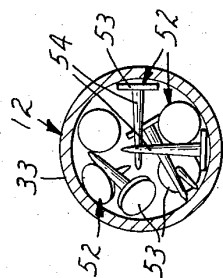


**FIG. 3**

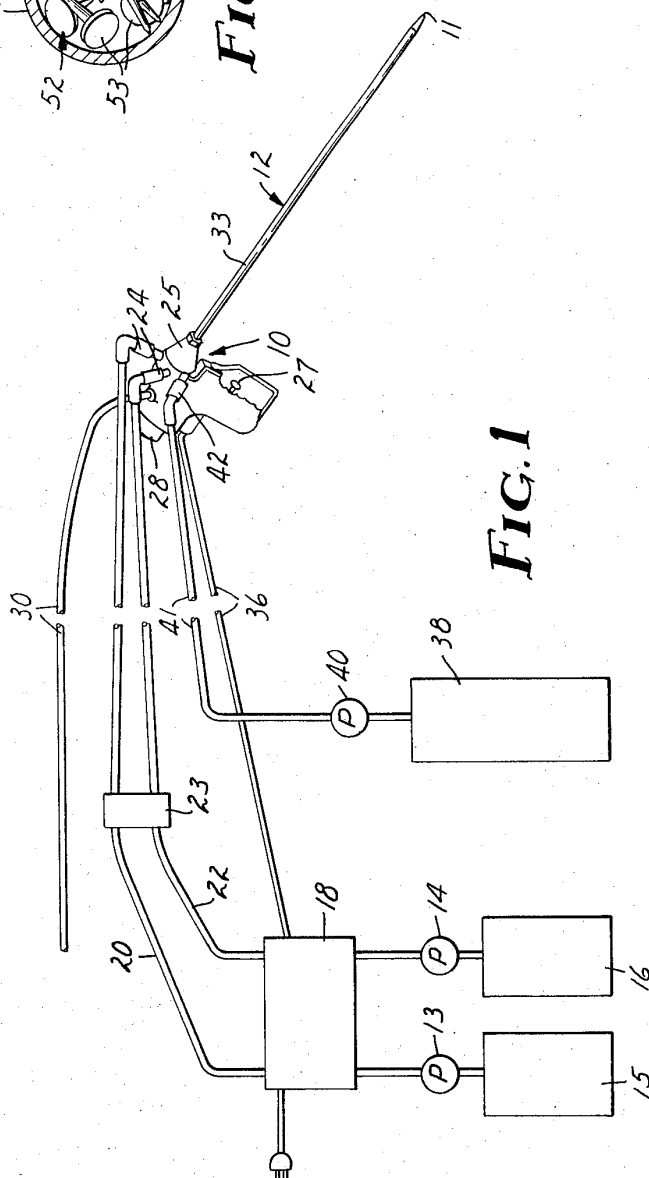


**FIG. 1**

# STATIC MIXING DEVICE

## BACKGROUND OF THE INVENTION

This invention relates to tubes for mixing and distributing fluids.

Static devices suitable for mixing fluids are known. Such devices include helical mixers where a single or double helix is disposed in a cylindrical mixing chamber. Helical mixers have a low pressure drop through the mixing tube but have a tendency to plug on one side during use thereby shortening the life of the tube.

A further class of mixing tubes are those tubes packed with particulate material, e.g., glass beads or shavings. Such tubes may provide thorough mixing, but the pressure drop through these tubes is excessive and the delivery rate of mixed material is low when mixing viscous fluids.

Also known are mixing tubes having other complex shaped mixing elements within the tube. Splitting and recombining means are shown in U.S. Pat. No. 3,051,453, and a "bow tie" shaped mixing element is disclosed in U.S. Pat. No. 3,286,992. These devices provide thorough mixing at an acceptable pressure drop; however, expensive fabrication techniques are required to make the mixing elements and the resulting mixing tubes are expensive. Also, these tubes can plug along one side resulting in poor mixing, without giving evidence of the defect, causing poor quality products until the defect is later discovered.

## BRIEF SUMMARY OF THE INVENTION

We have discovered a mixing tube which provides an unexpectedly thorough mixing of viscous resin components with a high flow rate and which is inexpensive, disposable and easily fabricated.

The device of the present invention comprises a hollow, cylindrical tube filled with a plurality of packed shaped pieces. The pieces have a generally circular disc shaped portion having a projection perpendicularly attached thereto, said projection being located near the center of the disc. The diameter of the disc is greater than about 0.25 but less than about 0.9 of the internal diameter of the mixing tube. The length of the projection is greater than about 0.25 but less than about 0.75 of the internal diameter of the tube.

