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## AIR FILTER



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BACKGROUND OF THE INVENTIONFIELD OF THE INVENTION

The present invention relates to an air filter used to create a ultra cleaned space such as a clean room for producing, for example, a liquid crystal, a semiconductor or the like.

DESCRIPTION OF THE RELATED ART

There is a conventionally known air filter having a size of 610 mm x 610 mm, in which a porous plate is mounted as a filter medium protecting means at a location downstream of a filter pack accommodated in a filter frame, as disclosed in Japanese Utility Model Application Laid-open No.60-91224.

There is also a conventionally known air filter, in which a reinforcing bar member is mounted at a location downstream of a filter pack as a support member for a separator used as a member for maintaining the distance between filter media of the filter pack, as disclosed in Japanese Utility Model Application Laid-open No.59-7022.

Further, there is a conventionally known a air filter in which a bar-shaped rigid member is disposed at a location downstream of a filter medium, as disclosed in Japanese Utility Model Application Laid-open No.62-62822.

The above techniques are also applicable to an air filter

in which ribbon-shaped mini-pleats are provided in a filter medium itself in place of use of the corrugated separator as the member for maintaining the distance between the filter media.

In recent years, from a need for making a clean room at a low cost, a large-sized air filter having a size of 4 feet x 4 feet or the like is required for reasons of a reduction in amount of aluminum material used for a ceiling frame and a reduction in number of fans existing in correspondence to the number of filters. However, such large-sized air filter suffers from the following problem: There is a possibility in some cases that the filter pack is deformed by an air pressure or by its own weight during service of the air filter in the horizontal disposition thereof, and damaged or broken due to such deformation, and such problem must be solved.

For example, when the porous plate is mounted as the filter medium protecting means at the location downstream of the filter pack accommodated in the filter frame, as disclosed in Japanese Utility Model Application Laid-open No.60-91224, a problem of a loss of pressure is encountered. Especially, when the air filter is large-sized, the following problem is encountered: The opening rate of the porous plate cannot be increased excessively in order to provide the porous plate with a large strength and for this reason, it is difficult to suppress the

increase in loss of pressure.

When the reinforcing bar member is mounted at the location downstream of the filter pack as the support member for the separator used as the member for maintaining the distance between the filter media of the filter pack, as disclosed in Japanese Utility Model Application Laid-open No.59-7022, there is a problem that the filter medium is flawed by the contact of the reinforcing bar member with the filter pack. Thus, it is necessary to dispose the reinforcing bar member and the filter pack in a separated relation, so that they are prevented from being brought into contact with each other. This arises a new problem that the blow-off speed is disturbed due to such separated disposition. Moreover, the reinforcing bar member does not have an air permeability and for this reason, disturbs the flow of air, thereby impeding such a function of the air filter that clean air must be brown off substantially uniformly.

In the air filter including the bar-shaped rigid member disposed at the location downstream of the filter medium, as disclosed in Japanese Utility Model Application Laid-open No.62-62822, when a well-shaped frame having a wide space is constructed, the weight of the filter pack cannot be supported up, even if a reinforcing rib is formed. Thus, the rib itself is flexed and thus, it is failed to enhance the strength. Therefore, this case does not reach the solution of the above

problem.

In the conventional air filter having the mini-pleats, a ribbon is formed continuously in a direction perpendicular to the folds of the filter medium and hence, it is common that there is no seam in the filter medium, or there is no lack portion in the ribbon.

Namely, in order to continuously form a ribbon in the filter medium in the production of an air filter, it is common to continuously apply a ribbon-shaped resin to the filter medium. For this reason, when the ribbon lacks, when the remaining portion of the supplied filter medium is too short to constitute one air filter, or when a defect with regard to the performance is produced even at one point on the surface of the folded filter medium, the connection of the filter medium cannot be achieved and hence, the entire remaining portion of the filter medium is discarded in many cases. This results in the wasteful use of resources, but also the discarded filter medium portion is disposed as an industrial waste by the land reclamation or the like to provide a non-disregardable influence to the environment, which is not preferred.

#### SUMMARY OF THE INVENTION

Accordingly, it is a first object of the present invention to provide a large-sized air filter having a size of 4 feet x 4 feet, in which the above problems have been solved, and in

which the filter pack is prevented from being deformed, and damaged or broken due to such deformation, and a uniform blow-off speed and a collecting efficiency can be maintained as in the prior art.

It is a second object of the present invention to ensure that the producing efficiency is enhanced, while eliminating the wasteful use of the filter medium, and the problem in the environment caused by the discarding of the filter medium is solved.

To achieve the above object, according to a first aspect and feature of the present invention, there is provided an air filter comprising a filter pack, and a net-shaped member disposed at least at a location downstream of the filter pack, the net-shaped member having at least one rib which is provided thereon, so that it is accommodated in a filter frame.

