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(19)

(54) A METHOD OF MANUFACTURING A FILTER ELEMENT

(71) We, LUCAS INDUSTRIES LIMITED, a British Company, of Great King Street, Birmingham B19 2XF, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a method of manufacturing a filter element which is intended for use in filtering particles from a flow of gas (such as air) or liquid, the filter element being of the kind (hereinafter referred to as the kind specified) in which a sheet of filter material is formed with a plurality of spaced parallel fold lines about which said material is folded to form a series of pleats, the ends of said pleats being directly connected together to form a plurality of pockets.

Filter elements of the kind specified may be used for example to filter particles from a flow of air used for forming a combustible mixture in an internal combustion engine and it is known to use such filter elements both in a flat or panel-like configuration or in a cylindrical configuration, the flat or panel-like type being frequently required where (as is the case in many modern designs of motor vehicle) the engine compartment is required to have a relatively low profile. A problem does however arise in ensuring that the ends of the series of pleats are securely connected together to form the plurality of pockets and thereby avoid any gaps in such pockets which would result in at least some of the fluid which is to be filtered bypassing the filter material. Adhesive may be used to connect together said pleats to form the pockets but another problem arises in ensuring that the pockets when formed in the completed filter element are spaced apart by the desired distance. Hitherto, in one known machine for forming such filter elements inter-meshing gear-like paddles are used but care has to be taken that such paddles do not come into contact with the adhesive where used and furthermore the speed of the machine and therefore the rate of production of filter elements are limited. Furthermore the use of such paddles to form the pleats may result in said pleats not being connected together by the adhesive over the whole depth of the pleats, e.g. because of problems that can arise with regard to the alignment and timing of the paddles, and therefore the subsequently formed pockets may in fact have the above-mentioned unwanted gaps formed in their ends.

The object of the present invention is to provide an improved method of manufacturing a filter element of the kind specified and which, inter alia, can be manufactured at a relatively high speed and in a manner which avoids the above-mentioned disadvantages.

In accordance with the present invention there is provided a method of manufacturing a filter element comprising the steps of forming a rectangular sheet of filter material adjacent to at least one longitudinal edge with a longitudinally extending fold line, forming a plurality of spaced parallel fold lines which each extend in a direction perpendicular to the longitudinally extending fold line, folding the filter material outwardly of said longitudinally extending fold line inwardly over the adjacent portion of the sheet of filter material, thereafter folding the sheet of filter material about the spaced parallel fold lines to form a series of pleats, and subsequently connecting the ends of the pleats directly together to form a plurality of pockets so that at least one end of each pocket comprises four thicknesses of material.

The sheet of filter material may be formed over its surface with a plurality of integrally formed spaced projections. Furthermore, material may be removed from said inwardly folded edge portion at positions adjacent to the ends of those fold lines which, when the sheet of filter material is folded to form pleats as aforesaid, will be disposed adjacent to the mouths of said pockets of the filter element.

The invention will now be more particularly described with reference to the accompanying drawings wherein:

Figure 1 is a perspective view of a partially folded filter element constructed by one example of a method in accordance with the invention, the element being shown however

without the projections which may be formed in the filter material;

Figure 2 is a plan view of a completed filter element constructed by one example of a method in accordance with the invention; and

Figures 3 and 4 are respectively an end and side view of the filter element shown in Figure 2, Figures 2, 3 and 4 showing the aforesaid projections.

Referring firstly to Figure 1 the partially formed filter element shown therein is formed from a generally rectangular sheet of filter material 10 of any convenient and known kind such as resin impregnated paper. At intervals along its length said sheet 10 is formed with a plurality of spaced parallel transverse fold lines 11 and at the same time the sheet is also formed with a plurality of spaced integral projections 12 (as for example may be seen in Figures 2, 3 and 4). Said projections 12 are formed by dimpling the filter material so that a projection on one surface of the sheet will correspond with a corresponding hollow on the other surface of the sheet. Furthermore the projections 12 are arranged so that some will project from one surface whilst the remainder project from the opposite surface.

The sheet 10 is also folded along at least one edge and, as shown, along each of two opposite edges which extend in directions transverse to said fold lines 11, namely the two longitudinal edges, so as to provide portions which are indicated by reference numeral 13 which are folded inwardly with respect to the remainder of the sheet to lie over the adjacent part of the sheet and thus form double thickness of material along each of said longitudinal edges.

