March 4, 1952 R. G. HANNEMAN 2,588,111

ELECTRICAL PRECIPITATION APPARATUS

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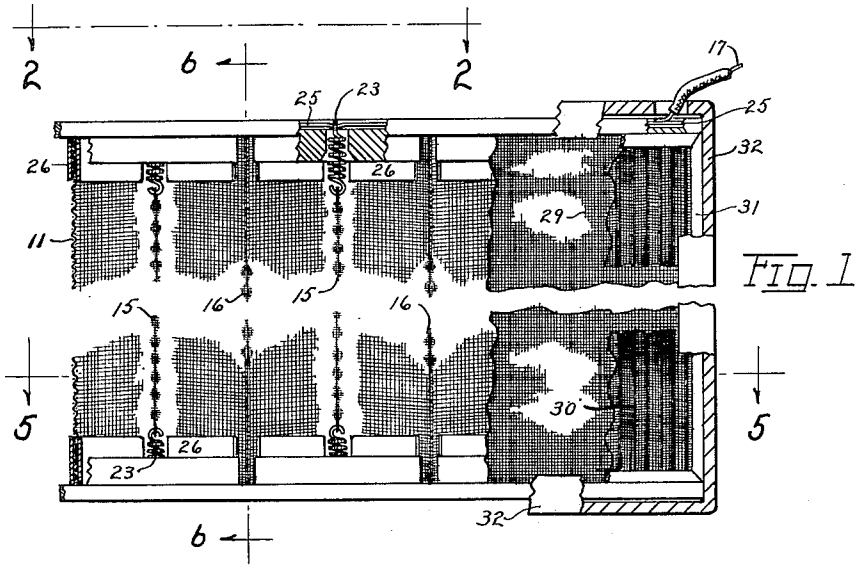