According to a second aspect and feature of the present invention, in addition to the first feature, the filter pack is comprised of a filter medium which is folded in a zigzag fashion and which has pleats, and the rib of the net-shaped member is provided in parallel to the pleats.

According to a third aspect and feature of the present invention, in addition to the first feature, the filter pack is comprised of a filter medium which is folded in a zigzag fashion and which has pleats, the filter pack being divided into

a plurality of portions in a direction perpendicular to the pleats, and the rib of the net-shaped member is provided in perpendicular to the pleats.

According to a fourth aspect and feature of the present invention, in addition to any of the first to third features, the rib of the net-shaped member is provided to face outwards.

According to a fifth aspect and feature of the present invention, in addition to any of the first to third features, the rib of the net-shaped member is provided to face inwards.

According to a sixth aspect and feature of the present invention, in addition to the second features, the rib of the net-shaped member is provided in parallel to the pleats, so that it is sunk into between fold-crests of the pleats of the filter medium.

According to a seventh aspect and feature of the present invention, in addition to the third features, the rib of the net-shaped member is provided perpendicular to the plates, so that it is sunk into between the portions of the filter medium which is divided into a plurality of portions.

According to an eighth aspect and feature of the present invention, in addition to any of the first to seventh features, a portion of contact of the filter medium with the rib of the net-shaped member is a non-permeable portion.

According to a ninth aspect and feature of the present invention, in addition to the first features, the filter pack

is constituted of a filter medium which is folded in a zigzag fashion, with folded portions being fixed with a ribbon-shaped resin, a lack portion free of the ribbon-shaped resin being provided in an extent corresponding to at least one fold-crest to constitute independent blocks, and the rib of the net-shaped member being sunk into the lack portion.

According to a tenth aspect and feature of the present invention, in addition to the ninth features, the independent blocks are bonded together at the lack portion to constitute the filter pack.

The air filter according to the present invention has the first feature that the net-shaped member is disposed at least at the location downstream of the filter pack, and at least one rib is provided on the net-shaped member, so that it is accommodated in the filter frame. Thus, the filter medium can be maintained in a predetermined shape without providing an increase in loss of pressure, and the air filter is suitable to be constructed mainly as a large-sized air filter having longitudinal and lateral dimensions of 915 mm or more x 915 mm or more and a thickness in a range of 30 to 290 mm.

The filter pack constituting the air filter according to the present invention can be formed by folding the filter medium made of a glass fiber, a synthetic resin fiber, a PTFE or the like in the zigzag fashion in such a manner that the distance

between the fold-crests of the filter medium may be maintained by a corrugated separator interposed therebetween, or may be maintained by a distance-maintaining portion formed by previously applying the ribbon-shaped hot melt resin in a direction of flow in the filter medium before folding of the filter medium.

The filter frame constituting the air filter can be formed using a plate made of a metal such as aluminum, a stainless steel and the like, a resin plate e.g., an extruded resin plate such as PC, a wood plate such as a plywood, or the like.

The net-shaped member, which may be used, is a lath net made of a resin or a metal and having a thickness of 0.5 mm or more and an opening rate in a range of 30 to 50 %, or a metal.

When the rib provided on the net-shaped member in the present invention is disposed in parallel to the pleats provided in the filter medium of the filter pack, the flow of air passed cannot be obstructed by the rib and moreover, the air is blown off around the rib. Thus, the disturbance of the flow of air is suppressed.

The height of the rib may be in a range of 5 to 285 mm. In this case, it is of course not very preferred to provide the rib perpendicular to the pleats, unless it is in the following form, because the flow of air is obstructed by a portion of the blow-off surface of the filter medium corresponding to the rib

to form a dead zone.

What is required in the present invention is that at least one rib is provided at a central portion of the net-shaped member. Alternatively, a plurality of the ribs may be provided at the central portion, or may be provided at equal distances of 50 to 100 mm on the entire net-shaped member. The rib may be formed by any of various means, e.g., by folding the net-shaped member, or by attaching a separate member to the net-shaped member by use of an adhesive or by welding, or by dividing the net-shaped member into a plurality of portions, folding-back ends and fixing the folded ends to each other by use of an adhesive or by welding. Particularly, when the rib is formed of a separate plate-shaped member having no permeability, the strength of the filter pack can be further increased.

When the rib is disposed in parallel to the pleats provided in the filter medium of the filter pack, as described above, the rib can be sunk into between the fold-crests of the filter medium. In this case, a space for accommodation of the rib in the filter frame of the air filter is not required. When the rib is provided to face outwards of the filter pack, a space for accommodation of the rib in the filter frame of the air filter requires an extent corresponding to the height of the rib.

