United States Patent [19]

Gilles et al.

[11] **3,831,350**

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[54] **FLUID DISTRIBUTOR**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .... **55/128**, 55/418, 55/DIG. 37, 98/40 V, 98/40 VM, 138/37

[51] **Int. Cl.** **B03c 3/36**

[58] **Field of Search** .... 55/128, 129, 124, 126, 55/418, DIG. 37; 98/40 R, 40 VM, 40 V, 121 R; 138/37

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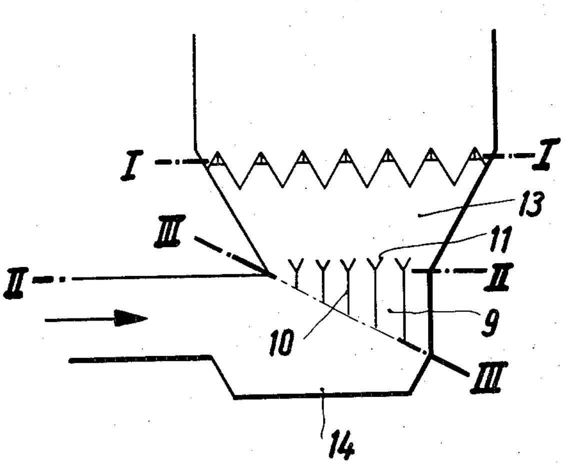
Primary Examiner—Dennis E. Talbert, Jr.
Attorney, Agent, or Firm—Karl F. Ross; Herbert Dubno

[57] **ABSTRACT**

A fluid distributor, especially for an electrostatic precipitator or the like, in which the fluid stream passes from a conduit of small cross-section into a region of larger cross-section, as in a diffuser, and the throttle and guide devices include a distributor plane in which V-section throttle elements are provided with a direction of convergence facing toward a source of dust or other particles and substantially independent of the gas-flow direction. The flanks of the V-section distributor are slotted alternately and the closeness or spread of the V-section member can be adjusted to suit distribution requirements. Below the distributor plane is an array of deflector blades of generally Y-shaped cross-section with shanks in stepped relationship along the gas-flow path.

