# United States Patent [19]

# Huber et al.

# [54] STATIC MIXING DEVICE

- [75] Inventors: Max Huber; Gerhard Schutz, both of Winterthur, Switzerland
- [73] Assignee: Sulzer Brothers Limited, Winterthur, Switzerland
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Apr. 18, 1973 Switzerland...... 5589/73

- [51]
- [58] 23/291; 261/101, 112; 48/180 R, 180 C, 180 M, 180 B

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

3,618,778	11/1971	Benton et al 261/112 X
3,785,620	1/1974	Huber

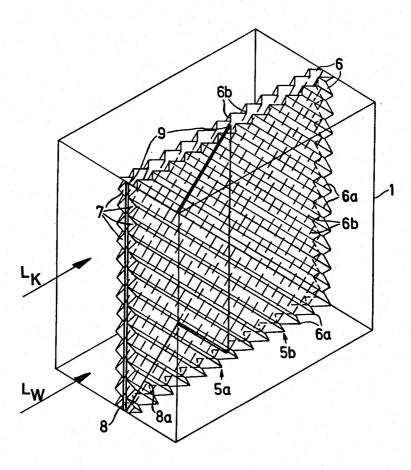
## 3,918,688 [11] [45] Nov. 11, 1975

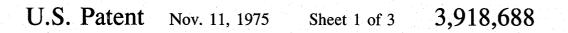
Primary Examiner---Harvey C. Hornsby Assistant Examiner-James A. Niegowski Attorney, Agent, or Firm-Kenyon & Kenyon Reilly Carr & Chapin

#### [57] ABSTRACT

The mixing device is constructed with a coarse mixing zone and fine mixing zone. The two zones are each generally constructed with corrugated plates or the like which are layered together to define a plurality of inclined criss-crossing flow ducts. The ducts in each layer are at least partially open to each other to allow cross-mixing. However, the upstream, or coarse, mixing zone is provided with a plate-like intermediate element, or the like, between each pair of adjacent corrugated plates to close off the adjacent flow ducts in the middle zones of the respective layers while leaving the edge zones open at least partially. This latter construction is to avoid a concentration gradient over the mixing zone and to provide a uniform distribution of the flowing media at the exit end of the zone.

### 9 Claims, 3 Drawing Figures





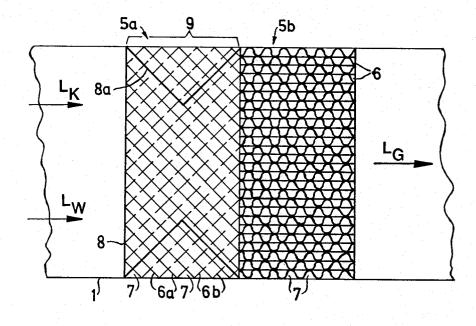
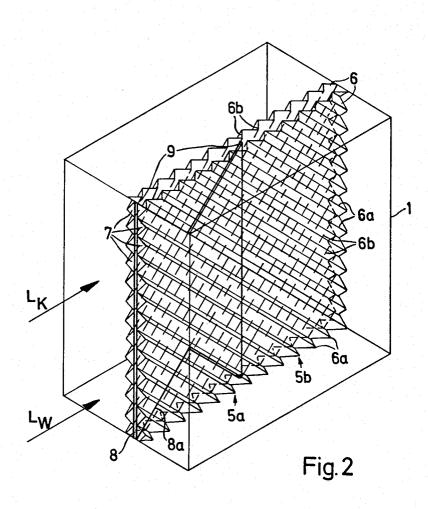
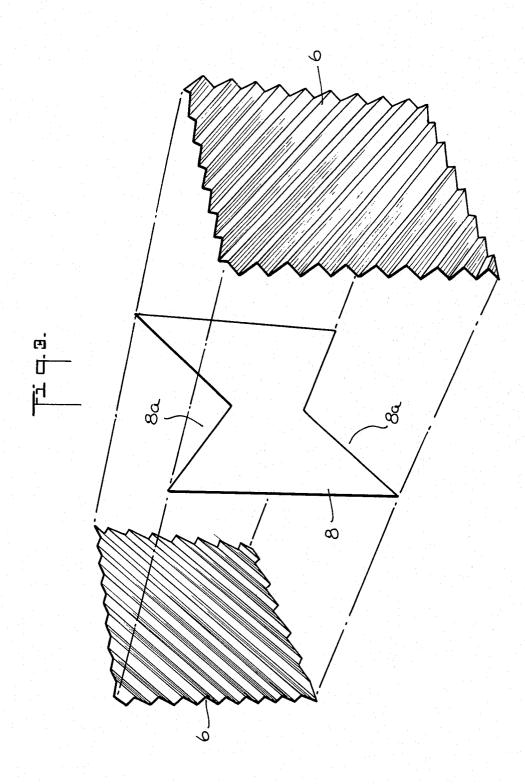