The sheet of material 10 provided with the fold lines 11 as aforesaid can thus be folded about said fold lines in order to produce a plurality of pleats as are shown in the right-hand side of Figure 1. Furthermore if adhesive is applied to the outer surfaces of said portions 13 a plurality of connected pockets, generally indicated by reference numeral 14, will be formed. The purpose of the aforesaid projections 12 is to ensure that such pockets will remain in an open condition as is shown for example in Figures 2 and 4, projections on opposite sides of the pocket engaging each other as will be seen in these Figures. However, when the folding is being effected it is necessary to protect said projections so that they do not become flattened and thereby be rendered ineffective. The provision of such folded portions 13 which provide a double thickness of material along each of the longitudinal edges of said sheet affords such protection for the projections 12 when folding is effected. However, if said portions 13 were to be continuous along the respective longitudinal edges of the sheet 12 it will be appreciated that when folding is carried out alternate folds will have, adjacent their opposite ends, portions of such material 13 which will be disposed on the outside of bends produced by such folds. In other words, looking at Figure 1, the next fold to be effected along the fold line 11 which lies adjacent to the already folded section will result in parts of the portions 13 lying at the bottom of the next formed pocket and these parts will of course be disposed on the inside of the bend which forms the bottom of the pocket. On the other hand the next fold that will be made will result in parts of said portions 13 lying on the outside of the next bend to be effected, these parts of course being at the top of the next pocket, i.e. adjacent to the mouth thereof. Such parts will be in tension and unless such tension is removed or relieved the filter element will tend to curl about an axis which is generally parallel to the said fold lines 11 and this may be unacceptable in an element of flat or panel-like configuration. In order to prevent this happening therefore some of the material from said portions 13 is removed adjacent to the ends of those fold lines which extend along the top of the filter element as seen in Figure 1. Such material can be removed in any convenient manner. It can for example be effected by cutting holes or notches at spaced intervals along the two longitudinal edges of the sheet 10 before the portions 13 are folded over such fold or notches being disposed at the ends of alternate fold lines. Alternatively, as shown in Figure 1 the sheet 10 can be formed with such notices, as indicated by reference numeral 15 after the portions 13 have been folded over, and the notches can be formed by means for example of a knife or by means of an emery wheel. As previously mentioned adhesive would also be applied to the outer surfaces of portions 13 so that on folding the sheet 10 a plurality of interconnected pockets 14 will be formed, such pockets being held open by the projections 12 so as to present the maximum area of filter material to fluid (such as for example air) flowing from one side of the filter element to the other. In comparison with hitherto known filter elements of similar overall size, a filter element in accordance with the present invention will thus provide increased filtration area. Furthermore in forming a filter element by the above-described method the aforementioned gear-like paddles and timing devices therefor can be dispensed with and the pleats can be formed by successively exerting pressure on the series of spaced parallel fold lines whereupon the pleat can be completed by pushing the material in a longitudinal direction (previously formed pleats being held or restrained by a suitable

means) in concertina fashion and the pockets which will then be formed by reason of the adjacent pleats being connected together by the adhesive will be automatically spaced apart at the desired distance by reason of the inter-engagement of said projections 12 acting in conjunction with the folded over portions 13.

A filter element formed as above described can be used in a flat or panel-like form in which it is mounted in a synthetic resin base or in a base formed as a metal frame. Alternatively said filter element can be arranged in a generally cylindrical roll and in this case material need not be removed from said inwardly folded edge portions as above-described so that the filter element will then tend to curl into a generally curved or cylindrical form.

Furthermore, whilst the projections 12 formed on the filter material are, as shown, of circular form, it is to be understood that they can be of elongated or other shape or they can be dispensed with altogether.

Also, instead of forming notches 15 to relieve or remove the tension when the filter element is to be used in a flat condition as above-described, the filter element may be slit across the double thickness of material at the ends of those fold lines 11 which, when the sheet of filter material is folded, will be disposed adjacent to the mouths (as opposed to the closed ends) of pockets of the filter element, i.e. at those positions corresponding to the positions of the notches 15 shown in Figure 1. Such slitting can be effected by means of a pair of rollers used to form said fold lines 11, one roller having a series of circumferentially spaced outwardly projecting fins and the other roller having a series of corresponding grooves, the ends of alternate fins and co-acting grooves being so shaped in relation to each other as to slit the material as above-described.

WHAT WE CLAIM IS:

1. A method of manufacturing a filter element comprising the steps of forming a rectangular sheet of filter material adjacent to at least one longitudinal edge with a longitudinally extending fold line, forming a plurality of spaced parallel fold lines which each extend in a direction perpendicular to the longitudinally extending fold line, folding the filter material outwardly of said longitudinally extending fold line inwardly over the adjacent portion of the sheet of filter material, thereafter folding the sheet of filter material about the spaced parallel fold lines to form a series of pleats, and subsequently connecting the ends of the pleats directly together to form a plurality of pockets so that at least one end of each pocket comprises four thicknesses of material.

2. A method of manufacturing a filter element as claimed in Claim 1 wherein the sheet of filter material is initially formed over its surface with a plurality of integrally formed spaced projections.

3. A method of manufacturing a filter element as claimed in Claim 1 or Claim 2 wherein the element is shaped so as to be of flat or panel-like configuration.

4. A method of manufacturing a filter element as claimed in any one of the preceding claims wherein material is removed from the inwardly folded edge portion at positions adjacent to the ends of those fold lines which, when the sheet of filter material is folded to form the series of pleats, will be disposed adjacent to the mouths of said pockets of the filter element.