FIG. 1

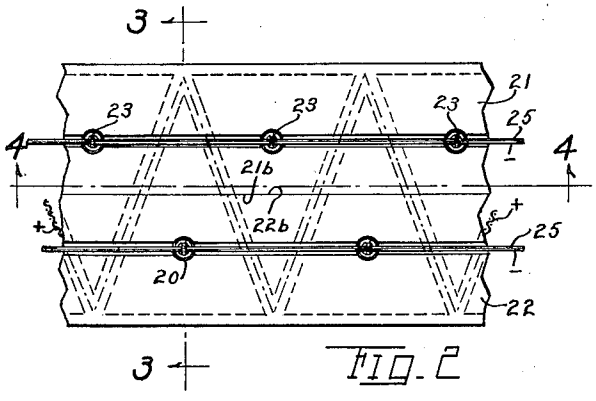


FIG. 2

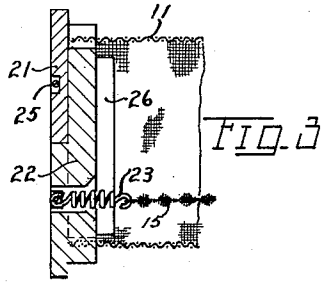


FIG. 3

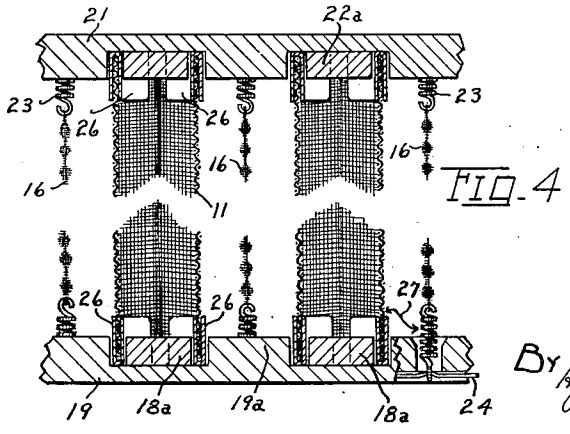


FIG. 4

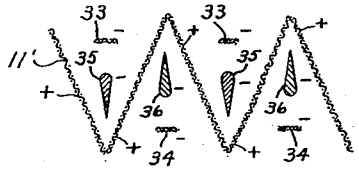


FIG. 10

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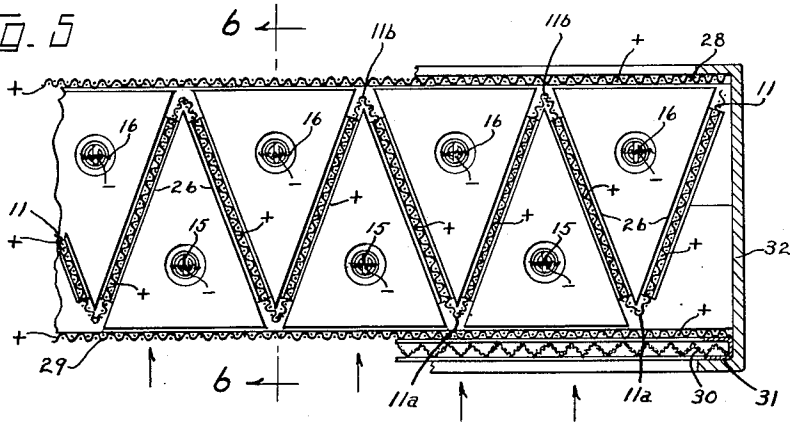
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ELECTRICAL PRECIPITATION APPARATUS