9 Claims, 15 Drawing Figures



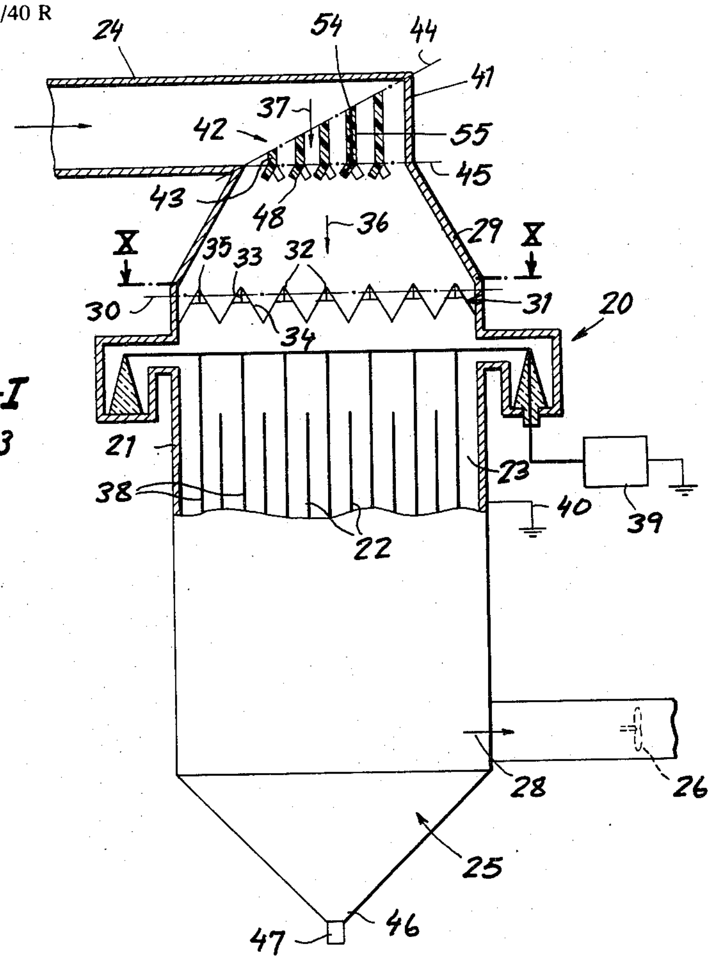


Fig.1

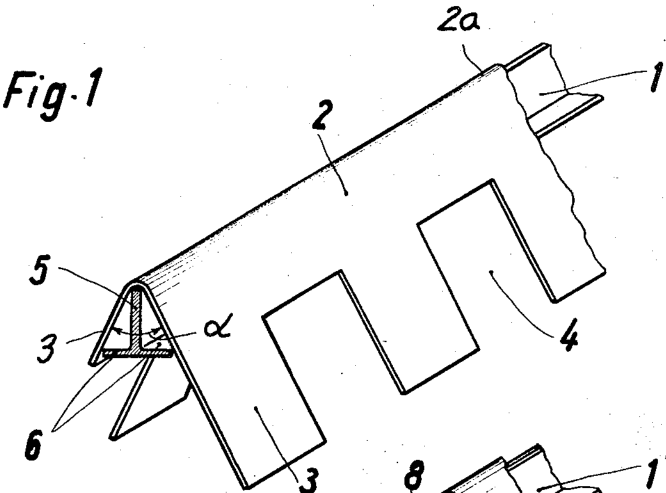


Fig.2

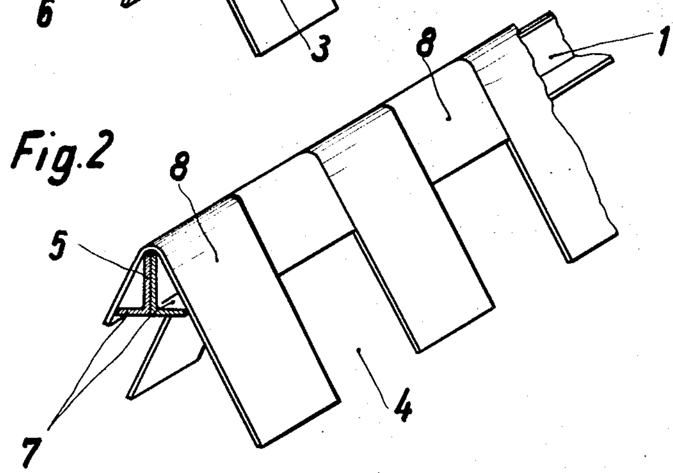


Fig.3

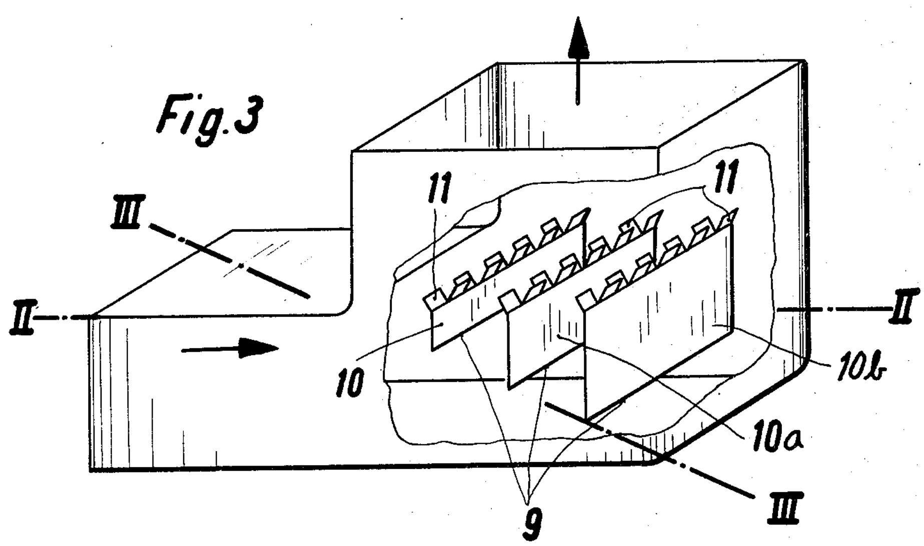


Fig. 4

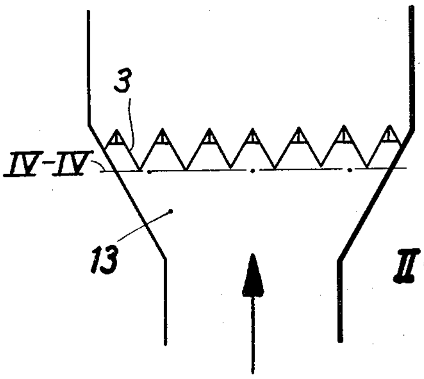


Fig. 5a

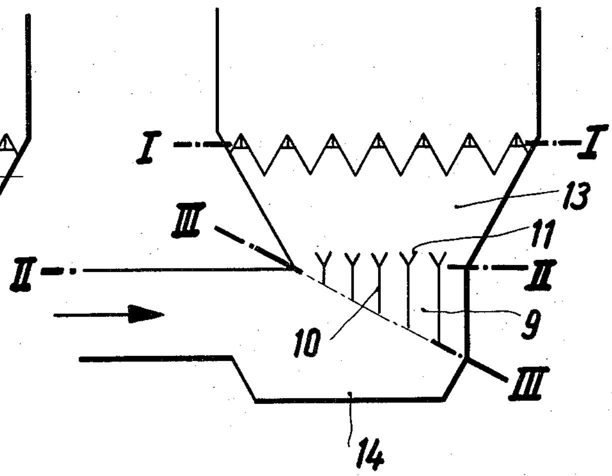


Fig. 5b

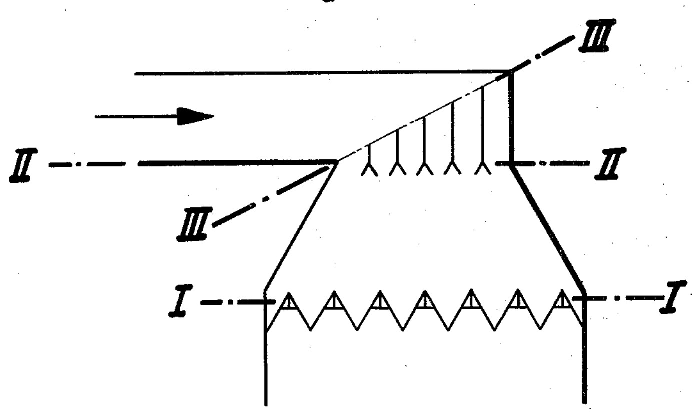


