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Holl

[11] **3,870,082**

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[54] **VENTURI-TYPE DEVICES**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 317,898, Dec. 26, 1972, abandoned.

[52] **U.S. Cl.** **138/40,** 261/DIG. 54

[51] **Int. Cl.** **F15d 1/02**

[58] **Field of Search** .... 138/37, 38, 40, 41, 44; 73/211, 213, 205 L; 261/DIG. 54

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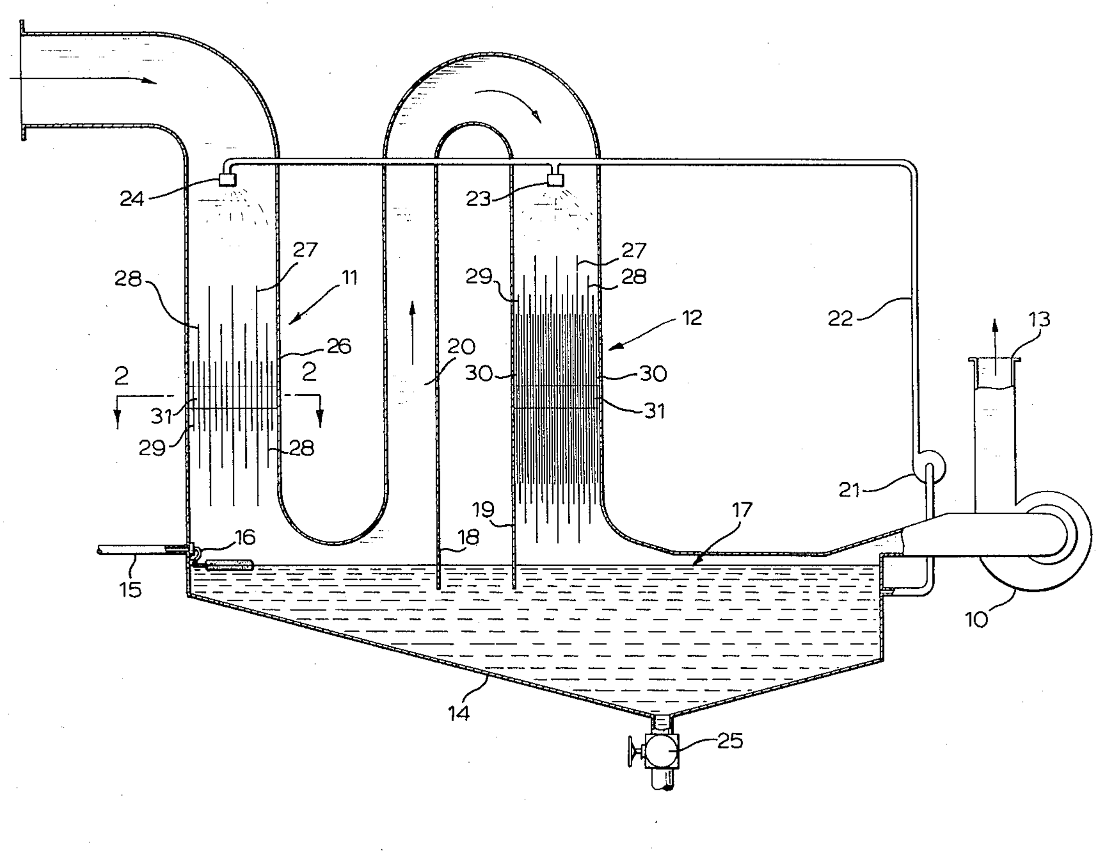
[57] **ABSTRACT**

A venturi-type device comprises a fluid flow passage containing in the direction of fluid flow, an upstream section of progressively reducing cross-section, a venturi throat section, and a downstream section of progressively increasing cross-section. The necessary changes in cross-section are produced by a plurality of physical barriers disposed in the passage and spaced from each other transverse to the direction of flow of the fluid, the changes in cross-section being caused by differences in length of the barriers. The barriers may be substantially flat parallel plates disposed longitudinally of the direction of the flow. The surfaces of the barriers may be coated with liquid or solid material. In an exchange device the barriers may be hollow to form other passageways for the flow of a second fluid through the device in exchange relation with the first fluid passing between the barriers.