## BRIEF DESCRIPTION OF THE DRAWING

A further understanding may be had by referring to the accompanying drawing, wherein like reference numerals refer to like parts and in which:

FIG. 1 is a perspective view of a system utilizing the mixing tube of this invention;

FIG. 2 is a perspective view in partial section of one embodiment of the mixing tube of this invention filled with one type of piece; and

FIG. 3 is a transverse section through a tube of this invention filled with a second type of piece.

Referring to the accompanying drawings and initially to FIG. 1, a mixing gun 10, having a mixing tube 12 attached thereto, is supplied with resin components pumped by pumps 13, 14 via lines 20, 22 from containers 15, 16. The resin components are mechanically metered by metering device 18, in a predetermined proportion and warmed by heater 23 to a suitable reaction temperature. The components then pass into manifold 25 of gun 10 and then into mixing tube 12 where the

various components are thoroughly mixed and dispensed via nozzle 11.

In greater detail, components of the two-part resin system to be mixed are pumped by pumps 13, 14 from reservoirs 15, 16 into metering device 18. The metered flow of components in lines 20, 22 is heated at heater 23 to the proper reaction temperature thereby insuring a rapid reaction when mixed and passes through check valves 24, which prevent backward flow, and into manifold 25.

When trigger 27 is depressed, a needle valve (not shown) is opened by an air operated cylinder 28, supplied with compressed air by line 20, and metering device 18 is activated via electrical line 36. The pressure from material entering manifold 25 forces the resin components into mixing tube 12 where they are thoroughly mixed and extruded through nozzle 11.

To clean mixing tube 12, pump 40 forces solvent from container 38 through line 41, check valve 42 into manifold 25 and thence through mixing tube 12. The solvent will clean the manifold and mixing tube of resin components.

FIG. 2 shows mixing tube 12 in greater detail. The tube contains a plurality of shaped pieces 44, each having a rim portion 46 and a tubular projection 47 perpendicularly attached thereto. Two washers 48 are positioned near entry end 50 of tube 12. These washers force the resin components to the center of the mixing tube thereby helping to insure a thorough mixing of the components. As the resin components pass through mixing tube 12, the streams of resin components are constantly being separated and recombined by passing over and through pieces 44, resulting in a thorough mixing of the resin components.

FIG. 3 shows a mixing tube filled with shaped pieces 52 each piece having a disc portion 53 and a solid projection or stud 54.

The cylindrical tube used in this invention may be constructed of various materials such as aluminum, steel, brass, glass, thermoset materials, and the like which are strong enough to withstand the pressure generated during mixing, such pressures being on the order of 50 to 300 psi. A preferred class of materials are the metals, especially aluminum which provide high strength, low weight tubes.

The shaped pieces which are packed in the tube can be formed in various shapes and have projections perpendicularly attached to the disc portion. The projections are attached near the center of the disc to assure substantially random packing. A preferred, shaped piece is a metal eyelet having a flared end which forms a disc and a hollow projection perpendicularly extending from the disc portion. The projection has a bore which communicates with an aperture in the disc and allows resin components to flow over, around and through the shaped pieces. The metal eyelets are inexpensive, readily available, and provide good mixing at high flow rates. Ordinary upholstery tacks, such as standard sizes 2, 3, 4 and 5 have also been found useful as shaped pieces because of their low cost, ready availability and uniform size. They provide good mixing but have a lower flow rate for a given pressure drop than eyelets. The shaped pieces can be formed from various materials, e.g., plastic or metal, which will not deteriorate upon exposure to the fluids being mixed and will not collapse at the operating temperatures, e.g. 100°-150°C., or pressures, e.g., 50-300 psi, used.

The disc portion of the piece will have a diameter somewhat less than the inner diameter of the mixing tube the minimum disc diameter being about 0.25 and the maximum diameter being about 0.9 of the tube's inner diameter. Discs with diameters below about 0.25 pack so tightly the pressure drop becomes excessive and the flow rate decreases, while discs above about 0.9 times the inner diameter constrict the flow rate of the resin components.

The projection from the disc will generally have a length of about 0.25 to 0.75 times the inner diameter of the mixing tube. Lengths less than about 0.25 allow the pieces to pack so tightly the pressure drop becomes excessive while above 0.75 the pieces do not pack randomly enough to insure thorough mixing of the fluids being mixed.

The preferred pieces are eyelets where the disc portion has a diameter of about 0.4 to 0.65 times the inner diameter of the mixing tube and a projection length of

in diameter. The tubes were packed with shaped pieces. Two washers having an aperture of 0.25 inch were inserted at the inlet end about 1.5 inches from the inlet end of the mixing tube.