Fig. 6a

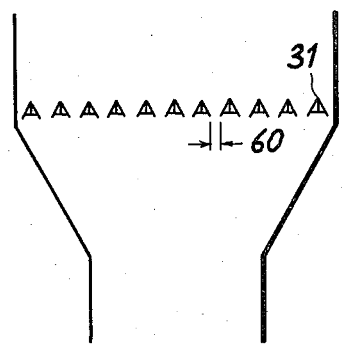


Fig. 6b

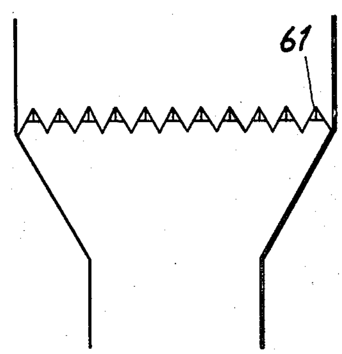


Fig. 6c

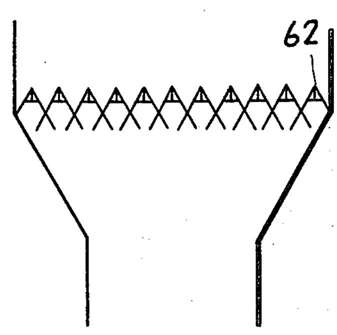


Fig. 7a

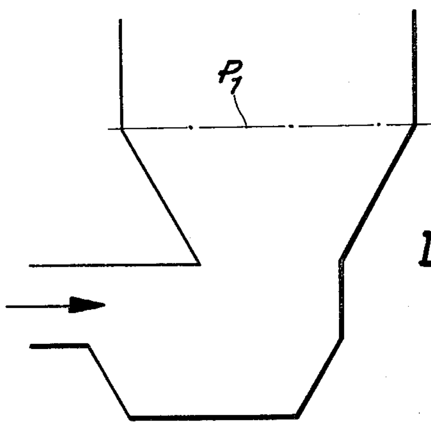


Fig. 7b

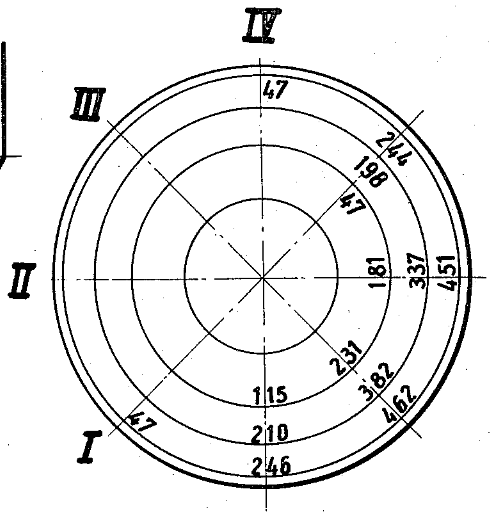


Fig. 8a

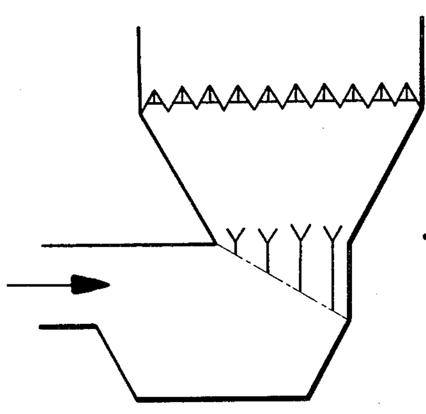
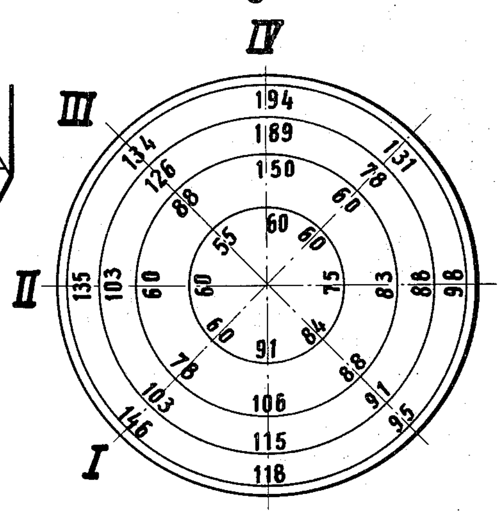


