United States Patent

[11] 3,623,704

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[21] Appl. No. 60,465
[22] Filed Aug. 3, 1970
[45] Patented Nov. 30, 1971

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[54] STATIC MIXING DEVICE
8 Claims, 5 Drawing Figs.

[52] U.S. Cl. 259/4
[51] Int. Cl. B01f 15/04
[50] Field of Search 259/4, 18, 36, 60; 222/137

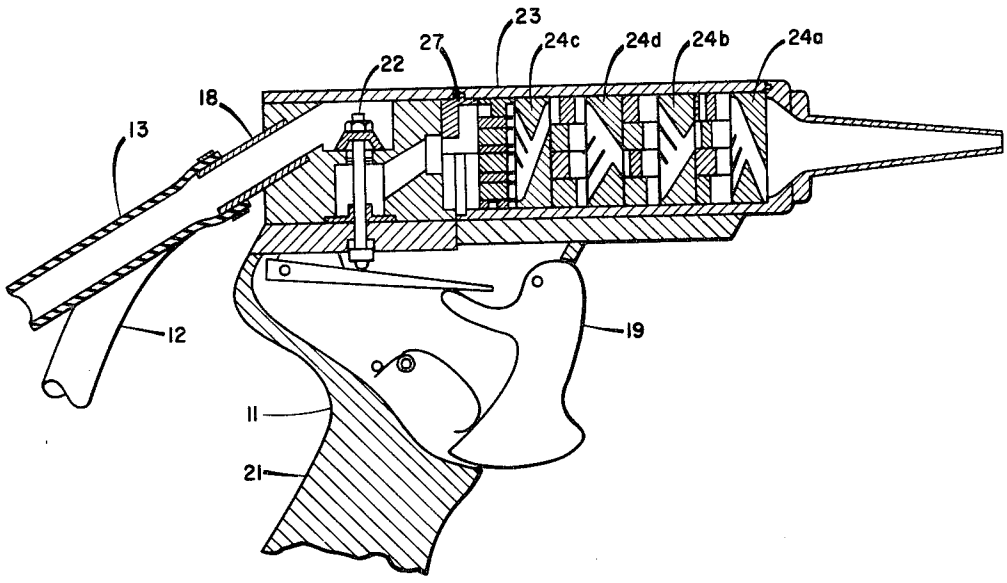
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ABSTRACT: A static mixing device for mixing two liquid components by sequentially combining, dividing and recombining streams including a sequential series of sets of parallel dividing and recombining elements, each element having a single point of entry or exit at one end and multiple points of exit or entry on its opposite end, all liquid paths through each element having substantially equal mean lengths. The device may be made extremely small and is adapted for hand-held operation.