35 Claims, 13 Drawing Figures



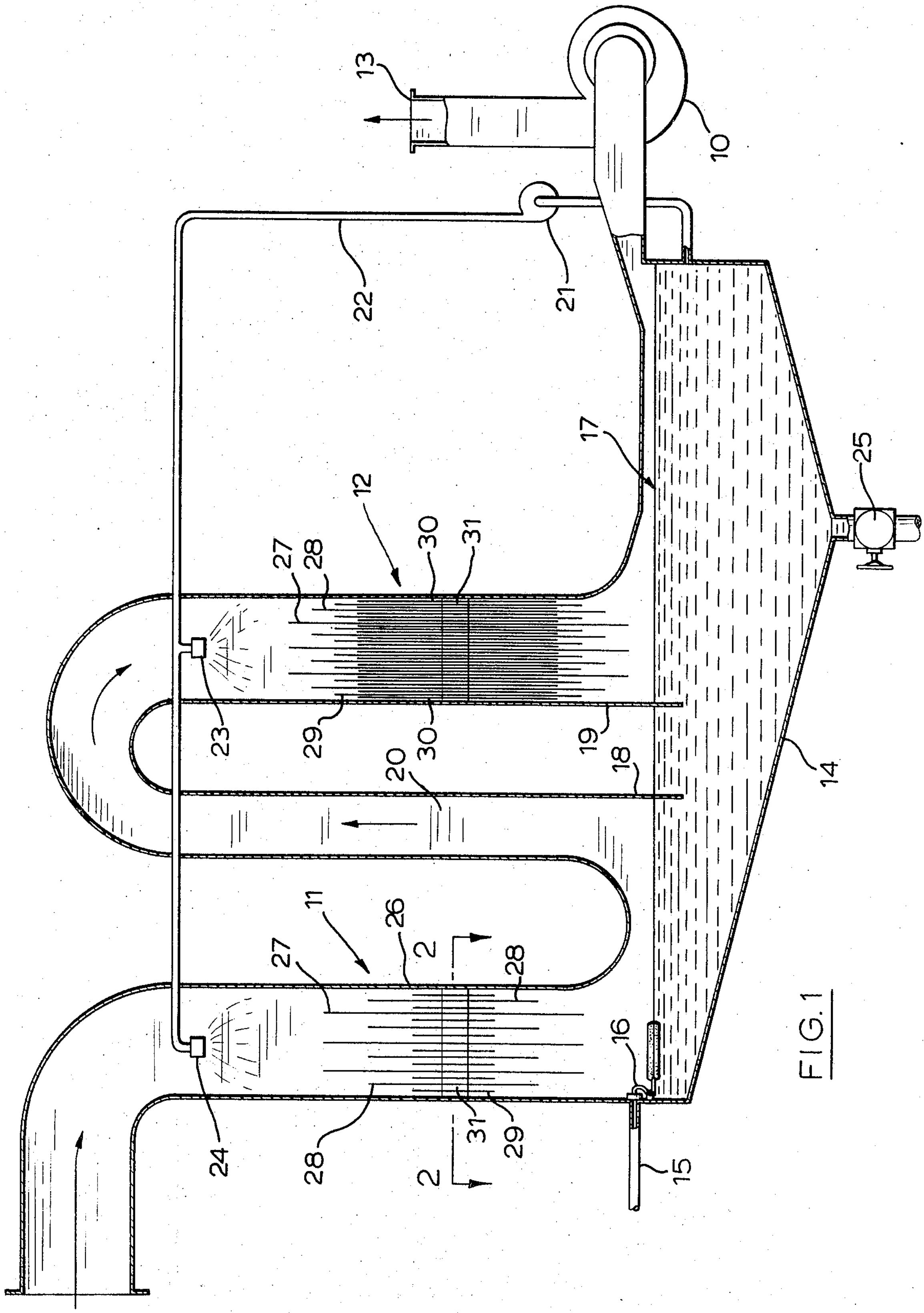

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FIG.1

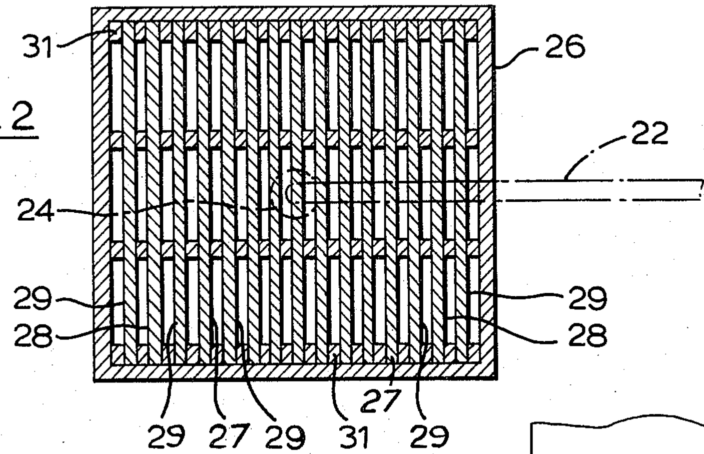


FIG. 2

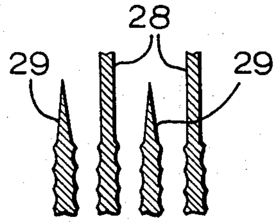
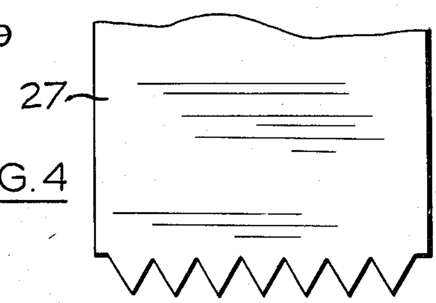


FIG. 3



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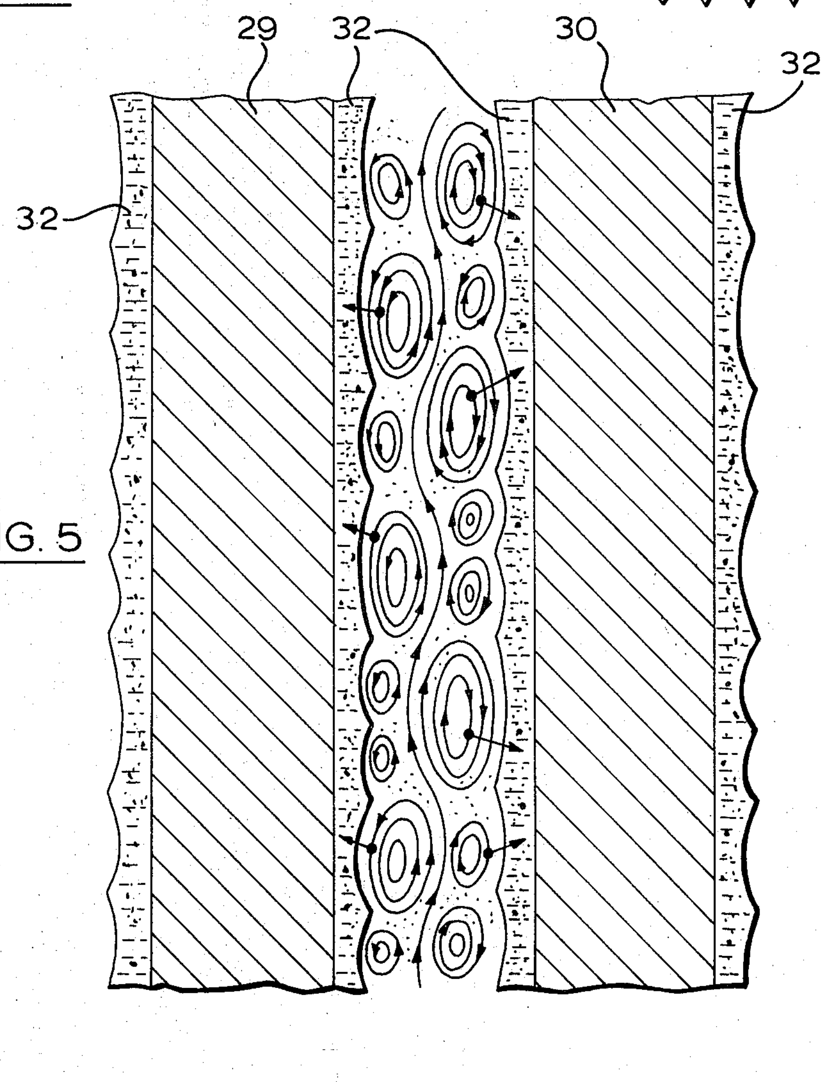