Fig. 8b



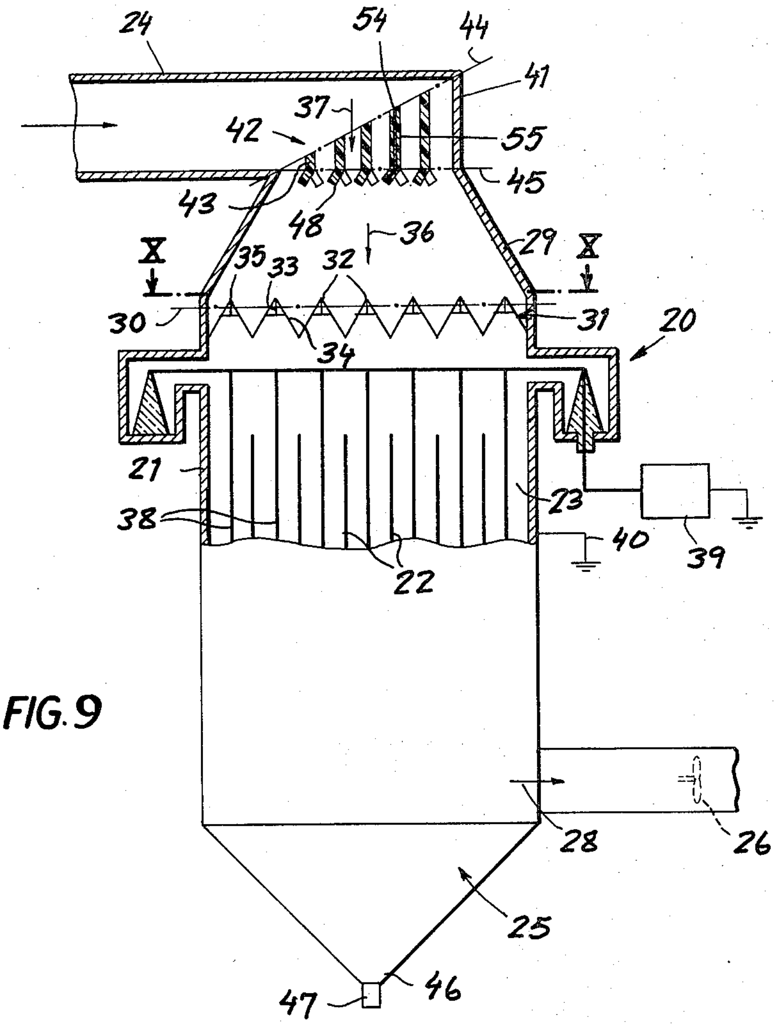

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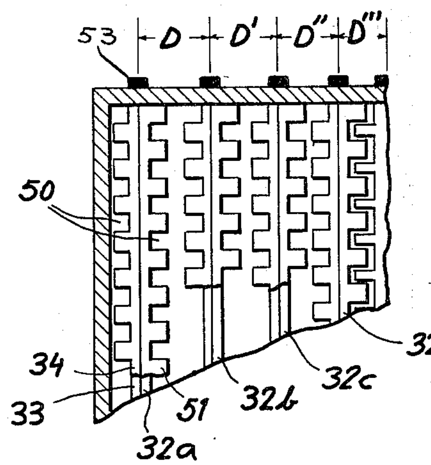
FIG. 9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32b
32c
33
51
32a

FIG. 10

FLUID DISTRIBUTOR

FIELD OF THE INVENTION

The present invention relates to a device for the distribution of a fluid, especially a gas, and for the guiding, throttling and flow-velocity homogenization of a gas stream. More particularly, the invention relates to improvements in gas-feed systems for electrostatic precipitators and the like.

BACKGROUND OF THE INVENTION

In gas-treatment systems generally and electrostatic precipitators in particular, it is desired to cause a gas stream or some other fluid to pass substantially through a number of discrete channels distributed uniformly across the cross-section of a housing which may have an overall cross-sectional area transverse to the direction of flow which exceeds the flow cross-section of a duct leading the fluid to the apparatus.

In such cases, it is common to provide, between the duct and the housing, a so-called diffuser which constitutes a transition piece between the region of small cross-section and the region of large cross-section and which permits the fluid stream to spread across the large cross-section at the discharge side of the diffuser. Frequently, the conduit opens into the diffuser at an angle to the axis thereof and to achieve a high degree of velocity and flow uniformity across the cross-section of the housing into which the diffuser opens, deflector means in the form of blades or the like may be required at the junction. The diffuser may be frustoconical, pyramidal, or prismatic and, in all cases, has walls which diverge from a region of small cross-section to an outlet of large cross-section.

Prior-art systems for throttling the flow at the outlet of a diffuser and achieving flow homogeneity have not always proved to be effective where other considerations were involved. For example, where the diffuser opens upwardly into an electrostatic precipitator of the parallel-plate or nested-tube or honeycomb-tube type, the descending particles of dust may clog the opening of the throttle members and interfere with the uniform flow of fluid therethrough. Furthermore, the fluid traversing the throttle means may interfere with a deposition of dust or the particulate solids.