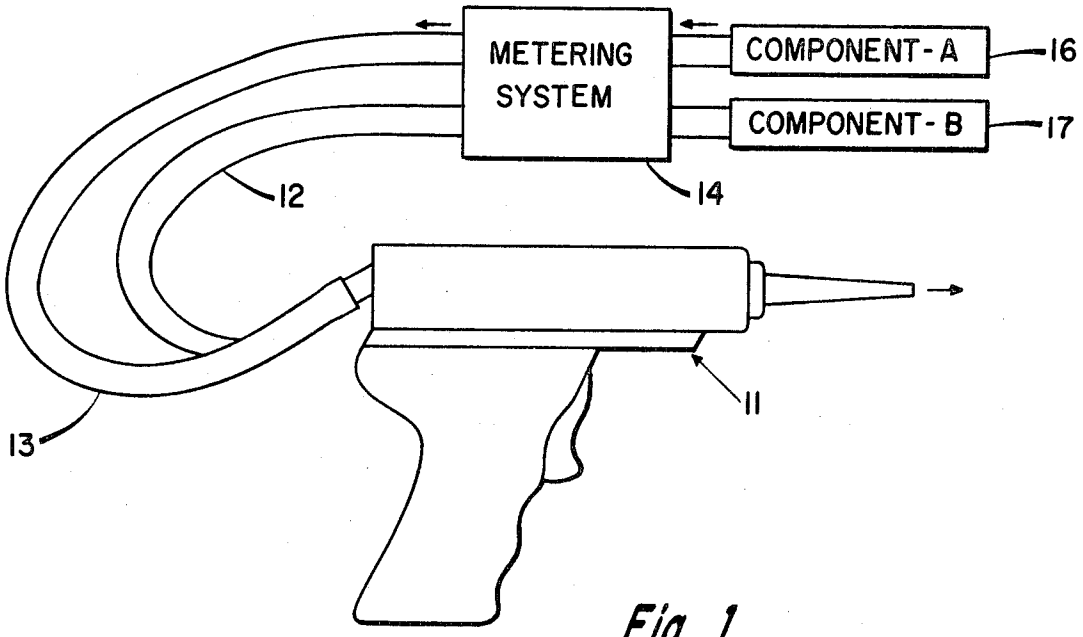


Fig. 1

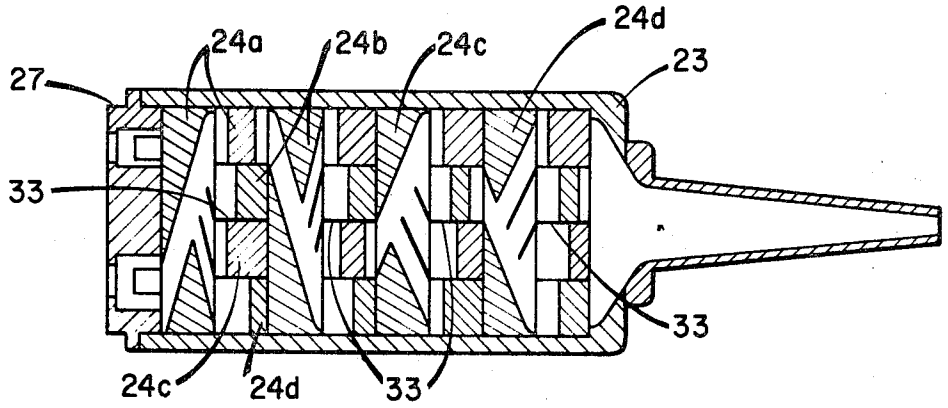


Fig. 3

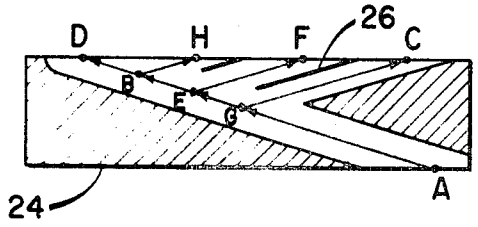


Fig. 4

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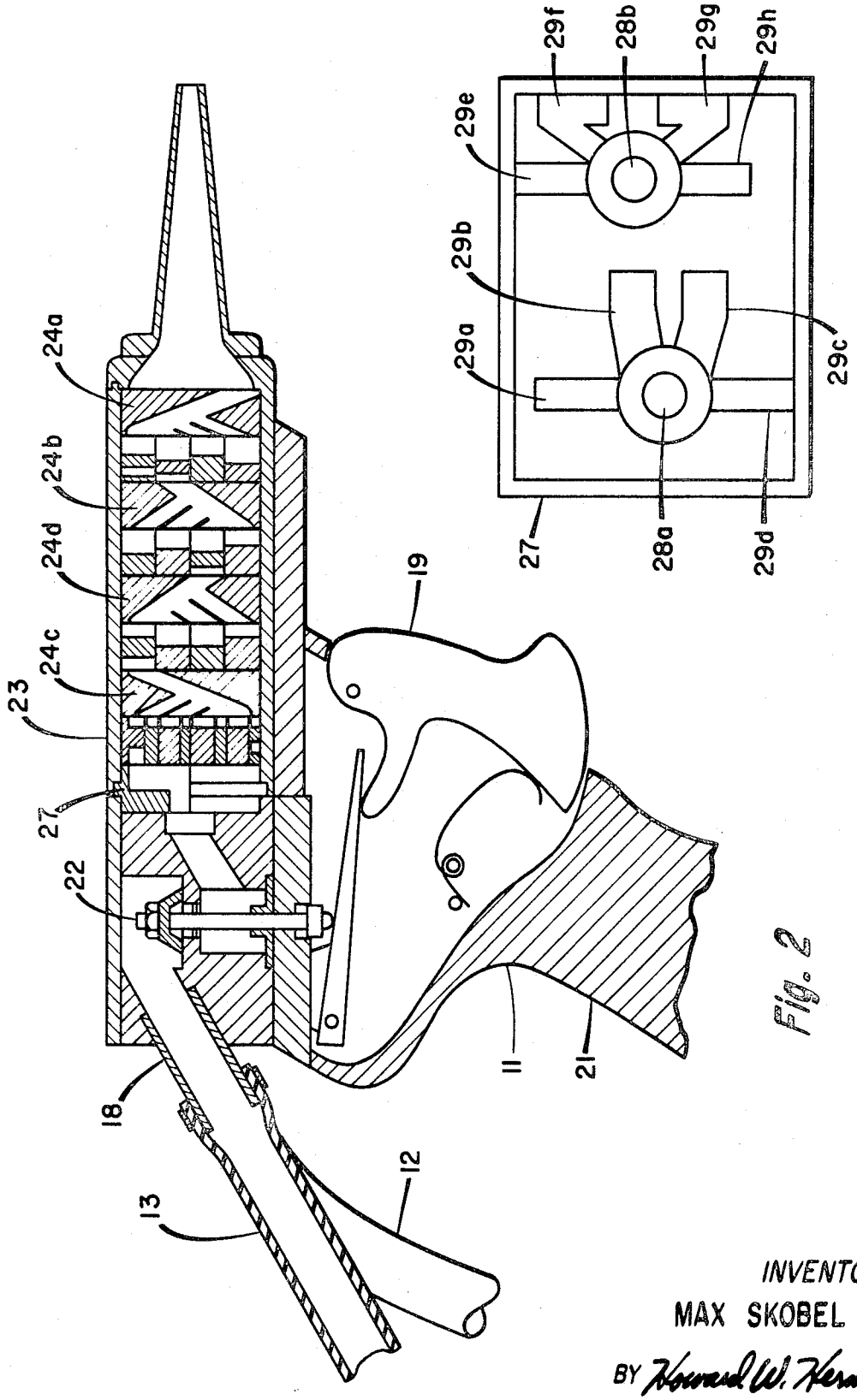