Fig. 1





# 1 STATIC MIXING DEVICE

This invention relates to a static mixing device particularly for flowable media.

Various mixing devices have been known for mixing 5 together various media. For example, in one known type as described in U.S. Pat. No. 3,785,620, the mixing device is made up of a plurality of lamellas or layers which are placed adjacent each other in parallel relation to define inclined flow paths in each layer which 10 are open to the flow paths in at least one adjacent layer. These mixing devices generally employ corrugated sheets to define the respective layers although other constructions may also be used. During use, two or more flowable media can be introduced into one end 15 of the mixing device on an individual basis and mixed within the device before exiting from an opposite end.

Generally, for manufacturing and hence economic reasons, it has been desirable to use identical layers, for tion width, for mixing devices of different diameters. As a result, where these mixing devices have been placed within jacket tubes of relatively large diameters, for example one meter or more, and of various crosssectional shapes, such as a circular cylindrical shape or <sup>25</sup> prismatic shape, i.e. square or rectangular, the number of points of contact or points of intersection of the flow ducts of adjacent layers increase considerably relative to jacket tubes of smaller diameter provided the individual layers have flow ducts whose dimensions are 30 identical to those of mixing devices of smaller diameters. Consequently, in many cases, where a flowing medium, for example waste water, fills the entire empty tube cross-section before entry into the mixing device or where, for example, in the case of a pH control, an  $^{35}$ acid or an alkali is fed into the mixing device in the center of the jacket tube, the flow paths at the edge zones of the mixing device are greatly depleted with respect to one of the media, particularly in the case of a large tube diameter. Because the flows of media divide up at 40the points of intersection of adjacent flow ducts, a concentration gradient, which may be considerable in some cases, thus occurs between the two media from the edge zones of the mixing device to the middle zone. As a result, the edge zones of the mixing device in the case indicated will carry practically only waste water. Thus, the edge zones do not participate in the mixing process.

Where the mixing devices are used in a chamber 50 formed by a jacket tube to mix hot and cold air for airconditioning purposes, the air currents usually enter the insert in two layers and the same problems arise as above.

Accordingly, it is an object of the invention to provide a mixing device of the above type which is capable of mixing different media together uniformly throughout the various zones of the mixing device.

It is another object of the invention to provide layers of material of uniform flow path dimensions which can be used to fabricate mixing devices of various sizes and shapes.

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It is another object of the invention to ensure a uniform distribution of flowing media in a mixing device of large diameter.

Briefly, the invention provides a static mixing device for flowing media which comprises a jacket having a wall defining a flow duct, at least one insert made up

of a plurality of contacting layers having parallel flow ducts disposed in inclined relation to carry out a mixing operation and a second insert of similar construction for coarse mixing of the flowing media prior to entry into the first insert.

The contacting layers of the downstream insert or inserts are each formed to orient the flow ducts in one layer in an inclined relation relative to the ducts in an adjacent layer and to open the ducts in adjacent layers at least partially to each other. The upstream insert has the same type of layers; however, while the ducts in adjacent layers are at least partially open to each other in an edge zone adjacent the jacket wall, these ducts are closed to each other in a middle zone.