Similar difficulties are encountered with evaporative cooler, wherein, for example, a liquid may pass in one or the other direction through these channels and may be collected or supplied by conduits of smaller cross-section.

Efforts to improve the distribution of fluid across the cross-section of a diffuser and to provide deflecting means enabling the fluid stream to swing through, say, 90° into a diffuser, may use grates, apertured plates, screens or the like with flaring slots or windows. These generally planar structures are readily clogged by deposition of dust and particle, the use of louvers has also proved to be unsatisfactory because of insufficient turbulence to ensure uniform fluid distribution, especially where the change in flow cross-section between the inlet and the outlet of the diffuser is in a ratio of 1:6 or greater. The fluid stream which emerges from the passages of the louvers tend to be directed against the diffuser wall in line with these passages.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved fluid throttling and distributing device whereby the aforementioned disadvantages can be obviated.

It is another object of the invention to provide a diffuser for forwarding a fluid from a small cross-section conduit to a large cross-section housing which will improve the distribution of the fluid and be less sensitive to clogging than conventional systems.

Another object of the invention is to provide a multi-passage apparatus, especially electrostatic precipitator or evaporative cooler with inlet means for improving the homogeneity of fluid distribution to the system.

A more general object of the invention is to provide improved means for obviating the above mentioned disadvantages and improving vertical gas flow distribution in systems which provide an increase in the flow cross-section between a supplying duct and the gas-treatment device.

SUMMARY OF THE INVENTION

These objects and others, which will become apparent hereinafter are attained, in accordance with the present invention, in a device for throttling and guiding a gas stream, preferably between a conduit of small cross-section and a housing of larger cross-section such as an electrostatic precipitator or for the throttling and guiding of a liquid stream to be fed to a heat exchanger or of any fluid, e.g., to be supplied to an evaporator cooler, which comprises a throttling structure lying generally in a plane transverse to the fluid-flow direction at the outlet side of a diffusor and provided with an array of transversely offset mutually parallel throttle members of inverted-V-cross-section, i.e., of upwardly converging and downwardly diverging coping for roof shape, the flanks of aprons of the throttle elements being provided with longitudinally spaced cutouts or slots, preferably staggered from one side to the next along the respective throttle element. The throttle elements comprise parallel beams and sheet aprons overlying the beams and forming the downwardly diverging or upwardly converging flanks or sides. Advantageously, the apices or ridges of the throttle elements are turned toward the source of dust or particles and possess an apex angle designed for shedding of the particles, preferably 90° or less.

Any particulate matter falling onto the sloping flanks of the throttle elements will possess a critical angle at which the particulate matter will remain upon the surface, this angle being defined as the angle of friction. At smaller angles, i.e., with sharper convergencies, the particulate matter will slide along the flanks under the influence of gravitational force without agitation or disturbance of the throttle elements. With less acute angles, of course, the particulate matter will accumulate.

The inverted-V-section throttling elements may be used to constrict the cross-section as much as is desired, the degree of throttling depending upon the spacing of the beams, the number and size of the cutouts, and the lengths of the aprons transverse to the beams. Preferably, a uniform velocity distribution is obtained by obstructing the free cross-section by 30 to 70 percent, preferably 45 to 55 percent, the degree of compression being the fraction of obstructed space to the total cross-section of space in percentage terms and as measured in a projection on the cross-section plane.

The throttling elements, according to the invention, are thus downwardly sloping in the direction of dust deposition and we have found that the direction of convergence may be independent of the direction of gas flow. In other words, the ridge may face the direction of gas flow or may face away from the direction of gas flow without difference in effect or result. The aprons or sides of the inverted-V-section elements preferably are smooth and can be provided with friction-reducing coverings or may be composed of low-friction materials such as polytetrafluoroethylene.

Surprisingly, we have found that the throttling effect and hence the turbulence-producing effect and gas distribution does not depend upon the direction in which the elements are approached by the flowing gas.

According to another feature of the invention, the beams may be adjustably mounted in their plane so that the mutual spacing of the beams may be adjusted. Where an approaching gas has a nonuniform velocity distribution, i.e., has a flow cross-section which is inhomogeneous with respect to velocity distribution, the adjustability of the beams allows compensation. Thus a greater constriction may be provided in regions of higher velocity and a reduced constriction in regions of lower velocity to redistribute the flow rates across the cross-section at the discharge side of the throttle plane. Of course such nonuniform spacing may be avoided by redistributing the flow velocities downstream of the throttle plane.

According to yet another feature of the invention, the beams are of T-cross-section and are invented when the ridges face upwardly as is commonly the case. The aprons may then be formed by bent sheets, e.g., of metal, metal-coated with synthetic resin, or synthetic-resin foil, with the staggered cutouts being uniformly distributed along the aprons. Where the throttle elements are to be so closely spaced as to interdigitate, the tabs intermediate the slots may be of a reduced width to fit into the slots of adjoining throttle elements. The lateral cutouts may be punched in a convenient and economical manner from sheet metal, when the latter is used to form the apron, and sheet-metal strips may simply be bent along a longitudinal axis to form the apex angle which is steeper than the angle of slip of the dust. The aprons rest along the crossbar of the T while the ridge or apex rests upon the foot of the shank. In general the strip need be secured to the T-beam, which is also inverted, only in cases in which a disturbance is to be expected because they normally rest in the proper position under their own weight.