5. A method of manufacturing a filter element according to any one of Claims 1–3 wherein the material is slit through the inwardly folded edge portion at the ends of those fold lines which, when the sheet of filter material is folded to form the series of pleats, will be disposed adjacent to the mouths of said pockets of the filter element.

6. A method of manufacturing a filter element as claimed in any one of the preceding claims wherein the sheet of filter material is formed from resin impregnated paper.

7. A method of manufacturing a filter element as claimed in any one of the preceding claims wherein one side of the inwardly folded edge is coated with an adhesive before the sheet of filter material is folded about said plurality of spaced parallel fold lines whereby upon such folding being effected said adhesive will act to connect together the ends of adjacent pleats to form the plurality of pockets.

8. A method of manufacturing a filter element as claimed in any one of the preceding claims wherein a longitudinally extending fold line is formed in the rectangular sheet of filter material adjacent to each longitudinal edge, the material outwardly of each longitudinally extending fold line being folded inwardly over the adjacent portion of the sheet of filter material before said material is folded about the spaced parallel fold lines to form a series of pleats, the ends of said pleats being connected together to form a plurality of pockets so that each end of each pocket comprises four thicknesses of material.

9. A method of manufacturing a filter element substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

10. A filter element when made in accordance with the method as claimed in any one of the preceding claims.

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1579231 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

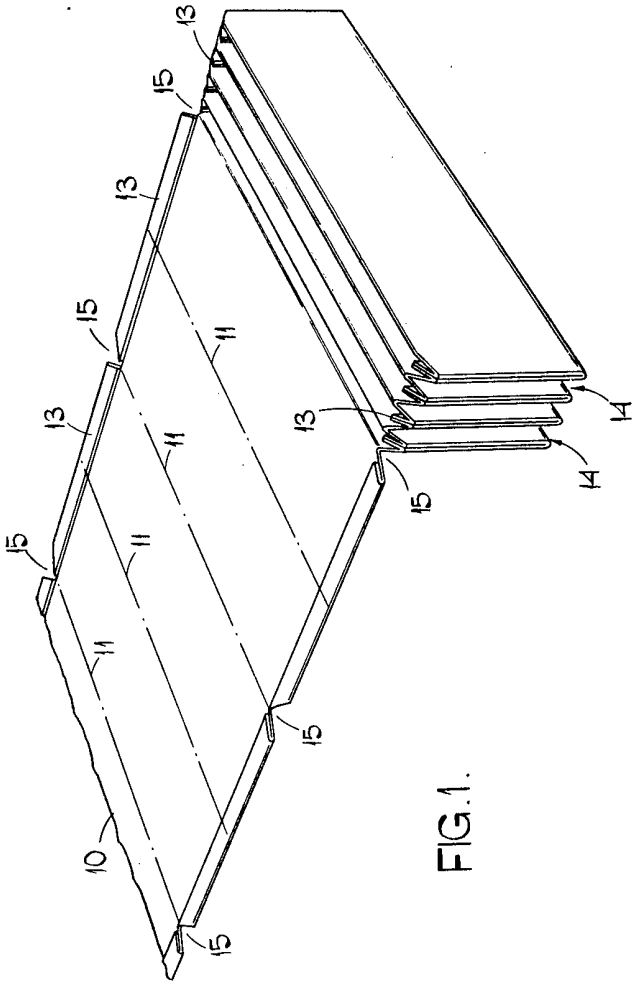

FIG.1.

FIG.2.

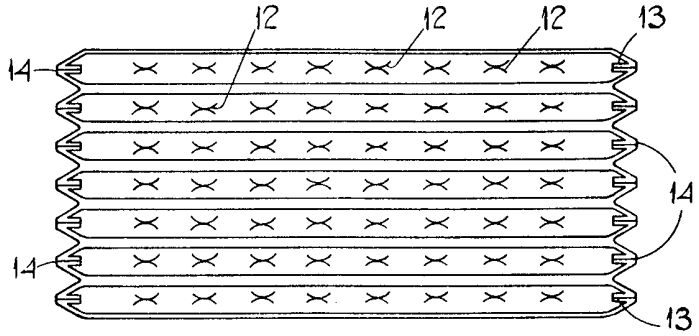

FIG.3.

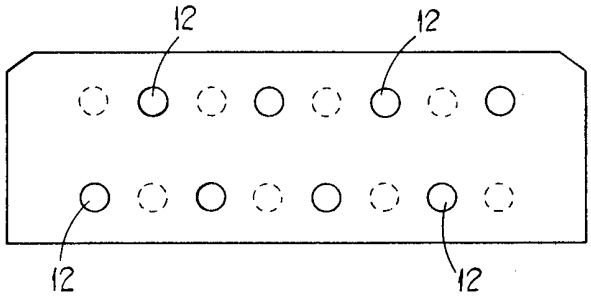

FIG.4.