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FIG. 5



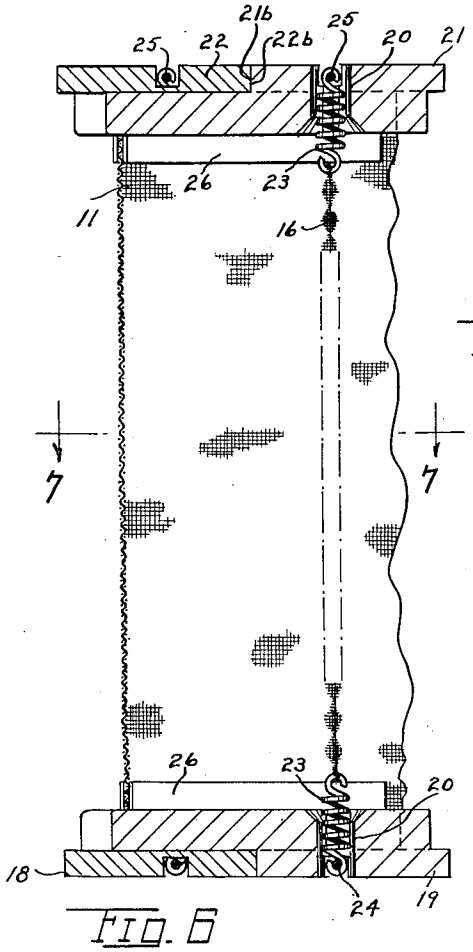


FIG. 6

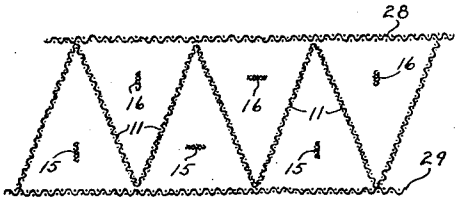


FIG. 7



FIG. 9

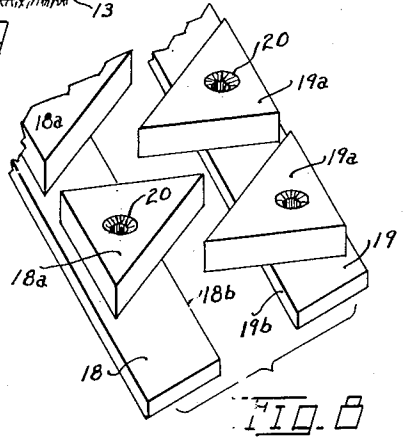


FIG. 8

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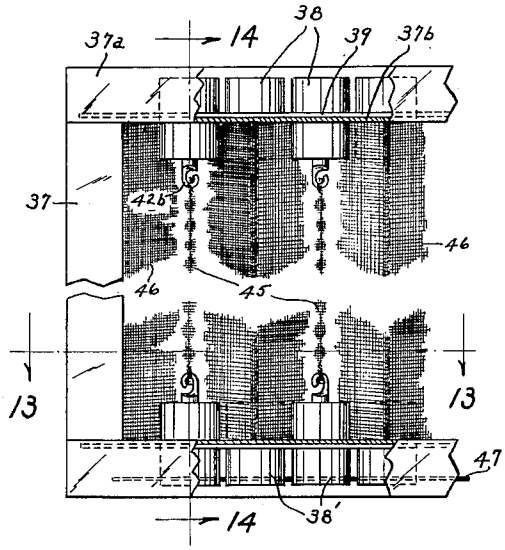


FIG. 11

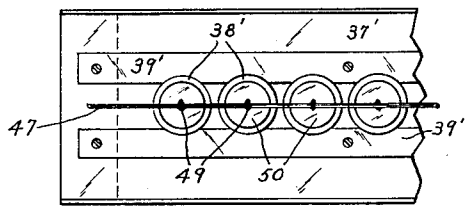


FIG. 12

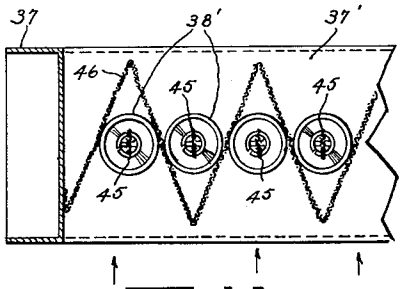


FIG. 13

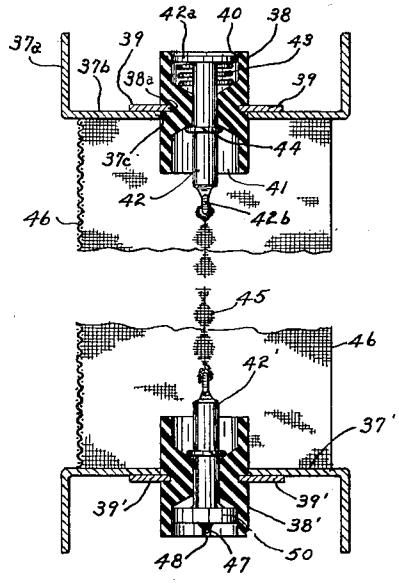


FIG. 14

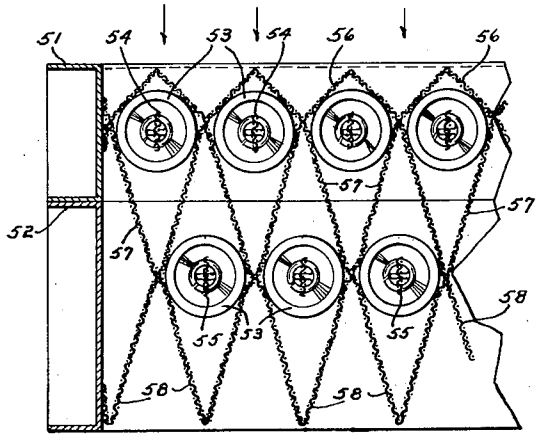


FIG. 15

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Patented Mar. 4, 1952 2,588,111

UNITED STATES PATENT OFFICE

2,588,111

ELECTRICAL PRECIPITATION APPARATUS

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Application April 8, 1946, Serial No. 660,312

3 Claims. (Cl. 183—7)

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This invention relates to improvements in electrical apparatus for the removal of particles from a fluid stream.

One of the objects of the present invention is to provide a novel arrangement of one or more fluid-pervious layers and discharge electrodes associated therewith.

Another object of the present invention is to provide in a fluid stream a fluid-pervious collection electrode positioned upstream from a discharge electrode.

Another object of the present invention is to provide a novel collecting electrode comprising an electrically conducting base having a coating consisting of a myriad of short fine filaments such as flocking, together with means for charging said electrode so as to cause the filaments to stand out from the collecting electrode thus providing a very great area for the collection of particles out of the fluid stream.