FIG. 5

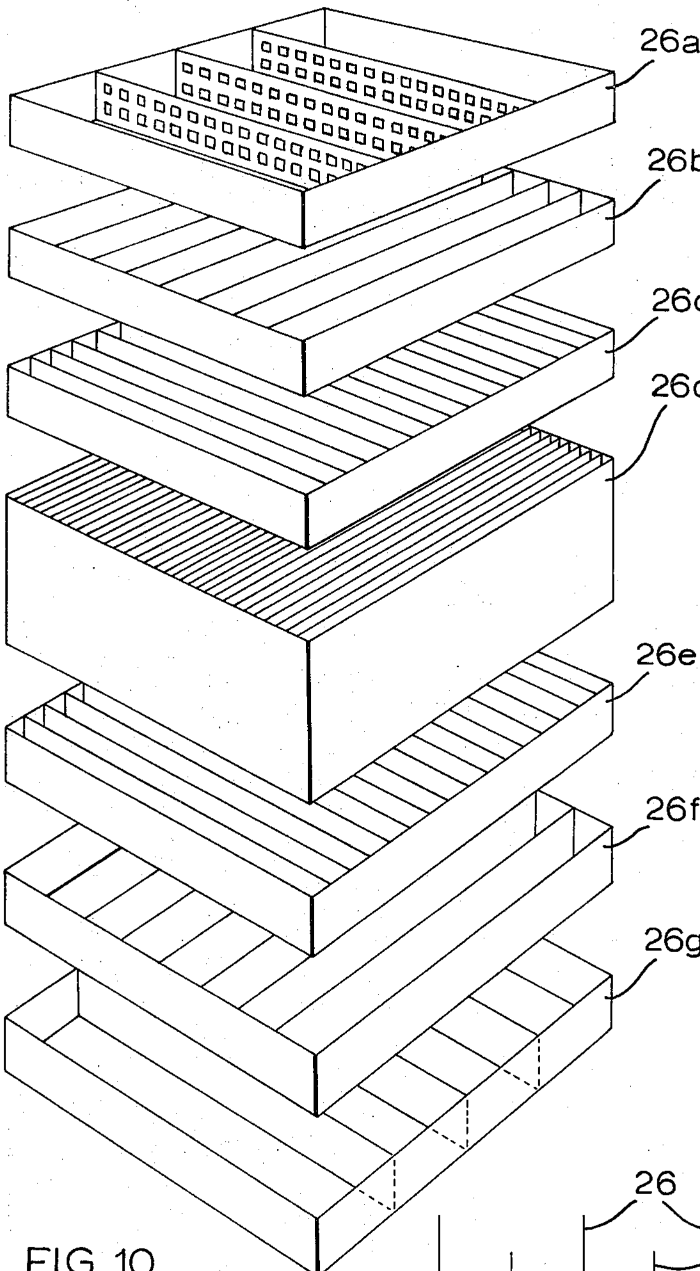

FIG. 10

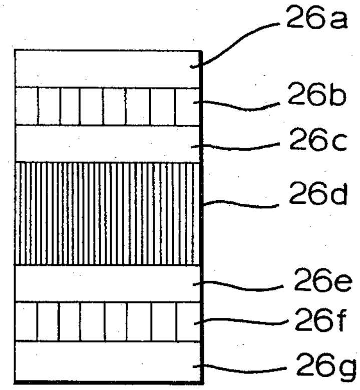

FIG. 9

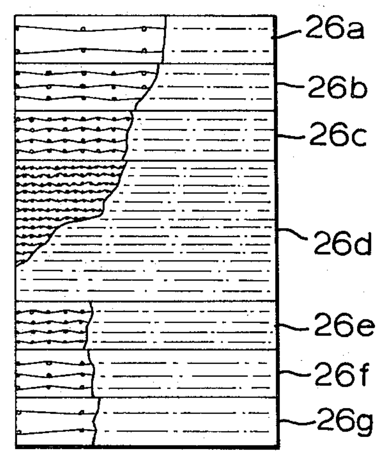

FIG. 11

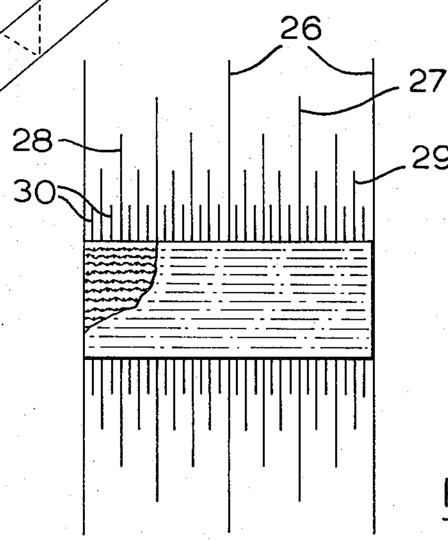

FIG. 12

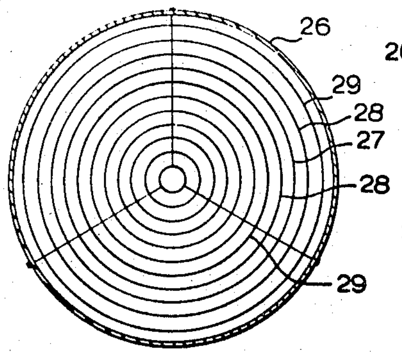

FIG. 7

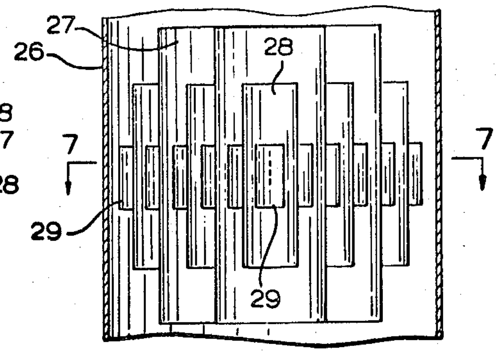

FIG. 6

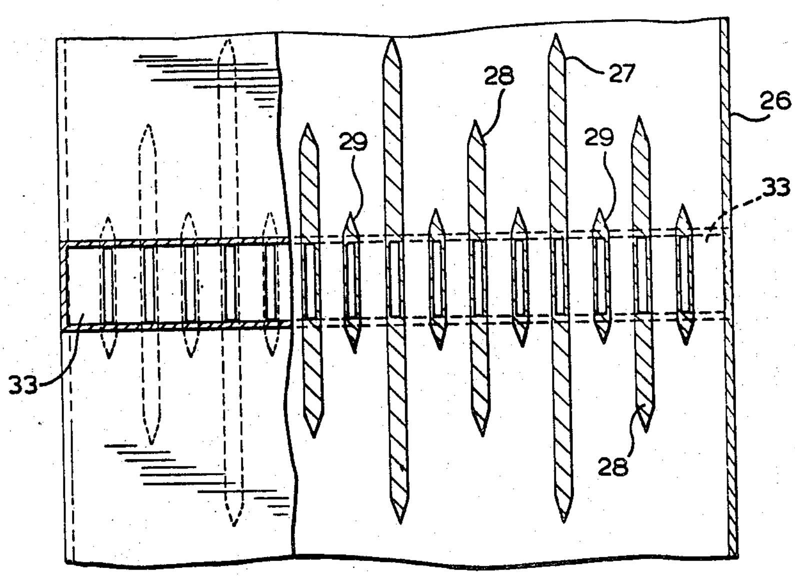

FIG. 8

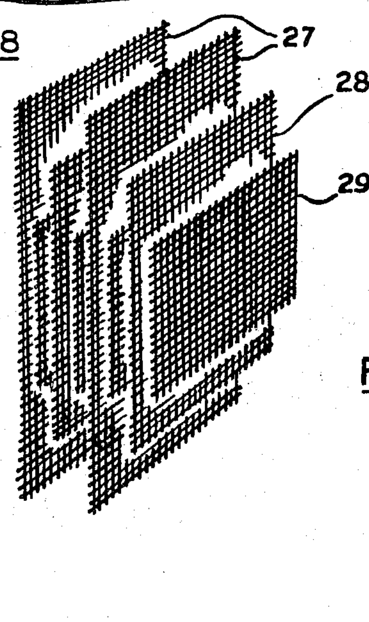

FIG. 13

VENTURI-TYPE DEVICES

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of my application Ser. No. 317,898, filed Dec. 26, 1972, now abandoned.

FIELD OF THE INVENTION

The present invention is concerned with improvements in venturi-type devices, and in apparatus incorporating such devices, such as gas cleaners, dissolvers, reactors, and heat exchangers.

REVIEW OF THE PRIOR ART

Venturi devices comprise a duct or pipe providing a fluid flow passageway that decreases progressively in cross-sectional area in an "upstream section" to a minimum at a "throat section," and then increases progressively again in a "downstream section." Fluid forced through the venturi device has its flow velocity increased progressively in the upstream section to reach a maximum at the throat, the velocity decreasing again in the downstream section, usually accompanied by a considerable turbulence of the fluid in the downstream section and in the duct- or pipe-work fed from the device. The passage of fluid through the device is accompanied by a pressure drop therein, the value of which is proportional to the amount of energy or power required to pass the fluid therethrough. It is usually one of the main endeavours of designers of these devices to keep this pressure drop as low as possible, so that the device and the apparatus in which it is incorporated will operate at maximum efficiency and minimum external power requirements.

In a typical gas scrubbing device a gas cleaning liquid, usually water, is injected into the gas stream at or very close the entrance to the venturi throat, where it is immediately atomised by the high-velocity gas stream into a mist or spray having a high probability of physical contact with solid material to be cleaned from the stream; this high probability results chiefly from the difference in velocity between the slower moving mist droplets and the faster moving gas-borne particles. This high contact probability is also enhanced by the abovementioned turbulence in the gas downstream of the throat.

DEFINITION OF THE INVENTION

It is an object of the present invention to provide a new device classifiable as being of venturi type.