In order to close off the ducts in the middle zone of the coarse mixing insert, a plate-like intermediate element is disposed between each pair of adjacent layers to block communication between the opposed flow ducts. Advantageously, the intermediate elements are example, in respect of corrugation height and corruga- 20 of rectangular shape and are of the same width as the associated adjacent layer and have apertures following a polygonal course on the side adjacent the jacket tube. In addition, each intermediate element is centered inside the jacket tube at least at two corners on opposite sides of the edge zones. The intermediate elements may, for example, have triangular apertures in the edge zones and, for example, may be formed of sheet-metal or plastic.

> Alternatively, the intermediate elements may be constructed of a rectangular shape having a smaller width than the associated adjacent layer and can be centered in the jacket tube, for example, by means of connecting members.

> The mixing insert which carries out the coarse mixing may be constructed as a separate insert i.e. as a unitary body for use as the mixing device per se. If a further fine mixing is required, such a mixing device may be directly followed by another mixing device in which the layers are at least partially open to one another throughout and which is disposed with a 90° offset from the device for coarse mixing.

Alternatively, the insert for fine mixing and the insert for corase mixing can be constructed as a unitary component with contacting layers constructed in the form of continuous surface elements and with an intermediate element disposed between each pair of contacting layers only in the corase mixing part.

Even with large jacket tube diameters, the mixing device avoids an unfavorable concentration gradient for the mixing of the flowing media from the edge zones to the middle zone while ensuring that the media leaving the corase-mixing device are uniformly distributed over the tube cross-section on flowing into the mixing device used for fine distribution. The fine distribution of the 55 media may, in very favorable cases, be effected by turbulence and diffusion in the empty tube following the insert.

In one advantageous embodiment of the mixing device, the layers of the insert consist of corrugated sheets which contact one another with the corrugations of adjacent sheets situated at an angle to the longitudinal axis of the mixing device, as considered in the direction of flow of the flowing media.

In another advantageous embodiment, the individual layers of an insert may be formed from plane surface elements to which sheet-like guide elements inclined at an angle are connected so that the individual flow ducts

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The expression "flowing media" denotes liquids, 5 gases or gas mixtures, low-viscosity or high-viscosity media and flowable solid particles. The device may, for example, carry two or more liquids in co-current, gases or gas mixtures, a liquid and a gas, or a liquid and a solid reduced to powder form.

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 diagrammatically illustrates a cross-sectional 15 ing view of one embodiment of a mixing device according to the invention:

FIG. 2 illustrates a perspective view of a second embodiment according to the invention; and

FIG. 3 illustrates an exploded view of a portion of the 20 mixing device of FIG. 1.

Referring to FIG. 1, the mixing device includes a horizontally extending jacket 1 having a wall defining a flow duct or passage for flowable media, for example, a flow of hot air  $L_W$  and a flow of cold air  $L_K$ . In addi- 25 tion, a pair of inserts 5a, 5b are placed consecutively within the jacket 1 in the direction of flow. Each insert 5a, 5b consists of a plurality of contacting layers 6formed from corrugated sheets and sandwiched together within the mixing chamber defined by the jacket 30 1.

The crests of the corrugations in the layers 6 which are disposed in planes parallel to the drawing plane of FIG. 1 - have the references 6a and 6b, 6a denoting the layer disposed in the drawing plane of FIG. 1 and 6b the layer situated behind the same. Open flow ducts 7 are formed between the corrugation crests and cross one another as a result of the fact that adjacent layers 6 are inclined to one another.

40 The upstream insert 5a serves for corase mixing and is provided with closed plate-like intermediate elements 8 disposed between pairs of adjacent layers 6. As particularly shown in FIG. 3, the individual intermediate elements 8 have triangular apertures 8a in their edge zones 9 adjoining the jacket wall. These apertures 8a are so formed that all the flow ducts 7 terminating at the jacket wall are open to one another. This obviates the formation of dead passages for the flow.