The throttle elements, according to the invention, may also be constituted from bent-metal strips having short and long legs bent at the desired apex angle to one another and hanging upon the inverted-T-beams in laterally contiguous relationship with the long and short legs alternating to opposite sides of the beam. The use of such individual strips allows the spacing to be adjusted in the longitudinal direction as well, in the event inhomogeneities of gas velocity distribution are detected in this direction.

According to yet another feature of the invention, the throttle elements are disposed in a throttle plane at the outlet side of a diffuser which widens in the direction of the housing of a fluid-treatment device, the diffuser axis lying at an angle, e.g., 90°, to the small cross-section conduit which delivers the fluid. In this case, we prefer to provide at the angle junction a fluid-deflecting array of slats or louvers which have common edges lying in a diagonal plane across the junction and providing an increase in cross-section parallel to the direction in which the gas is discharged. The slats may increase stepwise in height and are provided along edges facing the throttle plane with tongues for dispersing the fluid. Preferably the slats lie in respective planes perpendicular to the throttle plane and parallel to the gas flow direction in the diffuser while the tongues extend to through opposite sides of the slat to incept the fluid. The slats may thus be of Y-cross-section with the arms of the Y being formed by the tongues which are alternately bent in opposite direction to opposite sides of the plane of the slat. The tongues reach the slat or begin in a plane parallel to the throttle plane but perpendicular to the direction in which the gas is discharged.

The system has been found to be highly effective in redistributing a nonuniform velocity distribution of the type which arise when a gas stream is deflected and having a high gas velocity in the region of a far wall of the diffuser.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. **1** is a fragmentary perspective view showing a throttle element according to the present invention in detail;

FIG. **2** is a view similar to FIG. **1** of a throttle element according to another embodiment of the invention;

FIG. **3** is a perspective view, partly broken away, of a louver assembly according to the invention;

FIG. **4** is a diagram of a throttle arrangement in a throttle plane of a diffuser illustrating one configuration of the throttle elements;

FIG. ***5a*** is a diagram showing the use of a throttle plane with a deflector or louver arrangement according to the invention;

FIG. ***5b*** is a view similar to FIG. ***5a*** but showing the diffuser opening downwardly;

FIGS. ***6a*** through ***6c*** are diagrams showing other arrangements of the throttle arrangement of a throttle plane;

FIG. ***7a*** is a diagram of the diffuser portion of an apparatus without a throttle plane according to the invention;

FIG. ***7b*** is a graph of the gas velocity distribution for the system of FIG. ***7a*** without a diffuser slat array and without the throttle plane;

FIG. ***8a*** is a diagram similar to FIG. ***7a*** showing the system provided with throttle plane and the deflecting slat;

FIG. ***8b*** is a diagram of the velocity distribution for the system of FIG. ***8a;***

FIG. ***9a*** is a fragmentary vertical cross-section through a electrostatic precipitator embodying the invention; and

FIG. **10** is a cross-sectional view taken along the line X — X of FIG. **9.**

SPECIFIC DESCRIPTION

Referring first to FIGS. **9** and **10,** from which an overall indication of the invention may be obtained, it can be seen that the system may be used with an electrostatic precipitator **20.** The latter comprises a housing **21** of rectangular cross-section which is subdivided internally by upright plates **22** constituting collector electrode and defining gas-flow passage **23** between them. The cross-section of the housing **21** exceeds the cross-section of a conduit **24** feeding dust-laden gas to the electrostatic precipitator. At its lower end, the housing is provided with a frustopyramidal hood **25** communicating with a blower **26** to induce a flow of gas through the system in the direction of arrow **28.**

At its top, the electrostatic precipitator is provided with a downwardly divergent frustopyramidal diffuser **29** having a cross-section ratio of substantially 1:6 between its inlet and its outlet side. At its outlet side, in the horizontal plane **30,** referred to hereinabove as the throttle plane, the diffuser is provided with a throttle arrangement **31** in the form of longitudinally extending parallel throttle elements **32.** These elements may be any of those described in connection with FIGS. **1** through **6***c*.