In accordance with the present invention there is provided a device of venturi type comprising a passage member providing a passage for the flow of fluid therein in a predetermined direction, the passage having in the direction of flow of fluid in the passage and in the stated order an upstream section, a throat section and a downstream section, the flow cross-sectional area of the passage in the upstream section decreasing progressively toward the throat section, and the flow cross-sectional area in the downstream section increasing progressively away from the throat section, wherein at least one of said upstream and downstream sections comprises a plurality of physical barriers disposed in the passage, which barriers are spaced from each other transverse to said direction of flow and decrease the flow cross-sectional area of the part of the passage in which they are located, the said change of flow cross-sectional area being caused by differences in the said direction of flow of the physical lengths of the barriers in the corresponding section.

DESCRIPTION OF THE DRAWINGS

Particular preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings wherein:

FIG. **1** is a section through a gas cleaning apparatus in accordance with the invention and incorporating venturi-type devices of the invention wherein the said physical barriers are constituted by longitudinally-disposed laminae,

FIG. **2** is a cross section taken on the line **2—2** of FIG. **1**, and drawn to a larger scale,

FIG. **3** is a longitudinal cross section through some laminae constituting the physical barriers of the device of FIG. **1**, drawn to a larger scale, in order to show detail of construction thereof,

FIG. **4** is a side elevation of a laminae to show another constructional feature thereof,

FIG. **5** is a diagrammatic longitudinal cross section to a much enlarged scale to explain the operation of the embodiment of the invention illustrated by FIGS. **1** to **4**,

FIG. **6** is a longitudinal cross section through another device in accordance with the invention,

FIG. **7** is a section taken on the line **7—7** of FIG. **6**,

FIG. **8** is a longitudinal cross section through a heat-exchange device in accordance with the invention,

FIG. **9** is a longitudinal cross section through a further device in accordance with the invention,

FIG. **10** is an exploded view of the device of FIG. **9** to show the structure thereof,

FIG. **11** is a longitudinal cross section through a yet further device in accordance with the invention, wherein the physical barriers are constituted by transversely disposed perforated sheets,

FIG. **12** is a longitudinal cross section through a still further device in accordance with the invention, wherein the physical barriers are constituted by a combination of longitudinally-disposed laminae and transversely disposed perforated sheets, and

FIG. **13** is a perspective view of some laminae constituting the physical barriers of the device of FIG. **1**, drawn to a larger scale, to show the use of mesh sheets for this purpose.

In all of the figures of the drawings the relative scales of different parts and their spacing etc. are changed and/or exaggerated as necessary for clear illustration of the invention, and they may not therefore be scaled in any way.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An air-cleaning apparatus as illustrated by FIG. **1** is especially suited for the removal of particles such as dust and fume from gases, e.g. furnace exhaust gases. It may also be employed for the selective removal of one or more gases from other gases, e.g. by selective solution, adsorption, absorption or chemical reaction. The gas to be cleaned is drawn by a fan **10** through a primary coarse venturi-type separator **11** and a secondary fine venturi-type separator **12** before being discharged to atmosphere via an outlet **13.** Both separators are disposed over a common water tank **14** which is supplied with water from a pipe **15** via a level-control valve **16.** The level of the water in the tank is indicated by **17,** and is maintained above the lower edges of the partitions **18** and **19,** so as to isolate the separators from one another, and to force the air to pass between them only via the connecting pipe **20.** Water is drawn from the tank by a pump **21** and passed by a pipe **22** to nozzles **23** and **24** which spray the water onto their respective separators. The water draining from the separators is collected in the tank, the suspended solid material settling to the bottom in the form of a sludge and being removed therefrom as required via a valve **25.**

Referring now especially to FIG. **2,** in conjunction with FIG. **1,** the duct or pipe **26** of the primary separator is illustrated as of square internal cross-section. A plurality of physical barriers constituted by uniformly-spaced thin flat parallel plates are disposed within the gas flow passageway formed by the pipe with their larger faces parallel to the respective sides of the pipe, forming a corresponding plurality of narrow, uniform-width, parallel-sided straight passageways. As indicated above, the spacing and number of plates shown in the drawing as constituting the venturi-type device **11** is merely for clarity of illustration, and does not necessarily correspond to the parameters for an actual device, which will be discussed below.

Thus, the device is illustrated as comprising three parallel longest plates **27** equally spaced from one another and from the adjacent parallel walls of the pipe. Four shorter plates **28** are each disposed between two immediately adjacent plates **27,** or between a plates **27** and the adjacent pipe wall, with its leading and trailing edges substantially equally spaced from the respective edges of the plates **27.** Eight still shorter plates **29** are disposed in the spaces between the plates **27** and **28** and the pipe walls. In this embodiment the upper and lower edges of each plates are equally spaced from the respective edges of the immediately adjacent longer plates

It will be seen that the gas entering the device traverses a flow passageway that decreases progressively in cross-sectional area in an "upstream section" encompassing the leading ends of the plates **27** and **28** that extend beyond the shortest plates **29,** until a minimum is reached at the passageways bounded by the shortest plates, constituting the "throat section" of the device. The cross-sectional area of the passageway then increases progressively in a "downstream section," encompassing the trailing ends of the plates **27** and **28** that extend beyond the plates **29,** until a maximum is reached where the longest plates **27** terminate.

Similarly, the secondary venturi separator is illustrated as comprising laminae all plates **27, 28** and **29,** and in addition plates **30** which are shorter in length than the plates **29** and are disposed with their leading and trailing edges equally spaced from the corresponding edges of the plates **29.** Because of the addition of the plates **30** the final spacing between immediately adjacent plates is smaller than in the primary separator, and the secondary separator is effective with finer particles. It will be noted that the shortest plates **30** of the secondary separator are considerably longer than the shortest plates **29** of the primary separator to give longer passages in which the scrubbing liquid from the nozzles **24** is effective.

It is found with a venturi-type device in accordance with the invention that substantially less pressure drop is obtained across the device compared to a conventional high energy venturi scrubber of the same flow rate capacity, the particle collection efficiency of the venturi-type device in accordance with the invention being substantially higher.