A two-part resin comprising:

| A                                                                                                       | B                                                                    |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| a polyol containing pigments, fillers and a urethane catalyst, having a viscosity of 50,000 centipoise; | a polyisocyanate ("Mondur" MRS) having a viscosity of 600 centipoise |

was pumped at a ratio of 6 parts A to 1 part B into the entry end of the mixing tubes under 250-300 pounds per square inch pressure. The dimensions of the shaped pieces, pressure drop, flow rate and mixing quality are tabulated in TABLE I.

TABLE I

| Sample | Type of Pieces         | Pressure Drop in P.S.I. | Flow Rate in Gms/Min. | Piece Dimension in Decimals of The Internal Diameter of The Tube Disc Projection |     | Mixing Quality |
|--------|------------------------|-------------------------|-----------------------|----------------------------------------------------------------------------------|-----|----------------|
| 1      | None                   | 7                       | 600                   | —                                                                                | —   | Minimal        |
| 2      | No. 2 Upholstery Tacks | 150                     | 168                   | .83                                                                              | .67 | Excellent      |
| 3      | Eyelets                | 190                     | 174                   | .27                                                                              | .42 | Excellent      |
| 4      | do.                    | 150                     | 291                   | .40                                                                              | .42 | Excellent      |
| 5      | do.                    | 90                      | 378                   | .53                                                                              | .42 | Excellent      |
| 6      | do.                    | 50                      | 552                   | .65                                                                              | .42 | Excellent      |
| 7      | do.                    | 60                      | 492                   | .77                                                                              | .42 | Fair           |
| 8      | do.                    | 70                      | 492                   | .91                                                                              | .42 | Fair           |
| 9      | do.                    | 140                     | 291                   | .53                                                                              | .25 | Excellent      |
| 10     | do.                    | 115                     | 360                   | .53                                                                              | .33 | Excellent      |
| 11     | do.                    | 85                      | 384                   | .53                                                                              | .56 | Excellent      |
| 12     | do.                    | 80                      | 441                   | .53                                                                              | .6  | Good           |
| 13     | do.                    | 80                      | 468                   | .53                                                                              | .66 | Good           |
| 14     | do.                    | 75                      | 459                   | .53                                                                              | .75 | Fair           |

about 0.30 to 0.60 times the inner diameter of the mixing tube. Eyelets with these dimensions provide excellent mixing at low pressure drops and give good flow rates.

One application of the mixing tube of this invention is for mixing two part resin compositions such as those used in patching plywood. The components of such resins often have widely varying viscosities and consequently thorough mixing of these resins is a problem. One particular example of a patching resin is filled polyurethane, which is produced by reacting a polyol and an organic polyisocyanate in approximately stoichiometric amounts in the presence of a suitable catalyst. The resins can also contain fillers, e.g., glass bubbles, clay, pigments, fibers, resin stabilizers and the like.

Other classes of plural component resin systems which can be easily and readily mixed using the mixing tube of this invention include epoxies, polysulphides, polyesters and polyisocyanurates.

The invention is further explained by reference to the accompanying nonlimiting Example in which all parts are by weight, unless otherwise specified.

## EXAMPLE

Mixing tubes 13½ inches long were made from aluminum tubing having an outer diameter of 0.5 inch and an inner diameter of 0.375 inch. A nozzle portion was swaged at the exit end to provide an orifice 0.16 inch

As shown in the table, shaped pieces with a disc or circular rim diameter of about 0.25 to 0.9 times the inner diameter and a projection or tube length of about 0.25 to 0.75 times the inner diameter provide good mixing tubes. Those pieces having a disc diameter of about 0.4 to 0.65 and a projection of about 0.3 to 0.6 times the inner diameter provide good mixing at low pressure drops and high flow rates.

What is claimed is:

1. A static device for mixing a plurality of fluids comprising:

a hollow cylindrical tube having an inlet and an outlet; and

a plurality of shaped pieces filling said tube, said pieces comprising a circular disc having perpendicularly attached thereto at least one projection, the diameter of said disc being about 0.25 to 0.9 times the inner diameter of said tube and the length of said projection being about 0.25 to 0.75 times the inner diameter of said tube.

2. The device of claim 1, where said tube has at least one constriction in the inner diameter near the inlet of said tube.

3. The device of claim 1, where said shaped pieces are eyelets having an aperture in said disc in fluid communication with a bore in said projection.

4. The device of claim 1, where said disc has a diameter of about 0.4 to 0.65 times said inner diameter and said projection has a length of about 0.3 to 0.6 times the inner diameter of said tube.

\* \* \* \* \*