Another object of the present invention is to provide a novel arrangement of a zig-zag collecting electrode with associated discharge electrodes either with or without other collection electrodes extending across the ridges of the zig-zag electrode.

Another object of the invention is to provide novel frame means upon which the discharge electrodes are assembled, the frame means being so arranged as to hold the zig-zag collecting electrode in proper position.

Other objects and advantages of my invention will be apparent from the accompanying drawings and description and the essential features thereof will be set forth in the appended claims.

In the drawings,

Fig. 1 is a fragmental front elevational view of one form of my invention, parts thereof being broken away to more clearly show the construction;

Fig. 2 is a fragmental top plan view taken along the line 2—2 of Fig. 1;

Fig. 3 is a fragmental sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a fragmental sectional view taken along the line 4—4 of Fig. 2;

Fig. 5 is a fragmental sectional view taken along the line 5—5 of Fig. 1;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 5;

Fig. 7 is a fragmental sectional view taken along the line 7—7 of Fig. 6;

Fig. 8 is a fragmental perspective view showing parts of the coacting frame members;

Fig. 9 is a fragmental view greatly enlarged

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showing a wire coated with flocked material as utilized in one form of my invention;

Fig. 10 is a fragmental view similar to Fig. 7 but showing a modified arrangement of discharge electrodes;

Fig. 11 is a fragmental front elevational view of a modified form of my device;

Fig. 12 is a bottom plan view thereof;

Fig. 13 is a sectional view taken along the line 13—13 of Fig. 11;

Fig. 14 is a sectional view enlarged taken along the line 14—14 of Fig. 11; while

Fig. 15 is a view similar to Fig. 13, but showing a still further modification.

My invention is useful with different types of fluid streams for the separation of different types of particles carried thereby. For instance, it might be used for the collection of liquid particles from a gaseous stream or in some instances for the collection of solid particles out of a stream of dielectric liquid. I have chosen, however, to describe my device as utilized for the collection of solid particles out of a stream of gas or air with the understanding that I reserve the right to use the apparatus disclosed for any purpose for which it is adapted.

In the device as shown in Figs. 1 to 9, I have provided a collecting electrode 11 arranged in zig-zag form extending across the stream to be filtered, the flow of the stream being in the direction of the arrows of Fig. 5. This layer is of fluid-pervious material and preferably, it is formed of a screen mesh base of electrically conductive material such as wire, and to increase the effectiveness of collection, the wire base 12, as best seen in Fig. 9, is coated with a myriad of small particles preferably of a filamentary or fibrous character such as flocking. In Fig. 9, I have greatly exaggerated the structure wherein the wire 12 is first given a coating 13 of a lacquer or cement, preferably one having proper dielectric qualities. Thereafter, while the material is still tacky it is thoroughly covered and coated with a myriad of fibrous filaments 14 of cotton, wool, rayon, or other similar fiber. It will be noted that the zig-zag layer, as best seen in Figs. 5 and 7, presents a series of ridges 11*a* upstream and another series of ridges 11*b* downstream.

Intermediate the upstream and downstream ridges, and generally parallel thereto, I provide a series of discharge electrodes 15 which are spaced from the folds of the zig-zag layer, and in general, positioned somewhat centrally of the triangular area included in each of the folds.

Preferably, two of these series are provided, the series 15 on the upstream side of the layer 11 as above described, and a similar series 16 on the downstream side of the same layer. Means, not shown, is provided for supplying electrical charges of opposite sign to the discharge electrodes 15 and 16 on the one hand and the collecting electrode 11 on the other. Such means are well known in the form of power packs wherein ordinary alternating current electricity is stepped up to a higher voltage by means of a transformer, and this current, of high voltage, is then passed through rectifying tubes to provide a direct current which is connected by means of wires 17 to electrodes 15 and 16 by means later described, and the other side of the power system is connected through ground or otherwise to the collecting electrodes 11 or other collecting electrodes later described.