Basically, each element comprises an inverted-T beam **33** flanked by a pair of aprons **34** connected together at a ridge **35** facing in the direction of the oncoming gas and hence counter to the direction of dust fall (arrow **36**). The aprons **34** are provided with slots as will be described in further detail below to allow the gas to pass downwardly in the direction of arrow **37.** The diffuser is obstructed in the throttle plane by 45 to 55 percent. The electrostatic precipitator, is also provided with arrays of corona discharge wires **38** which may be connected to one terminal of high-voltage direct-current source **39** the other terminal of which is grounded, the housing **21** is likewise grounded at **40.**

At its upper end the diffuser may communicate via a neck **41** with the conduit **24** at a deflector array **42,** the latter constituting of a multiplicity of parallel slats **43** which lie in transversely spaced parallel planes perpendicular to the throttle plane **30.** At their upper ends, the slats may be staggered so that the shortest slat lies proximal to the discharge end of conduit **24** while the longest slat lies remote therefrom. The upper edges of the slats lie along a diagonal plane **44.** At their lower ends the slats terminate in a common plane **45** parallel to plane **30** and perpendicular to the gas-flow direction **37.** Below the precipitation, there is provided a dust collecting bin **46,** the door **47** of which may be removed to empty the dust.

The lower edges of the slats are provided with alternately oppositely bent tongues **48** forming arms of a Y.

In operation, the gases from conduit **24** are intercepted by the slats **43** and are deflected downwardly through passages between the slats and are dispersed by the tongues **48,** the latter cause substantial turbulence and significantly reduce any nonuniformity of flow velocity across the inlet to the diffuser. The gases then traverse the throttle plane **30,** pass downwardly between the collector electrodes of the electrostatic precipitator and are ionized by the discharge at corona electrode **38.** The dust particles are thereby charged and accumulated upon the collector electrode until dislodged by a conventional rapping device. The dust particles cascade downwardly.

In FIG. **10,** we show a system in which the nonuniform velocity distribution of the gas may be rectified at the throttle plane. As earlier indicated the throttle elements, e.g. the elements **32***a*, **32***b*, **32***c* and **32***d* consist of beams **33** overlain by apron **34,** here shown to be bent sheet-metal strips whose staggered slots **50** are punched and separate tabs **51** from one another. In some cases the throttle elements (**32***c* and **32***d*) can have their tabs interdigitated (see also FIG. **6***c*) although a space arrangement of the throttle elements is also possible (see elements **32***a* and **32***b*). The beams **33** are guided in horizontal slots of the diffuser wall and can be locked in place by milled nuts **53** which, when loosened, allow the spacings D, D′, D″ etc. to be adjusted. These spacings determine the effective flow cross-section in the indicated region, the flow cross-section being obstructed to a greater extent in the high velocity region than in the low velocity region. The width of the slots **50** may also be varied to increase the extent of obstruction at the high velocity region.

In FIG. **9** we also have shown that the slats **43** may be composed of synthetic resin or of a sheet-metal core **54** coated with a synthetic resin **55.**

FIGS. **1** and **2** show the throttle elements in somewhat greater detail. In FIG. **1,** for example, the inverted-T beam **1** is a metal profile whose shank carries the ridge **2***a* of a sheet-metal strip **2** whose aprons **3** rest against the ends of the crossbar **6** of the T. The height of the shank **5** and the width of the crossbar or flange **6** determine the apex angle α of the element, this angle being selected such that it is steeper than the sliding angle of the dust descending from the electrostatic precipitator. The slots **4** are punched in the unitary sheet-metal strip **2** which is folded about a longitudinal axis to produce the ridge. In the system of FIG. **2,** however, the sheet-metal strips **8** are narrow and are laterally contiguous while being bent transversely to have long and short slots disposed alternately on opposite sides of the beam. In this embodiment, as in the case of FIG. **1,** the inverted-T beam **1′** can be formed by a pair of angle bars **7.** The cutouts are here formed between long legs of the strip **8.** The strips are preferably provided with an anticorrosion and/or friction-reducing layer such as polytetrafluoroethylene or with a protective coating of rubber. Alternatively, the strips may be made entirely of synthetic resin material.

In FIG. **3,** we have shown in somewhat greater detail a deflection array comprising louver slats **10,** **10***a* and **10***b* in the form of sheet-metal strips or synthetic resin strips, or metal strips coated with synthetic resin or rubber. At the upper edges, the strips are provided with tongues **1′** separated by slats and bent to opposite sides alternately. The tongues extend upwardly and outwardly on each slat from a plane II — II which is parallel to the plane I — I of the throttle elements described in greater detail hereinafter. The lower edges of the strip **10** lie along the diagonal of the L-shaped duct structure at the heel of which the slats are disposed.

Various arrangements of the throttle elements and the slats have been shown in FIGS. **4,** **5***a* and **5***b*, e.g., for use in an evaporative collector or an electrostatic precipitator. In all of these embodiments, the vertically extending gas space has a diffuser **13.** In FIG. **4** the diffuser inlet is provided below the gas-treatment space and is approached by the gas from below along a straight path. In this case, the deflector slats are not necessary. It can be seen that the lower edges of the aprons **3** of the diffuser elements are in contact along a plane IV — IV parallel to the planes I — I and II —

II. Where, however, the diffuser **13** must communicate with a conduit at right angles thereto, the slats **10** are provided as described in connection with FIG. **3.** This combination has been illustrated in FIG. **5***a*. The slats occupy a triangular region at the junction of the conduit with the diffuser in elevation. The beam **14** collects the separated dust.