In its most elementary form a venturi-type device of this aspect of the invention can have the necessary physical barriers constituted by a single set of plates disposed in the passageway, the plates being of progressively different lengths with their leading and trailing edges so disposed that the plates form the required upstream, throat and downstream sections. In the embodiment illustrated the progressive increase and decrease are of substantially the same rate, but in other embodiments this need not be the case, the different rates being achieved by corresponding location of the leading and trailing edges of the plates.

It is possible also to profile the leading and/or the trailing edges of the plates, for example, as illustrated by FIG. **4** for the plates leading edges, so as to obtain a further decrease of pressure drop by sharpening these edges.

In the case of a device such as that illustrated by FIGS. **1** to **4,** wherein a liquid is sprayed into the device, it is found that a layer of the liquid adheres to the leading edges to effectively "profile" those edges. These layers can also protect the edges against erosion by mechanical particles entrained in the gas stream, provided those particles are below a certain minimum size, e.g. about 50 micrometers in the embodiment illustrated. In applications in which the gas to be cleaned includes a substantial guantity of particles above the corresponding preferred minimum size, it may be preferred to provide a coarser scrubbing device ahead of the device of the invention, e.g. a simple open chamber in which the gas is passed through a liquid spray. Other forms of such coarser scrubbing devices will be apparent to those skilled in the particular art.

In the preferred embodiments illustrated herein the device is formed by thin flat plates spaced accurately from one another to provide passageways of corresponding width by narrow longitudinal spacing elements **31,** and the ease and simplicity of manufacturing by such an arrangement will be apparent. It is also possible for the device to be formed by spaced plates that are not flat, e.g. curved in the directions transverse to the direction of gas flow and/or curved in the directions parallel to the gas flow. An extreme example of a device with plates curved transverse to the gas flow consists of a plurality of spaced concentric cylinders, as illustrated in FIGS. **6** and **7.**

The apparatus illustrated by FIG. **8** is a heat exchange device where one fluid may not come in contact with the other fluid. In such a device at least the plates **29** immediately bounding the throat are hollow and constitute a flow passage for the second fluid, these hollow plates communicating with headers **33** provided with inlets and outlets that are not shown. Other forms of exchange between two fluids may also be effected by the device of the invention and, for example, the walls of the hollow plates may be permeable.

Many of these devices will be fed with a spray of liquid as a gas cleaning and/or cooling agent from the respective nozzle **23** or **24,** the nozzles being arranged to provide as uniform a spray as possible over the cross-sectional area. The liquid runs down the surfaces of the physical barriers to provide thin films **32** (FIG. **5**) thereon, which are contacted by the dust-laden air and wet and remove the dust therefrom. The resulting dust-laden liquid drips from the lower trailing edges of the barriers, and in the case of laminae barriers these edges may be toothed or otherwise formed, as illustrated for example by FIG. **4**, to promote the formation of large drops which fall into the reservoir. It is found however that the devices of the invention are particularly efficient at coalescing fine vapours of the spray into droplets of sufficient size not to remain entrained in the gas stream.

It is found that for efficient operation as a gas cleaner or the like the transverse spacing between each immediately adjacent pair of plates in the throat section should be closely correlated with the maximum size of particle that is to be removed by the device. In particular this spacing preferably is from 5 to 15 times the said maximum size, and more specifically is about 10 times.

The length of the throat section also is correlated with the particle size and should increase with decrease of particle size, owing to the greater difficulty usually experienced in separation with decrease of particle size. It is also preferred that in the upstream and downstream sections the ratio of length thereof to width perpendicular to the plane of the plates should be not less than about 3:1 in order to give a sufficiently uniform distribution of velocity and flow.

It is believed that with these preferred spacings the gas flow between the plates is in the form of two back-to-back turbulent boundary layers, as illustrated by FIG. **5**, between the two immediately-adjacent liquid films, giving a very high probability that the particles will be trapped by the liquid films and removed from the air stream. The liquid can be provided with a surface tension reducing agent to increase its capture efficiency.

As indicated above, the spacing between the plates is correlated with the maximum size of particle to be handled by the device, and will therefore decrease for smaller particles. As illustrated by FIG. **3**, the surface of each Plates, at least adjacent the leading edge thereof, may be provided with transverse ridges or corrugations to promote the capture of the particles, although this will result in an increase in pressure drop through the device.

As a specific example of the results obtained a device in accordance with this aspect of the invention was constructed with a minimum spacing of about 0.016 inch between the laminae of the throat section to give a velocity ratio of 2:1. The longest laminae were 30 inches in length, while the shortest laminae were 6 inches long. The air velocity at the intake was 1600 feet per minute, and the pressure drop measured across the device by a manometer was 8.5 inches water gauge. This device was able to remove cigar smoke fume (comprising particles in the sub-micron to colloidal size range) from an air stream to the extent that the exhaust from the device was not visible. A conventional known venturi scrubber to operate with particles of this size cannot give the same efficiency of particle removal, since the air velocities become excessive. For example, it has been reported that to give a comparable cleaning efficiency of non-visible exhaust with sub-micron fume particles requires an air velocity of over 30,000 feet per minute in the throat, such a device operating with a pressure drop of over **60** inches water gauge. Moreover, the device of the invention does not require a centrifugally-operated mist-removal chamber that may always be provided for such known venturi scrubbers in order to deposit the water with its entrained solid material.