Novel means is provided for assembling the electrodes as follows. Referring especially to Figs. 6 and 8, at the bottom I provide two frame members 18 and 19, each of which extends entirely across the open bottoms of the zig-zag folds. Integral with the frame member 18 are a series of triangular blocks 18*a* and in staggered relation thereto is a series of similar blocks 19*a* on the frame portion 19. Each of the blocks 18*a* and 19*a* is drilled as indicated at 20 to receive one of the dischange electrodes 15 or 16. When the parts of Fig. 8 are assembled, the frame portions 18 and 19 meet along their entire length at the faces 18*b* and 19*b*. This will cause the apexes of the blocks 18*a* to overlie the frame portion 19 and in similar manner, the apexes of blocks 19*a* overlie the frame portion 18. In this assembled position the blocks 18*a* and 19*a* snugly embrace the ends of the zig-zag layer 11 between them as clearly shown in Fig. 4. The construction at the top of the panel is the same as that just described and comprises frame members 21 and 22 in all respects similar to those described at 18 and 19. These meet along the faces 21*b* and 22*b* as shown in Figs. 2 and 6 when the frames are assembled. Thus, the upper frame portions 21 and 22 provide blocks 21*a* and 22*a*, respectively, for snugly engaging opposite sides of the zig-zag layer 11 at the upper ends thereof.

Novel means is provided for mounting the discharge electrodes 15 and 16 in the top and bottom frame portions. As clearly shown in Figs. 1, 2, 3, 5 and 6, the openings 20 drilled through the frame portions and blocks 18, 19, 21 and 22 are adapted to receive the upper and lower ends respectively of each of the electrodes 15 or 16. For holding these electrodes taut I have provided small helical springs 23 at each end of each electrode 15 and 16, these springs being held in tension between the end of the electrode and a wire retainer member 24 at the bottom and 25 at the top. Each of these wires lies on the outside of its associated frame portion and extends through the end loop of one of the springs 23. As clearly shown in Fig. 1, the wires 24 and 25 thus withstand the tension of the springs 23 which hold the electrodes taut. The wires 17 for conducting current to the electrodes 15 and 15 are electrically connected to the wires 24 or 25 for this purpose.

Means is provided at the tops and bottoms of the zig-zag folds to provide an elongated path to prevent arcing of current between the positive and negative electrodes. This means comprises a strip 26 of insulating material such as a suitable synthetic resin, folded along both the bottom and top edges of each of the zig-zag folds where they enter the bottom frame members 18, 19 and the top frame members 21, 22. The strips 26 extend for a short distance along the members 11 away from the end frame members so that if the current is to arc over from an electrode 15 or 16 to the electrode 11 it must travel the path indicated at 27 in Fig. 4. In other words, it must travel from the bottom of one of the pockets 20 along the beveled or frustronconical end surface thereof, then along one of the surfaces of the blocks 18*a* or 19*a*, and then along that portion of one of the strips 26 which extends part way along the electrode 11. This effectively prevents arc-over at these points.

Obviously, a plurality of the layers 11 might be provided in series in the direction of gas flow in order to more effectively filter particles from the gaseous stream. This would be a duplication of the principles involved.

Other means may be provided to aid in the collection of particles out of the gaseous stream. Referring to Figs. 5 and 7, a collecting electrode 28 may be provided on the downstream side of the panel extending across and substantially touching the ridges 11*b* of the layer 11. This electrode is given a charge of the same sign as that of the layer 11. The layer 28 is pervious to gas flow and may be of wire mesh 12, also provided with the lacquer coating 13 and the flocking coating 14. Any particles which are not caught on the layer 11 are provided additional collecting means on the electrode 28.

Futher collecting means may be provided by by a collecting electrode 29 on the upstream side of the layer 11. This electrode extends across and adjacent the ridges 11*a* of the layer 11. It is given an electrical charge of the same sign as the layer 11. It is of gas-pervious material and may likewise be constructed of woven wire mesh 12 having a coating 13 of lacquer and a coating 14 of fllocking material, if desired. To my knowledge, it is new in this art to thus provide a collecting electrode upstream of the electrodes 15.