In the present invention, the direction of the rib provided on the net-shaped member may be provided perpendicular to the

pleats of the filter medium. Even if the rib is provided perpendicular to the pleats of the filter medium in the above manner , the flow of air cannot be obstructed by the blow-off surface of the filter medium , and any influence cannot be exerted to the function of the air filter , whereby a reinforcing effect can be exhibited.

In other words, the filter pack having the pleated filter medium accommodated therein may be divided into a plurality of (two or more) portions, and the rib on the net-shaped member may be interposed between the adjacent portions of the divided filter pack.

The other feature of the present invention is that the filter pack is constituted of the filter medium which is folded in the zigzag fashion; folded portions are fixed with the ribbon-shaped resin; the lack portion free of the ribbon-shaped resin is provided in the extent corresponding to at least one fold-crest to constitute the independent blocks, and the rib of the net-shaped member is sunk into the lack portion.

Therefore, when a defect regarding the performance of the air filter has been produced, only the block having such defect can be removed. When a plurality of blocks are bonded together, the performance of the air filter can be recovered by bonding the remaining blocks utilizing the ribbon-shaped lack portion free of the ribbon-shaped hot melt resin. Therefore, the

remaining blocks other than the block having the defect can be used effectively. As a result, the filter medium corresponding to one unit and including the normal portion has been discarded in the prior art, but according to the present invention, the amount of filter medium discarded can be reduced.

In addition, the remaining portion of the filter medium shorter than the length of one unit, which has been discarded in the prior art, can be used for every block to constitute an air filter unit by bonding the blocks, leading to an effective use of resources.

Moreover, the present invention is applicable to air filters having various sizes. Particularly, the present invention is applicable to a large-sized air filter having a longitudinal dimension of 915 mm or more, a lateral dimension of 915 mm or more and a thickness in a range of 30 to 290 mm. The length of the lack portion free of the ribbon is set to correspond to about one to ten crests of the folded filter medium, but may be varied as desired depending on the size and the specification of the product.

As described above, in the air filter according to the present invention, the strength of the filter pack can be maintained by provision of the at least one rib and hence, it is possible to avoid the possibilities of the deformation of the large-sized air filter and the damage or breaking of the large-sized air filter due to such deformation. Moreover, the uniform blow-off speed and the collecting efficiency can be maintained without occurrence of the disturbance of the blown-off air flow by employment of a deformation-preventing means as described above.

According to the present invention, one unit is constituted by the plurality of independent blocks and hence, the present invention is applicable to a large-sized air filter provided with mini-pleats (e.g., a large-sized air filter provided with mini-pleats and having a size of 4 feet x 4 feet). Moreover, when a defective portion has been produced, the normal blocks can be used continuously by removing only the block having the defective portion. Thus, it is possible to effectively utilize the filter medium and to reduce the industrial waste produced due to the discarding of the filter medium.

In addition, the plurality of independent blocks are bonded to one another to constitute one unit and hence, it is possible to effectively utilize the filter medium and to reduce the industrial waste produced due to the discarding of the filter

medium, as described above.

The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a plan view of an air filter according to an embodiment of the present invention;

Fig.2 is an enlarged sectional view taken along a line A-A in Fig.1;

Fig.3 is a plan view of an air filter according to another embodiment of the present invention;

Fig.4 is an enlarged sectional view taken along a line B-B in Fig.3;

Fig.5 is a perspective view of an air filter according to a further embodiment of the present invention;

Fig.6 is a plan view of an air filter according to a yet further embodiment of the present invention;

Fig.7 is an enlarged sectional view taken along a line C-C in Fig.6;

Fig.8 is a plan view of an air filter according to a yet further embodiment of the present invention;

Fig.9 is an enlarged sectional view taken along a line D-D in Fig.8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described by way of embodiments with reference to the accompanying drawings.

Referring to Figs.1 and 2, an air filter 1 is formed as a large-size air filter having longitudinal and lateral dimensions of 1,220 mm and 1,220 mm and a thickness of 75 mm. The air filter 1 is comprised of a filter pack 10 having a folding width of 65 mm, a filter frame 20 made of aluminum and having a thickness of 15 mm, and a lath net 30 having a thickness of 1 mm and an opening rate of 35 %.

A filter medium 11 made of a glass fiber and constituting the filter pack 10 is folded up in a zigzag fashion with fold-crests fixed with a ribbon-shaped hot-melt resin to provide a fixed folding distance.

Further, end faces 11a and 11b of the filter medium 11 are fixed to an inner wall surface 21 of the filter frame 20 by an adhesive 12, and end faces 11c and 11d of the filter medium 11 are fixed in a sealing manner to an inner wall 23 of the filter frame 20 by a sealant 13.