The construction of a device using plates physical barriers involves the assembly of a large number of thin sheets of different sizes in correct order and such an operation is very susceptible to error, even with a careful assembler, resulting in a device plates incorrect characteristics and reduced efficiency. The assembly operation can be simplified and such errors avoided by means of the construction illustrated by FIGS. **9** and **10.** The pipe constituting the fluid flow passage is subdivided into a plurality of units, each of which is preassembled with plates portions all of the same length. Thus the throat portion is constituted by a corresponding pipe segment **26*d*** containing all of the plates **30** together with the central portions of the longer plates **29,** 28 and **27.** At each end of the throat section there are mounted respective pipe segments **26*c*** and **26*e*** in registry with the segment **26*a*** and containing the end parts of the plates **29** together with the corresponding parts of the plate **27** and **28.** Similarly, pipe segments **26*b*** and **26*f*** contain the end sections of plates **28** and corresponding parts of the plates **27,** while pipe segments **26*a*** and **26*g*** contain only the end sections of the laminae **27.** In constructions in which very close spacing is required between the plates the segments may be disposed, as illustrated, so that the plates segments in successive pipe segments are transverse to one another, preferably at right angles to one another.

It is not essential for the laminae to be continuous surfaces, and instead perforated plates can be employed provided the size of the perforations is made such that the surface performs with the liquid used as if it were a continuous surface. Thus, the surface energy of the liquid will ensure that it will form a continuous film over a perforated surface when the perforations are of sufficiently small size. The perforated plates can for example be formed of wire or plastic mesh, preferably a woven mesh, as illustrated by FIG. **13,** and a useful reduction in weight of material achieved by such use. A woven mesh has the additional advantage that it will provide what is effectively a ridged or undulated surface transverse to the direction of fluid flow and the advantage of such a construction was explained above in relation to FIG. **3.** By way of illustration in the embodiment of FIG. **10** only the laminae of the segments **26*a*** are shown as perforated, but it will be understood that any or all of the other segments can be similarly constructed.

With such a construction the segments can be preassembled with no chance of error since all laminae segments in each pipe segment are of the same length. Moreover each segment can itself be formed of one or more units or modules each of standard length in the direction of flow. For example, if each unit is of length n inches then a throat section of any length xn can easily be assembled by aligning and fastening end to end *x* number of pre-assembled units. The lengths of the upstream and downstream portions can also be determined in the same manner. It may also be necessary to dispose each unit transverse to the immediately preceding and succeeding unit to avoid obstruction of the channels in the units.

The device illustrated by FIG. **11** employs a different form of physical barrier to provide the upstream throat and downstream sections, namely a plurality of perforated screens disposed transverse to the direction of flow of the fluid in the passageway. Thus, the pipe segments **26***a* and **26***g* contain a number of transverse perforated sheets juxtaposed closely against one another, the spacing of immediately successive barriers in the direction of flow being such that substantially continuous films of liquid can form parallel to the direction of fluid flow under the action of the liquid surface energy, as explained above in connection with the use of perforated laminae. These sheets of the segments **26***a* and **26***g* are the most coarsely perforated, so that they provide the least reduction in flow cross-sectional area of the passage. The pipe segments **26***b* and **26***f* contain another two groups of juxtaposed sheets that are more finely perforated than the sheets **26***a* and **26***g* so that they provide a greater reduction of flow cross-sectional area. Similarly, the sheets of segments **26***c* and **26***e* are more finely perforated than those of **26***b* and **26***f* respectively, while the pipe segment **26***d* contains sheets of the finest perforation and greatest flow cross-sectional area reduction to constitute the throat section.

As with the other described embodiments fewer or more segments may be employed ahead of and after the throat section to provide the required progressive changes effective in flow cross-sectional area, each segment containing a sheet or sheets of a different degree of perforation. The number of segments in the upstream and downstream sections can be quite different from one another. Preferably the size of perforation in the throat section is about twice the maximum particle size to be handled by the device. In a specific embodiment of a device intended to operate with particle size 20 μm and smaller the sheets of section 26*d* comprise wire mesh screens of openings 40 μm square, those of sections **26***c* and **26***e* are of mesh screens of 80 μm openings, those of sections **26***b* and **26***f* are mesh screens of 160 μm openings, and those of sections **26***a* and **26***g* are mesh screens of openings 320 μm.

In the embodiment of FIG. **12** both types of physical barrier are employed, the throat section being constituted by transverse perforated sheets, while the upstream and downstream sections are constituted by longitudinally disposed flat parallel plates.

The invention has been particularly described as applied to a gas cleaning device, but is applicable to all cases in which a venturi-type device must be provided. Other specific examples of uses for the device of the invention are as follows:

a. A gas reaction device in which the gas passing through the apparatus is brought into intimate contact with a chemical flowing over the surfaces of the physical barriers.

b. A gas reaction device in which the gas is brought into intimate contact with a solid material, such as a catalytic material, coated on the surfaces of the physical barriers.

c. A gas reaction device in which two or more separate gases are fed simultaneously to the device and are mixed therein, either alone or in combination with a solid or liquid material on the surfaces of the physical barriers.

d. A gas velocity and/or flow measuring device in which a low-ratio throat is employed and a suitable pressure detecting meter is located in the throat, such a device operating with a low overall pressure drop.

e. A heat exchange device as illustrated in FIG. **8**.

I claim:

1. A device of venturi type comprising a passage member providing a passage for the flow of fluid therein in a predetermined direction, the passage having in the direction of flow of fluid in the passage and in the stated order an upstream section, a throat section and a downstream section, the flow cross-sectional area of the passage in the upstream section decreasing progressively toward the throat section, and the flow cross-sectional area in the downstream section increasing progressively away from the throat section, wherein at least one of said upstream and downstream sections comprises a plurality of physical barriers disposed in the passage, which barriers are spaced from each other transverse to said direction of flow and decrease the flow cross-sectional area of the part of the passage in which they are located, the said change of flow cross-sectional area being caused by differences in the said direction of flow of the physical lengths of the barriers in the corresponding section.

2. A device as claimed in claim **1**, wherein both of the upstream and downstream sections comprise parallel physical barriers of different physical length.

3. A device as claimed in claim **2** wherein the physical barriers in both of the upstream and downstream sections comprise a plurality of spaced parallel plates.