Fig. 5

Fig. 2

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STATIC MIXING DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to static mixing devices and more particularly to improvements in mixing devices for combining a plurality of fluid streams. Numerous types of static mixing devices for mixing two or more liquid streams are known in the art. For example, see U.S. Pat. Nos. 3,051,453, granted Aug. 28, 1962; 3,195,865 granted July 20, 1965 and 3,159,312 granted Dec. 1, 1964. Numerous other such devices have also been patented.

A number of these devices are in use commercially, generally in large volume industrial processes, such as polymer production for filamentary materials, for example. It has been found, however, that for very viscous materials at relatively low flow rates, these devices known in the art are not completely satisfactory. This is particularly true in applications where a catalyst composition is added to a base polymer and at least one of the materials is relatively viscous. The flow through the prior art devices is not completely uniform and there are "dead spots" in the flow through the device. In these areas the catalyst causes curing of the system resulting in a partial block of flow which increases with time. The resultant effect is an impedance of the volume of material flowing through the device and often incomplete mixing as well.

There is also a definite need in the art for a device of this type which can be made in extremely compact form for use, for example, in a hand-held injection gun for providing a bead of sealant along an open seam or the like. The shortening of the path length along the prior art devices tends to aggravate the problem set forth in the preceding paragraph. With many prior art designs it becomes impossible to obtain complete mixing in a relatively short path length. When mixing elements are placed in series, undesirable pressure drops occur across the mixing unit.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a static mixing device which eliminates the aforesaid problems inherent in prior art devices of this type. A further object is the provision of a static mixing device which is capable of being made in extremely compact form.

In accordance with these and other objects, it has been found that the problems inherent in prior art devices can be substantially reduced or eliminated by providing equal path lengths through the device and through each element of the device. The present invention uses the principle shown in a number of prior art patents of mixing two liquid components by sequentially combining, dividing and recombining streams a number of times. The device comprises a sequential series of sets of parallel pluralities of stream dividing and recombining elements.

Each element consists of a single point of entry or exit depending upon its position in the device and multiple points of exit or entry at the opposite end of the element. These elements are placed in parallel to form a set; the sets alternating in orientation at right angles to one another along the sequential series.