The downstream insert 5b serves for fine mixing and 50 is of a construction - apart from the absence of intermediate elements - identical to the insert 5b. This insert 5b is turned through 90° in the direction of its individual layers 6 with respect to the upstream element 5a.

During use, the compact layers of cold air  $L_K$  flowing 55 from left to right into the mixing device, and of the hot air L<sub>B</sub> flowing in the same direction, are coarsely mixed with one another in the upstream insert 5a before entering the insert 5b, which serves for fine mixing. The layers are thus distributed relatively uniformly over the 60 entire cross-section of the insert 5b at that time. Any differences in the concentration of cold air and hot air which may exist over the cross-section are at least substantially completely eliminated in the insert 5b so that the mixed air  $L_{G}$  flowing into a room (not shown) for 65 air conditioning has a unitary temperature.

Referring to FIG. 2, wherein like reference characters indicate like parts as above, the inserts 5a, 5b are constructed from common layers which are continuous in the direction of flow and between which intermediate elements 8 are inserted in the upstream part to form the insert 5a. As shown, the jacket 1 is of rectangular cross-sectional shape.

The mixing device of the invention can be used for various sized jackets, and particularly for jackets of large diameters of one meter or more. The corase mixing insert which may be used of itself or in combination 10 with one or more fine mixing inserts, ensures a uniform distribution of the introduced flowing media at the exit side of the insert.

What is claimed is:

1. A static mixing device for flowing media compris-

- a jacket having a wall defining a flow passage for the flowing media;
- at least one insert in said jacket comprising a plurality of contacting layers, each layer including a plurality of parallel flow ducts, said ducts in one layer being inclined relative to said ducts in an adjacent layer, and said ducts in adjacent layers being at least partially open to each other; and
- a second insert for coarse mixing in said jacket comprising a plurality of contacting layers each including a plurality of parallel inclined flow ducts, said ducts in adjacent layers being at least partially open to each other in an edge zone adjacent said jacket wall and closed to each other in a middle zone of said second insert, said second insert being disposed upstream of said first insert.

2. A static mixing device as set forth in claim 1 which further comprises a plate-like intermediate element disposed between each pair of adjacent layers in said second insert to block the communication between said flow ducts of adjacent layers in said middle zone.

3. A static mixing device as set forth in claim 2 wherein each intermediate element is of rectangular shape of the same width as an adjacent layer and has apertures following a polygonal course on a side adjacent said jacket wall, each said intermediate element being centered inside said jacket wall on opposite sides of said edge zones at least at two corners.

4. A static mixing device as set forth in claim 2 wherein said intermediate element is of rectangular shape having a smaller width than an adjacent layer and being centered in said jacket.

5. A static mixing device as set forth in claim 1 wherein said second insert is constructed as a separate insert from said first insert and said first insert is a top insert for fine mixing.

6. A static mixing device as set forth in claim 1 wherein said inserts are constructed as a unitary component in vertical disposed relation with contacting layers constructed in the form of continuous surface elements, and with said second insert disposed below said first insert and which includes an intermediate element disposed between each pair of contacting layers only in said second layer.

7. A static mixing device for flowing media comprising

- a jacket having a wall defining a flow passage for the flowing media, and
- an insert in said jacket comprising a plurality of contacting layers, each layer including a plurality of parallel flow ducts, said ducts in one layer being inclined relative to said ducts in an adjacent layer,

said ducts in at least two adjacent layers being at least partially open to each other in an edge zone adjacent said jacket wall and closed to each other in a middle zone thereof.

8. A static mixing device as set forth in claim 7 which 5 further comprises a plate-like intermediate element disposed between pairs of adjacent layers to block communication between said flow ducts in said pairs of adjacent layers within said middle zone.

9. A static mixing device as set forth in claim 8 wherein said element is of rectangular shape with a cutout in each of two opposite edges, each cut-out being disposed in a respective edge zone and being of a shape to open the flow ducts of each adjacent layer terminating at said jacket wall within said edge zone to each other.