In all forms of my device where the flocking coating 14 is utilized, upon applying an electrical charge to the apparatus every one of the fibers of flocking material is charged and stands out from the collecting electrode providing a tremendous charged area for the collection of very fine dust particles even as small as particles of cigarette smoke.

Means may be provided upstream of the electrically charged apparatus above described, if necessary, for a preliminary screening of the gaseous stream to be filtered. Such a construction is illustrated in Fig. 5 where a layer 30 of filter material without electrical charge is mounted in a subframe 31 which in turn is mounted in the main frame 32 which provides a common holding means for the filter 30 and the electrically charged filter first described. The purpose of the filter 30 is to remove particles such as lint, or other large particles which may be collected on an impingement type of filter not requiring an electrically charged filter for retaining the particles.

Instead of a single electrode in each of the zig-zag fold compartments, as shown at 15 and 16 in the first described form of my device, I may provide a plurality of such electrodes in each of these compartments. In the modification of Fig. 10, I have illustrated diagrammatically such a construction where a layer 11′ of gas-pervious material is provided and charged by means not

shown with an electrical charge of one sign. The electrodes **33** and **34** are analogous to the electrodes **15** and **16** previously described, and are provided by means not shown with an electrical charge of a sign opposite to that of the layer **11'**. Additional electrodes **35** and **36** are provided nearer the apexes (as viewed in section) of the V-shape zig-zag folds, as shown in Fig. 10. By electrical means not shown, the electrodes **35** and **36** are given a charge of the same sign as electrodes **33** and **34**. By this means, I provide a more uniform flux throughout the area of the layer **11'** so as to increase the efficiency of collection over that possible with the first described form of my apparatus.

A modification of my device is shown in Figs. 11 to 14 inclusive. The principles used here are the same, the difference consisting in the manner of mounting the electrodes. Here the frame **37** may be, but need not be, of electrically insulating material. The upper frame member **37*a*** has a web **37*b*** through which are provided a series of openings **37*c***. In each of these openings is mounted a generally cylindrical insulator **38** having suitable dielectric qualities. In each side of each insulator there is provided a notch **38*a*** and strips **39** which enter these notches, extend entirely along the web **37*b*** and are secured thereto in order to hold the insulators in place. Each of the insulators has a cup-shape opening **40** at the top thereof and a cup-shape opening **41** at the bottom thereof. In the narrow mid portion of the insulator a stem **42** is mounted for reciprocation. On the upper end of the stem is a fixed head **42*a***. A helical spring **43** engages between a shoulder of the insulator and the head **42*a*** to force the stem **42** upwardly. A snap ring **44** limits this upward movement. To a hook **42*b*** on the lower end of stem **42** is secured an electrode **45** in all respects like the electrodes **15** and **16**, previously described. The bottom ends of the electrodes are held by the stem **42'** mounted in an insulator **38'** which may be exactly like the insulator **38** previously described, but, as shown, the spring **43** may be omitted, as one spring is sufficient to hold the electrode taut. These bottom electrodes are held in position by plates **39'** which are secured to the bottom frame member **37'**.

The collecting electrode **46** is of zig-zag form, as clearly shown in Fig. 13, and is folded back and forth between the insulators **38** at the top and **38'** at the bottom, being sufficiently stiff to be held in place by contact with the insulators. A comparison of Fig. 13 with Figs. 5 and 7 of the first described form will show a similar arrangement, namely, pockets of the zig-zag electrode opening upstream, other pockets of the zig-zag electrode opening downstream and a discharge electrode **45** in each of these pockets. The collecting electrode **46** touches the top, bottom and sides of the frame **37** so that it is sealed at these points. The material of this electrode may be any of those mentioned in connection with the first described modification.

Means is provided for applying electrical charges of opposite sign to the electrodes **45** on the one hand, and electrode **46** on the other. The connection to electrodes **45** comprises a wire **47** clearly shown in Figs. 11, 12 and 14 as extending along the bottom row of insulators **38'** and through notches **48** cut in the ends thereof. This wire **47** is brazed or soldered at the points **49** where it touches each of the heads **50** of the stems **42'**. One side of a direct current power supply is connected to the wire **47** and the other side thereof, either through ground, or otherwise connected to the electrode **46** by means not shown.

A further modification is shown in Fig. 15 wherein two frames **51** and **52**, each similar to the frame **37** just described, are placed side by side in abutting relationship with the openings through the panels in alinement. Across the top and bottom members of these frames are secured a series of insulators **53**, the ones at the top being exactly like those shown at **38'** and the ones at the bottom being like either **38** or **38'** described above. These insulators support the series of electrodes **54** and **55**. In this form of my device two or preferably three collecting electrodes are provided, namely, **56**, **57** and **58**. Each of these collecting electrodes may be like that described at **11** in my first described form, but I find where the flow of the gaseous stream is in the direction of the arrows of Fig. 15, I may provide the electrode **56** of bare screen wire having electrical conducting properties. The electrodes **57** and **58** may then be made of flocked wire screen as previously described. It will be noted that the zig-zag folds of the electrode **56** are much shallower than the folds of the electrodes **57** and **58**. In each case, they are held in place by contact with the insulators **53**. It should be understood that electrodes **56**, **57** and **58** completely fill the frame in the same manner as described in connection with electrode **46** of Figs. 11 to 14, so that the edges are sealed against the passage of gas. Note that the downstream ridges of electrode **56** abut the upstream ridges of electrode **57**. Also, the downstream ridges of electrode **57** abut the upstream ridges of electrode **58**.

Means, not shown, is provided for applying an electrical charge of one sign to the electrodes **54** and **55** and for supplying a charge of the opposite sign to the electrodes **56**, **57** and **58**. It results from the above construction that a very strong electrical flux is provided between the electrodes **54** and both electrodes **56** and **57** at the upstream side of the panel, while a similar flux is created between the electrodes **55** and both electrodes **57** and **58** at the downstream side of the panel. This form of my device is therefore very efficient in collecting particles out of a gaseous stream passing through the panels in the direction of the arrows.

What I claim is:

1. Means for filtering particles out of a fluid stream comprising a layer of electrically conductive material pervious to said fluid, said layer having a generally zig-zag folded formation providing ridges facing alternately upstream and downstream, holding frames extending across the open ends of said zig-zag folds, a pair of said frames at each end of said folds, each pair providing triangular blocks for engaging in a trough and two adjoining flanks of each fold on opposite sides thereof, each pair of frames when assembled with said layer causing said blocks to firmly engage between them and to hold the ends of said zig-zag folds, means for holding said frames so assembled, and a series of discharge electrodes intermediate said upstream and downstream ridges and generally parallel thereto and spaced from said zig-zag folds, each of said electrodes having its opposite ends mounted in said frames at opopsite ends respectively of said folds.

2. The combination of claim 1 wherein said frames are of insulating material, and dielectric material is provided at each end of each fold where it engages between said blocks, said dielectric material extending along each fold a

short distance toward the opposite end thereof, and means for applying electrical currents of opposite sign to said layer and to said electrodes.

3. Means for filtering particles out of a fluid stream comprising a layer of electrically conductive material pervious to said fluid, said layer having a generally zig-zag folded formation providing ridges facing alternately upstream and downstream, holding frames extending across the open ends of said zig-zag folds, a pair of said frames at each end of said folds, each pair providing triangular blocks for engaging in a trough and two adjoining flanks of each fold on opposite sides thereof, one frame of a pair carrying all of said blocks on one side of said layer at one end of said folds, the other frame of the pair carrying all of said blocks on the other side of said layer at the same end of said folds, each pair of frames when assembled with said layer causing said blocks to firmly engage between them and to hold the ends of said zig-zag folds, means for holding said frames so assembled, and a series of discharge electrodes intermediate said upstream and downstream ridges and generally parallel thereto and spaced from said zig-zag folds, each of said

electrodes having its opposite ends mounted in said frames at opposite ends respectively of said folds, there being a series of said electrodes on each side of said layer, and all of the electrodes of one series being carried by one of a pair of said frames, whereby, upon disassembly each series of electrodes may be removed as a unit.

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