In FIG. **5***b*, a system similar to that of FIG. **5***a* is shown except that the conduit communicates with a downwardly divergent diffuser at its top so that the direction of gas flow and the direction of dust **4** are the same.

In FIGS. **6***a* through **6***c*, we show how the extent of construction of the cross-section of the diffuser can be varied by modifying the length of the aprons of the throttle elements in FIG. **6***a*, for example, the throttle elements **31'** are equally spaced apart but have short aprons defining the gaps **60** between them. In FIG. **6***b*, the throttle elements **61** have a spacing similar to that of FIG. **6***a* but aprons of greater length so that the bottom edges of the aprons touch and the only free cross-section is that defined within the slots. In the system of FIG. **6***c*, the throttle elements **62**, having the same ridge or crest spacing as in the systems of FIGS. **6***a* and **6***b*, have interdigitating aprons so that the free cross-section is a fraction of the slot cross-section.

FIGS. **7***a* and **7***b* show the velocity distribution in a diffuser having no throttle elements or guide members but provided with the right-angle inlet for the fluid as described. The velocity distribution of FIG. **7***b* which is taken in a plane P_1, demonstrates that the maximum velocity is found at the far side of the diffuser. The values given are taken with respect to an overall average as 100 percent, the velocities as measured ranging from 0 to 451 percent. When the throttle plane is in place and deflector elements are provided below the throttle plane as shown in FIG. **8***a*, the distribution immediately above throttle plane is represented in FIG. **8***b*. The maxima and minima vary between 194 percent and 55 percent based upon an average of 100 percent. In the embodiment illustrated and described in connection with FIGS. **8***a* and **8***b*, it is found that a reduction of the free cross-section to 50 percent before the deflecting means will not substantially change the velocity distribution. In this example, moreover, the ratio of the free cross-section of the duct to that of the diffuser inlet was about 1:1.6, the ratio of the free cross-section of the diffuser inlet to the free cross-section of the diffuser outlet was 1:4.25, the included angle of the diffuser was 60° and the ratio of the free cross-section of the feed duct to the free cross-section of the diffuser outlet was 1:6.8. Where the duct cross-section was reduced in the throttle plane to 50 percent of its original value, the ratio of the free cross-section of the feed duct to the actual cross-section of the diffuser in the throttle plane was 1:13.6.

We claim:

1. A device for feeding a fluid to a chamber comprising:

a housing forming a duct opening at one end into said chamber and communicating at another end with a source of fluid; and

a planar array of mutually parallel throttle elements extending across the cross-section of said duct, each of said throttle elements having a V-cross section with codirectionally facing ridges, and aprons divergent from said ridges, said chamber being a treatment space containing means spaced from said one end of said duct for treating said fluid, said fluid being a gas and solid particles descending from said chamber through said array of throttle elements, said ridges being turned toward said chamber, each of said throttle elements comprising a support beam of T-cross-section having a shank and a cross bar, and at least one sheet-metal strip defining said aprons and resting on said beam with the ridge of said strip extending along the shank of the T and flanks of said strips resting against the ends of said cross-bar.

2. The device defined in claim **1** further comprising means for adjustably shifting said throttle elements in the plane thereof.

3. The device defined in claim **1** wherein each of said throttle elements comprises a single strip resting upon the respective beam and formed with slots longitudinally spaced apart along each apron.

4. The device defined in claim **3** wherein the slots and the aprons of each element alternate therealong.

5. The device defined in claim **1** wherein each of said elements is provided with a multiplicity of contiguous bent metal strips having long and short legs disposed alternatively on opposite side of the respective beam to form alternating slots along the aprons of said elements.

6. The device defined in claim **1** wherein said source communicates with said duct at an angular junction, said device further comprising an array of transversely spaced mutually parallel deflector slats disposed at said junction and lying in planes perpendicular to the plane of said throttle elements.

7. The device defined in claim **6** wherein said slats are of stepwise increasing height in the direction of fluid flow with bottom edges terminating in a diagonal plane through a junction and upper edges terminating in a plane parallel to the plane of said throttle elements, said upper edges of said slats being provided with arrays of tongues bent alternately in opposite directions to impart a Y-section to each slat, said tongues extending toward said throttle elements from the plane of the upper edges of said slats.

8. The device defined in claim **7** wherein said chamber forms part of an electrostatic precipitator.

9. In a device for feeding a fluid to a chamber comprising a housing forming a duct opening at one end into said chamber and communicating at another end with a source of fluid, wherein said chamber contains means to treat the fluid, said means to treat the fluid being spaced from said one end of said duct, and a planar array of mutually parallel throttle elements extending across the cross section of said duct, each of said throttle elements having a V-cross section with codirectionally facing ridges and aprons divergent from said ridges and wherein said fluid is a gas and solid particles descend from said chamber through said array of throttle elements, said ridges being turned toward said chamber, the improvement wherein each of said throttle elements comprises a support beam of T-cross section having a shank and a cross-bar and at least one sheet metal strip defining said aprons and resting on said beam with the ridge extending along the shank of the T and flanks of said strips resting against the ends of said crossbar.

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