In each case the mean lengths of the flow path between the single point and the multiple points is of substantially equal length in each element and the cross-sectional area of all the multiple points are substantially equal. In this manner the amount of liquid material flowing between each of the various points of entry and exit is maintained substantially equal. In the instance where the single point of each element is the point of entry, the material flowing through the entry point is divided in the element into a group of streams having equal cross sections and equal rate of flow. Similarly, in the situation where the multiple points form the points of entry of material into each element, each of the entering streams is equal in cross section and rate of flow and the streams are combined in the element and leave from the single point of exit. The device must be connected to a metering system to assure the proper relationship of flow between the components being mixed. Valve means are provided for controlling flow into the mixing device. In a preferred embodiment the device is provided with a pistol grip and the valve means is actuated by a trigger.

The device is simple to manufacture and is efficient in operation when compared with prior art devices of this type. It may be manufactured in extremely compact form and in such form desirably may be made as a disposable unit, rather than a unit which must be cleaned each time that the device is used. The amount of material retained in the unit is extremely small; therefore, due to its simplicity the disposable concept makes the device more economical than attempting to clean similar devices. The pressure drop across the mixer is minimized, resulting in more uniform flow through the device, regardless of viscosity. In addition to being useful for mixing sealants, the device has obvious application in producing extrusions and in automatic molding operations.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and attendant advantages of the present invention will become better understood by those skilled in the art by referring to the following detailed description when read in connection with the accompanying drawings wherein:

FIG. 1 is a somewhat diagrammatic view of an embodiment of the present invention.

FIG. 2 is a vertical cross-sectional view of the mixer gun shown in FIG. 1.

FIG. 3 is another cross-sectional view in greater detail of the mixer head of the gun of FIG. 2, taken at right angles to the cross section of FIG. 2.

FIG. 4 is a diagram of one of the stream dividing or recombining elements illustrating the principles thereof.

FIG. 5 is a plan view of the distributor plate shown in the cross sections of FIG. 2 and 3.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawings wherein like reference characters designate like or corresponding parts throughout the figures thereof. There is shown in FIG. 1 a mixer gun 11 connected by a pair of lines 12 and 13 to a metering system 14 which in turn is supplied by a pair of material supplies 16 and 17. The materials in the supplies 16 and 17 are metered to provide the desired relative quantities by the metering system 14 and are supplied under pressure to the gun 11.

Referring now to FIGS. 2 and 3, the gun 11 may be seen in greater detail. The material supply lines 12 and 13 are connected to the gun 11 by means such as threaded connections like that shown at 18 at the rear of the mixer. A trigger 19 biased by a spring 20 and mounted in a pistol grip 21 actuates a pair of valves 22 (only one of which is shown) which open and close the inlets from lines 12 and 13.

The mixing head proper is a hollow tubular member 23, preferably generally rectangular in cross section, comprising a sequential series of sets of parallel pluralities of stream dividing and recombining elements 24. In the embodiment shown, four elements are stacked in parallel in each set. This provides in effect four parallel streams through each of the sets of stream dividing and recombining elements. Since four streams are required, four configurations of stream dividing elements 24 designated in FIG. 3 as 24*a*, *b*, *c*, and *d* are provided. The four configurations are required to provide four different positions of inlet for each set of elements. The four basic configurations can be seen from FIG. 3.

Each of the elements 24*a–d* is so designed that the mean length of path from the side with the single inlet or outlet designated in FIG. 4 as point A to each point of outlet on the multiple outlet side is identical and the mean length of path to the outlet, assuming A is the inlet, from any point of division in the device is also identical. Looking at FIG. 4, therefore, the distance from point A to point B to point C, is equal to the distance from point A through point B to point D. Similarly,

the distance from point B to point C is equal to the distance from point B through point E to point F and the distance from point B through points E and G to point H.

While it is desirable in some instances to have a third divider strip **26** positioned midway between points H and D, it has been found that the divider strip at this point is not a necessity. This is particularly true since the next element serially in the mixing device will automatically have a divider at that point because the next set of elements is placed at right angles to the elements in each preceding set, as may be seen more clearly from FIGS. **2** and **3**. Thus, the one large opening encompassing the points H and D, FIG. **4** should be considered in effect to be two openings of equal cross-sectional area. Of course, in a larger device that the miniaturized hand-held one shown in the embodiment of the drawings, it will be realized that a divider fin **26** will be placed at that point.