4. A device as claimed in claim **3**, and for passage of gas flow having solid material entrained therein, wherein the minimum spacing between immediately adjacent plates of said upstream and downstream plates is from **5** to **15** times the size of the largest particles of solid material to be handled by the device.

5. A device as claimed in claim **2**, and for passage of gas flow having solid material entrained therein, wherein the minimum spacing between immediately adjacent physical barriers is from **5** to **15** times the size of the largest particles of solid material to be handled by the device.

6. A device as claimed in claim **2**, and comprising a fluid reaction or contacting device, including means for supplying a liquid to the physical barriers to coat the surfaces thereof.

7. A device as claimed in claim **2**, and comprising a fluid reaction or contacting device, wherein surfaces of the physical barriers are coated with a solid material to be contacted by the fluid.

8. A device as claimed in claim **1**, wherein the physical barriers in either of the upstream or the downstream sections comprise a plurality of spaced parallel plates.

9. A device as claimed in claim **1**, wherein the said throat section comprises a plurality of spaced parallel physical barriers all of the same physical length in the said direction of flow.

10. A device as claimed in claim **9**, wherein the throat section comprises a plurality of spaced parallel plates.

11. A device as claimed in claim **10**, and for passage of gas flow having solid material entrained therein, wherein the minimum spacing between immediately adjacent plates of said throat plates is from 5 to 15 times the size of the largest particles of solid material to be handled by the device.

12. A device as claimed in claim **9**, wherein the throat section comprises a plurality of section segments with the physical barrier segments in each section segment all of the same physical length.

13. A device as claimed in claim **9**, and comprising a fluid reaction or contacting device, including means for supplying a liquid to the physical barriers to coat the surfaces thereof.

14. A device as claimed in claim **9**, and comprising a fluid reaction or contacting device, wherein surfaces of the physical barriers are coated with a solid material to be contacted by the fluid.

15. A device as claimed in claim **9**, wherein at least some of the barriers of the throat section are hollow and constitute flow passages for a second fluid to be in heat exchange relation with the first-mentioned fluid passing between the barriers.

16. A device as claimed in claim **9**, wherein the throat section comprises a plurality of spaced parallel mesh plates.

17. A device as claimed in claim **1**, wherein all of the said sections comprise parallel physical barriers that extend in the same direction of flow, the barriers of the upstream section being of different physical length, the barriers of the throat section being of the same physical length and the barriers of the downstream section being of different physical length.

18. A device as claimed in claim **17**, wherein the barriers of the upstream and throat sections are constituted by flat parallel plates extending between the two sections.

19. A device as claimed in claim **17**, wherein the barriers of the downstream and throat sections are constituted by flat parallel plates extending between the two sections.

20. A device as claimed in claim **17**, wherein the barriers of the upstream, throat and downstream sections are constituted by flat parallel plates extending between the three sections.

21. A device as claimed in claim **20**, wherein the barriers of the upstream, throat and downstream sections are constituted by spaced parallel mesh plates extending between the three sections.

22. A device as claimed in claim **17**, wherein all of said barriers comprise spaced parallel plates.

23. A device as claimed in claim **19**, and for passage of gas flow having solid material entrained therein, wherein the minimum spacing between immediately adjacent plates of all of said upstream, downstream and throat plates is from 5 to 15 times the size of the largest particles of solid material to be handled by the device.

24. A device as claimed in claim **17**, and comprising a fluid reaction or contacting device, including means for supplying a liquid to the physical barriers to coat the surfaces thereof.

25. A device as claimed in claim **17**, and comprising a fluid reaction or contacting device, wherein surfaces of the physical barriers are coated with a solid material to be contacted by the fluid.

26. A device as claimed in claim **1**, wherein the upstream section comprises a plurality of parallel barriers of different physical lengths, said upstream section comprising a plurality of section segments with the physical barrier segments in each section segment all of the same physical length.

27. A device as claimed in claim **1**, wherein the downstream section comprises a plurality of parallel barriers of different physical lengths, said downstream section comprising a plurality of section segments with the physical barrier segments in each section segment all of the same physical length.

28. A device as claimed in claim **1**, wherein the upstream and downstream sections each comprise a plurality of parallel barriers of different physical lengths, each said upstream and downstream section comprising a plurality of section segments with the physical barrier segments in each section segment all of the same physical length.

29. A device as claimed in claim **1**, wherein the upstream and downstream sections each comprise a plurality of parallel barriers of different physical lengths, and the throat section comprises a plurality of parallel barriers of the same physical length, each section comprising a plurality of section segments with the physical barrier segments in each section segment all of the same physical length.

30. A device as claimed in claim **29**, wherein each barrier of each of the said section segments comprises a mesh plate.

31. A device as claimed in claim **1**, and for passage of gas flow having solid material entrained therein, wherein the minimum spacing between immediately adjacent physical barriers is from 5 to 15 times the size of the largest particles of solid material to be handled by the device.

32. A device as claimed in claim **31**, wherein the said minimum spacing is about 10 times the said size of the largest particle.

33. A device as claimed in claim **1**, and comprising a fluid reaction or contacting device, including means for supplying a liquid to the physical barriers to coat the surfaces thereof.

34. A device as claimed in claim **1**, and comprising a fluid reaction or contacting device, wherein surfaces of the physical barriers are coated with a solid material to be contacted by the fluid.

35. A device as claimed in claim **1**, wherein the said physical barriers are constituted by spaced parallel mesh plates.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,870,082 Dated 03/11/75

Inventor(s) Hall, Richard Adolf

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, lines 31 & 37)
5, line 41) Alter "plates" to - plate -
6, lines 5, 15 and 29)

Column 4, line 32 Alter "quantity" to - quantity-

Column 6, line 9 Alter "plates" to - with -
, lines 26 and 27 Alter "laminae" to - plates-

Signed and sealed this 24th day of June 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks