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3,181,284

ELECTROSTATIC AIR FILTER

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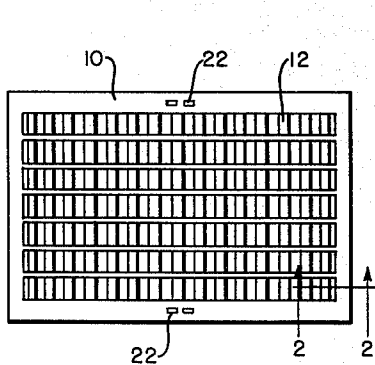


FIG. 1

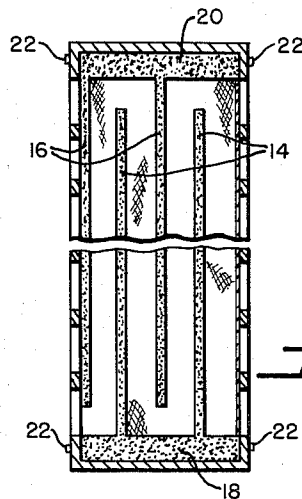


FIG. 3

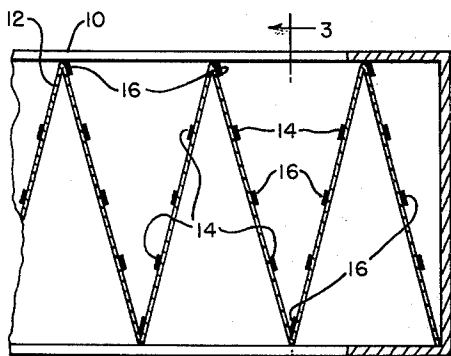


FIG. 2

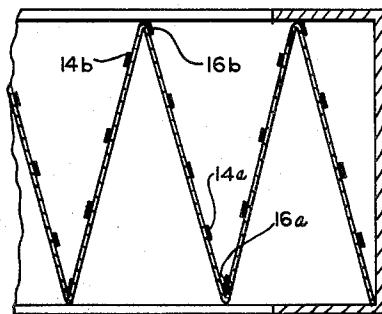


FIG. 4 (PRIOR ART)

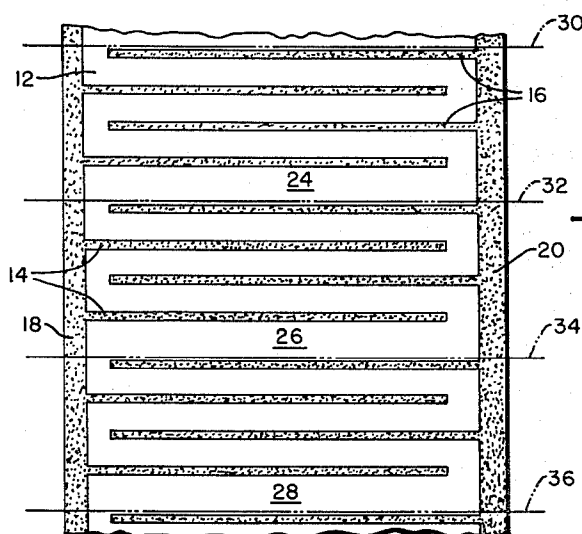


FIG. 5

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ELECTROSTATIC AIR FILTER

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5 Claims. (Cl. 55—132)

This invention relates to electrostatic air filters.

Rivers' U.S. Patent 2,868,319 and Rivers et al. U.S. Patent 2,908,348 disclose an electrostatic air filter wherein an air porous, dielectric web, filter medium provided with a condenser-like series of equally spaced conductive stripes for distributing an electrostatic charge thereover is arranged in accordion pleated fashion in a cell. In one form shown in the patents each half pleat has an average of four spaced conductive strips with a pleat fold line occurring in the middle of every fourth stripe so that each crest and each trough line splits a stripe. In practice this arrangement has not been followed since the conductive ink used results in a stripe that, when dry, is too stiff to permit folding the web on the stripe without tearing the web. Therefore, in practice the fold lines have been provided closely adjacent the edge of every fourth stripe. With this folding arrangement and with the rather wide heavy stripes employed to insure the conductive continuity of the stripes, there has been a problem at times of arcing between the alternate stripes (connected to one electrical potential) and adjacent intermediate stripes (connected to another electrical potential), in the trough areas particularly and in the crest areas to a somewhat lesser extent.

Therefore, the object of this invention is the provision of a conductive stripe arrangement which substantially minimizes the arcing problem with a filter medium of the described character.

In accordance with the invention, the series of stripes on the half pleats facing in one way, and the series of stripes on the adjacent half pleats facing in the generally opposite way are spaced apart sufficiently, as measured along the contour of the web, that in pleated form the straight line distance between the last stripe on one half pleat and the first stripe on the next adjacent half pleat is not substantially less than the spacing between adjacent alternate and intermediate stripes in any one series. The spacing is also arranged so that alternate stripes on adjacent half pleats are substantially directly opposite each other, and intermediate stripes on the adjacent half pleats are also substantially directly opposite each other.

The invention will be explained in more detail in connection with the accompanying drawing wherein:

FIGURE 1 is a face view of a filter cell containing a corrugated web according to the invention;

FIGURE 2 is an enlarged fragmentary section taken through FIGURE 1 along the line 2—2 which extends at a right angle to the corrugations;

FIGURE 3 is a broken section corresponding to one taken through FIGURE 2 along the line 3—3, which extends parallel to the corrugations and the pleat lines;

FIGURE 4 is a fragmentary section corresponding to the FIGURE 2 section, but illustrating the prior art commercial practice with respect to the spacing of conductive stripes; and

FIGURE 5 is a plan view of a dielectric web in flat form provided with conductive stripes arranged according to the invention.

Details of the frame structure, the character of the dielectric web material, the means for supporting the filter cell in a housing and connecting the cell to a source of electrical power are detailed in the noted Rivers and

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Rivers et al. patents and therefore will be herein described only briefly.

The frame is a generally open-faced, perimetric frame 10 of non-conductive material in which the air pervious, dielectric web 12 is secured in pleated form by an adhesive where the web contacts the frame.

The conductive stripes (FIGURES 2 and 3) applied to the web are herein characterized as alternate stripes 14 adapted to be connected to one electrical potential, and intermediate stripes 16 adapted to be connected to another electrical potential. The alternate stripes merge into one longitudinal conductive margin 18, and the intermediate stripes merge into the opposite longitudinal conductive margin 20. As shown, the alternate stripes terminate short of the margin to which the intermediate stripes are connected, and the intermediate stripes terminate short of the margin to which the alternate stripes are connected. While the conductive stripes and margins may be applied to the web in various ways, the presently preferred way is to print the web with a graphite ink. A fairly heavy coating is applied to insure electrical continuity of the lines since the surface of the presently preferred web is not ideal from the standpoint of printing.

The electrical connections between a power source and the conductive margins, which serve to conduct the respective potentials to the respective stripes, may be effected in one way through metal staples 22 (FIGURES 1 and 3) projecting through the frame margins and contacting the margins. When the filter cell is installed in a housing (not shown), these staples serve as conductors between a stationary contact exterior of the cell and the conductive margins 18 and 20.

An understanding of the significance of the arrangement of conductive stripes provided in accordance with the invention will be facilitated, it is believed, by preliminary consideration of the striping arrangement of the commercially practiced prior art generally illustrated in FIGURE 4. In that case the web is printed, before pleating, with the conductive stripes being equally spaced along the entire length of the web, and the web is then pleated closely adjacent one edge of every fourth stripe. In one web, which will herein be used as an example, each half pleat is $1\frac{1}{8}$ inch wide and carries four equally spaced, nominally $\frac{1}{16}$ inch wide stripes thereon. Because of the relative roughness of the web surface, and the printing method employed, the stripes frequently have portions thereof up to $\frac{3}{32}$ inch wide rather than the intended $\frac{1}{16}$ inch.

In the example, the pleated web is confined within a frame having an inside thickness or depth dimension of $1\frac{1}{16}$ inches and is secured therewithin with adjacent half pleats forming isosceles triangles. With this arrangement the adjacent stripes along any half pleat are uniformly spaced $1\frac{1}{32}$ inch center-to-center, and the space between adjacent edges of adjacent stripes is nominally $1\frac{1}{32}$ inch. However in the trough area formed between adjacent half pleats, the straight line distance between adjacent edges of the last alternate stripe 14a and the first intermediate stripe 16a is $\frac{1}{32}$ inch or less because of the folding back of the web upon itself and the depth of the printing ink itself forming a stripe. In practice this space is usually even closer because of the stripes being of greater width than $\frac{1}{16}$ inch, and the pleat lines being spaced $\frac{1}{32}$ to $\frac{1}{16}$ inch from the extreme edge of the stripes. As a result, arcing between stripes normally occurs most frequently in the trough area, and this condition is aggravated by dust and lint gathering in the trough in a manner which tends to bridge the gap between the two trough stripes of different electrical sign.

The area in which arcing next most frequently occurs after the trough areas is the crest areas, with the arcing

occurring between the alternate line 14b and intermediate line 16b (FIGURE 4). Even though these lines are on oppositely facing surfaces of the adjacent half pleats, the folding of the web and the width of the stripes results in the adjacent edges of the two stripes being closer together, in a straight line distance, than any of the adjacent stripes on any one half pleat.

In accordance with the invention, and in contrast with the commercial prior art practice, the conductive stripes are arranged in successive distinct series of stripes on successive half pleats. The stripes within any one series are uniformly spaced, but the spacing between the last stripe of one series and the first stripe of the next successive series is greater than between adjacent stripes within a series. This arrangement of separate series of stripes is perhaps best illustrated in FIGURE 5 wherein a printed web is shown before pleating. The successive series of stripes are separated by the successive spaces 24 and 26 and 28 which are of greater width than the space between alternate and intermediate stripes 14 and 16, respectively, within any one series. One fold line corresponding to a crest is indicated by a broken line 30, another fold line corresponding to a trough is indicated by a broken line 32 and the next crest and fold lines are indicated by the broken lines 34 and 36, respectively. The web half pleat of FIGURE 3 may be considered as corresponding with the web area between either the fold lines 30 and 32, or 34 and 36, of FIGURE 5.

With this stripe spacing arrangement in the flat web, the resulting stripe arrangement in the pleating web is perhaps best perceived from FIGURE 2. There it will be seen that the spacing between, (1) the lower edge of the last or lowest alternate stripe 14 on a half pleat generally facing the right and, (2) the upper edge of the first or lowest intermediate stripe 16 on the adjacent half pleat generally facing the left, is approximately equal to the spacing between any two adjacent stripes of a series on a half pleat. It will also be noted that alternate stripes 14 on one half pleat are approximately direct across from the alternate stripes on the adjacent half pleat; and the intermediate stripes 16 on adjacent half pleats are correspondingly opposite each other. This arrangement is superior to the commercial prior art arrangement of FIGURE 4 in that if any two adjacent half pleats define a lesser angle than proper (i.e., are collapsed toward each other in accordion fashion), the stripes of the same sign will tend to register with each other rather than being offset from each other, and the distance between stripes of different electrical sign will remain the same. This is so regardless of whether the adjacent half pleats have the stripes on the surfaces facing each other or oppositely facing. In contrast thereto, if the FIGURE 4 adjacent half pleats are collapsed toward each other, the spacing between stripes of different electrical sign will be substantially reduced.

While the invention has been described in connection with series having an even number of stripes in each series, it is equally applicable where each series has an odd number of stripes, the only difference being that the first stripe of each successive series will alternate in electrical sign from the first stripe of the immediately preceding series.

The invention claimed is:

1. An accordion pleated dielectric filter medium having an arrangement of conductive stripes disposed thereon for distributing an electrostatic charge thereover, comprising:

- (a) a series of alternate and intermediate stripes adapted for connection to respectively different electrical potentials on each half pleat, the stripes on each half pleat being substantially equally spaced and disposed parallel to the pleating lines of said medium, all half pleats facing in one direction having their first stripes closely adjacent but not on crests and their last stripes spaced a substantial dis-

tance from troughs, and all half pleats facing in the generally opposite direction having their first stripes closely adjacent but not in troughs and their last stripes spaced a substantial distance from crests,

- (b) the last stripe of said series on each half pleat which faces one way, and the first stripe of said series on each adjacent half pleat which faces the generally opposite way being spaced apart a sufficiently greater distance, as measured along the contour of the medium, than the distance between adjacent stripes in any one series that, in pleated form, the straight line distance between the said last stripe on one half pleat and the said first stripe on the next adjacent half pleat is not substantially less than the distance between adjacent stripes in any one series,
- (c) said filter medium being devoid of any of said stripes lying on crest fold lines and lying in trough fold lines formed between said half pleats.

2. In a dielectric filter medium having spaced conductive stripes on one face thereof for distributing an electrostatic charge thereover, said medium being arranged in pleated form with said stripes extending in generally parallel relation to the crests and troughs of the medium in that form, the improvement comprising:

- (a) a series of substantially equally spaced conductive alternate and intermediate stripes on each half pleat,
- (b) all half pleats facing in one direction having their first stripes closely adjacent but not on crests and their last stripes spaced a substantial distance from troughs,
- (c) all half pleats facing in the generally opposite direction having their first stripes closely adjacent but not in troughs and their last stripes spaced a substantial distance from crests,
- (d) the distance, following along the contour of said medium, between the last stripe of each half pleat and the first stripe of each adjacent half pleat being sufficiently greater than the distance between adjacent alternate and intermediate stripes on any one half pleat that the straight line distance between adjacent edges of each last stripe on a half pleat and each first stripe on an adjacent half pleat is at least as great as the distance between adjacent alternate and intermediate stripes of any one series,
- (e) said filter medium being devoid of any of said stripes lying on said crests and in said troughs formed between said half pleats.

3. An accordion pleated dielectric filter medium having an arrangement of conductive stripes disposed thereon for distributing an electrostatic charge thereover, comprising:

- (a) a series of alternate and intermediate stripes adapted for connection to respectively different electrical potentials on each half pleat, the stripes on each half pleat being substantially equally spaced and disposed parallel to the pleating lines of the said medium,
- (b) the series of stripes on each half pleat which faces in one direction having a first stripe closely adjacent but not on a crest and a last stripe spaced a first distance from a trough, said first distance being greater than the distance between adjacent alternate and intermediate stripes on a half pleat,
- (c) the series of stripes on each half pleat which faces in the generally opposite direction having a first stripe closely adjacent but not in trough and a last stripe spaced from the crest a distance equal to said first distance,
- (d) the spacing distance between adjacent stripes on all said half pleats, and said first distance, being such that the last stripe on each half pleat is substantially directly opposite the second stripe on an adjacent half pleat, and successive stripes preceding said last stripe are substantially directly opposite correspondingly successive stripes following said second stripe,

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- (e) said filter medium being devoid of any of said stripes lying on said crests and in said troughs formed by said pleating lines of said medium.
4. An accordion pleated dielectric filter medium having an arrangement of conductive stripes disposed thereon for distributing an electrostatic charge thereover, comprising:
- (a) a series of alternate and intermediate stripes adapted for connection to respectively different electrical potentials on each half pleat, the stripes on each half pleat being substantially equally spaced and disposed parallel to the pleating lines of said medium,
- (b) the series of stripes on each half pleat which faces in one direction having a first stripe closely adjacent but not on a crest and a last stripe spaced a substantially greater distance from the trough than the spacing distance between adjacent stripes in said series,
- (c) the series of stripes on each half pleat which faces in a generally opposite direction having a first stripe closely adjacent but not in a trough and a last stripe spaced from a crest a distance substantially equal to said distance between the last stripe and trough of said other half pleats,
- (d) the spacing distance between adjacent stripes in a series, and the distance of said last stripes from said trough and said crests respectively, being such that except for first stripes in a series alternate stripes on adjacent half pleats are substantially directly opposite alternate stripes, and intermediate stripes on adjacent half pleats are substantially directly opposite intermediate stripes,
- (e) said filter medium being devoid of any of said stripes lying on said crests and in said troughs formed by said pleating lines of said medium.
5. An accordion pleated dielectric filter medium having an arrangement of conductive stripes disposed thereon for distributing an electrostatic charge thereover, comprising:
- (a) a series of alternate and intermediate stripes adapted for connection to respectively different electrical potentials on each half pleat, the stripes on

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- each half pleat being substantially equally spaced and disposed parallel to the pleating lines of said medium,
- (b) alternate half pleats having first stripes of their series closely adjacent but not on crests and last stripes of their series spaced from troughs a distance greater than the distance between adjacent alternate and intermediate stripes within said series,
- (c) intermediate half pleats having first stripes of their series closely adjacent but not in troughs and last stripes of their series spaced from crests a distance greater than the distance between adjacent alternate and intermediate stripes within said series,
- (d) and except for first stripes of said alternate and intermediate half pleats, alternate stripes of alternate half pleats being substantially directly opposite alternate stripes of adjacent intermediate half pleats, and intermediate stripes of alternate half pleats being substantially directly opposite in intermediate stripes of adjacent intermediate half pleats,
- (e) said filter medium being devoid of any of said stripes lying on said crests and in said troughs formed by said pleating lines of said medium.

References Cited by the Examiner

UNITED STATES PATENTS

2,502,560	4/50	Dahlman	55—132
2,650,672	9/53	Barr et al.	55—138
2,729,302	1/56	True	55—132
2,864,460	12/58	Powers	55—132
2,868,319	1/59	Rivers	55—132
2,888,092	5/59	Powers	55—132
2,908,348	10/59	Rivers et al.	55—132

FOREIGN PATENTS

163,097 5/55 Australia.

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Examiners.