Material entering the mixer proper from the valve **22**, enters through a distributor plate **27**, which can be seen in FIGS. **2** and **3**, and more clearly seen from FIG. **5**. In the four parallel stream device shown, there need to be eight points of entry of material into the mixing head proper from the distributor plate **27**. Material from each of the two streams enters the distributor plate **27** through an aperture **28***a* or **28***b*. and flows through one of four equal length runners **29***a–h* associated with the apertures **28***a* or **28***b*. The runners associated with the aperture **28***a*, i.e. runners **29***a–d*, are all of equal length, and likewise the runners **29***e–h* associated with the aperture **28***b* are also all of equal length. Similarly, the cross-sectional areas of all of the runners associated with either of the apertures are also of equal dimensions.

Altogether, there are eight runners, four for each component, in the embodiment shown. The first set of parallel pluralities of stream dividing and recombining elements, therefore, comprises eight elements rather than four, each of the elements being of diminished thickness so that a pair of adjacent elements in the set is of substantially equal thickness to a single element in the next set of parallel elements serially adjacent thereto. One of each of the components being mixed is introduced from the runners **29***a–h* into each pair of elements.

For example, as viewed in FIG. **2**, the inlets of the top pair of elements in the first set of parallel elements correspond in location with the points **29***e* and **29***a*, and the inlets of the next pair below the top correspond with the points **29***f* and **29***b*. The material entering each pair of elements is divided into eight streams by the pair: four streams of each component; and enters all four of the next set of four elements of the next serial set of elements along the flow path.

In the second set of elements, streams coming from all eight of the elements of the first set are recombined in four streams leaving the second parallel set of elements. The four streams leaving the second parallel set are in turn each again divided into four streams in the third set of elements and recombined in the fourth set of elements, etc. By dividing and recombining the streams, even assuming laminar flow, mixing occurs over a very short distance.

The elements of the preferred embodiment of this invention may be combined as shown for purposes of manufacture. That is, each adjacent pair of elements in a set may be molded in a single operation so that a single piece in effect forms two elements. A solid divider spacer **33** is provided between adjacent pairs of elements to divide the exit or entrance paths between such adjacent elements in the set. Alternatively, of course, each element may be molded as a single piece and the pieces simply stacked to form the sets and placed in series to form the sequential series of sets. The elements may be made of any suitable material. For example, they may be from zinc die-cast or molded thermoplastic material or the like. In use, the device may be used to inject sealant, for example, into open seams and after use the unit may be simply thrown away due to its small size and low cost. The device can also be used for producing extruded shaped parts and for molded parts in situations where two-component systems are needed. The device can also be adapted to mix three or even more components. For greater volume throughput, it is possible to place several mixing elements in parallel if desired.

Obviously, many other modifications and variations of the present invention will occur to those skilled in the art from a reading of the foregoing. Therefore, it is to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

That which is claimed is:

1. In a static mixing device for mixing liquids by combining, dividing and recombining streams along a tortuous path, the improvement which comprises:

a sequential series of sets of parallel pluralities of stream dividing and recombining elements, each element consisting of a single point of entry or exit at one end thereof and multiple points of exit or entry at the opposite end thereof, the mean length of flow path between said single point and each of said multiple points being of substantially equal length and the cross-sectional area of all said multiple points being substantially equal, whereby the amount of liquids flowing between each of the various points of entry and exit is maintained substantially equal.

2. The improvement defined in claim **1**, wherein:

each set of parallel elements is positioned at right angles to all sets of parallel elements positioned immediately serially adjacent thereto.

3. The improvement defined in claim **2**, wherein feeding means are provided in the liquid inlet to said sequential series for feeding said points of entry in the first of said sequential sets of stream dividing and recombining elements with the liquids to be mixed.

4. The improvement as defined in claim **3**, wherein said feeding means comprises a prestage array of stream dividing elements similar in configuration to said sets of parallel elements but having exit points of smaller cross-sectional area than the inlet points of said first of said sequential sets, whereby two elements of the prestage array feed each inlet point of said first sequential set, different liquid components being fed from each of said two elements.

5. The improvement defined in claim **4**, and further including a distributor plate feeding said prestage array, said distributor plate comprising an inlet port for each of said liquids and a plurality of feeder paths extending from each said inlet port points adjacent the inlet points of the elements of the prestage array, all feeder paths extending from each of said ports being of substantially equal mean length and of substantially equal cross-sectional area.

6. The improvement defined in claim **5**, and further including valve means for controlling flow of liquid to said inlet ports.

7. The improvement defined in claim **6**, and further including trigger means mounted in a hand grip for operating said valve means.

8. The improvement defined in claim **7**, and further including metering means supplying said valve means for maintaining equal flow differentials between the two liquids supplied to the device.

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