Three ribs 31, 31, 31 having a height of 10 mm are provided by folding of the lath net 30 at a central portion thereof in parallel to pleats of the filter medium 11 and at distances of 50 mm to face outwards. A cutout 25 is provided in inner walls 21, 22, 23 and 24 of the filter frame 20 at a location such that

the ribs 31 do not protrude from the filter frame 20 on a downstream side, and the periphery of the lath net 30 is fitted into and fixed in the cutout 25.

The air filter according to the present invention is constructed, as described above, and hence, the strength of the filter pack 10 is maintained by the ribs 31 provided on the lath net 30. Therefore, there is not a possibility of deformation or the like of the filter pack, and moreover, a uniform blow-off speed of air and a collecting efficiency can be maintained.

Figs.3 and 4 show another embodiment of the present invention. This second embodiment is different from the previously described embodiment in respects of the shape and position of ribs provided on a lath net 30.

More specifically, ends of two lath nets 30, 30 are folded back, and the folded-back ends are butted against and fixed to each other by using an adhesive or by welding or the like, whereby a single rib 31 having a height of 30 mm is formed in an inward-facing manner at a location of butting of the lath nets 30, 30 in parallel to pleats provided in the filter medium 11. The mesh of the lath net 30 is of a fan shape and hence, the lath nets are used in offset states.

In this case, the rib 31 is inserted into between the crests of the pleats. Therefore, the thickness of the air filter is 75 mm. Even in this case, the lath net 30 is fitted into and

fixed in a cutout 25 provided in inner walls 21, 22, 23 and 24 of a filter frame 20.

To insert the rib 31 into the pleat in this embodiment, there is a possibility that a filter medium 11 is rubbed and/or damaged or broken. For this reason, a non-permeable portion 32 is formed, so that the pleat portion having the rib 31 inserted therein is occluded using an adhesive.

Even in the second embodiment, the strength of a filter pack 10 is maintained by the rib 31 and hence, there is not a possibility that the filter pack is deformed, and a uniform blow-off speed and a collecting efficiency can be maintained.

Fig.5 shows a further embodiment of the present invention. This embodiment is different from the above-described embodiment in respect of the direction of a rib on a net. Namely, the rib is provided perpendicular to the plates.

In Fig.5, an air filter is formed as a large-sized air filter having longitudinal and lateral dimensions of 1,220 mm and 1,220 mm and a thickness of 75 mm. The air filter is comprised of two filter packs 10, 10 disposed in a vertically separated manner with four surfaces fixed with a resin and each having longitudinal and lateral dimensions of 610 mm x 1,220 mm and a folding width of 65 mm, a filter frame 20 made of aluminum and having a thickness of 15 mm, and a lath net 30 made of aluminum and having a thickness of 1 mm and an opening rate of about 35

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A filter medium 11 made of a glass fiber and constituting each of the filter packs 10 is folded in a zigzag fashion with fold-crests fixed with a ribbon-shaped hot melt resin 14 to provide a fixed folding distance.

In the third embodiment, a single rib 31 is provided at a central portion of the lath net 30 in a direction perpendicular to pleats of the filter medium 11 and sunk into the filter packs 10, 10 vertically separated from each other.

The filter packs 10, 10 are air-tightly accommodated and fixed in the filter frame 20 using a sealant or an adhesive (not shown) and likewise, the lath net 30 is also fixed in the filter frame 20.

In the embodiments shown in Figs.3, 4 and 5, the two ribbed lath nets or the two filter packs have been illustrated in a separated manner. Alternatively, a more number of lath nets and a more number of filter packs may be provided, and even in this case, a similar strength is provided.

Figs.6 and 7 show a yet further embodiment of the present invention. An air filter 1 is formed as a large-sized air filter having longitudinal and lateral dimensions of 1,220 mm and 1,220 mm and a thickness of 75 mm. The air filter 1 is comprised of a filter pack 10 having a folding width of 65 mm, a filter frame 20 made of aluminum and having a thickness of 15 mm, and lath

nets 30, 30 made of aluminum and having a thickness of 10 mm and an opening rate of about 35 %. A filter medium 11 made of a glass fiber and constituting the filter pack 10 is folded in a zigzag fashion, with fold-crests fixed with a ribbon-shaped hot melt resin 15 to provide a fixed folding distance, excluding a ribbon-shaped lack portion 14.

Further, ends 11a and 11b of the filter medium 11 are fixed to inner wall surfaces 21 and 22 of the filter frame 20 using an adhesive, and ends 11c and 11d of the filter medium 11 are fixed to inner wall surfaces 23 and 24 of the filter frame 20 using a sealant 13.

The lath nets 30, 30 are each folded back at one end thereof, and the folded-back ends are butted against and fixed to each other using an adhesive or by welding or by another means, thereby forming a rib 31 having a height of 30 mm in parallel to pleats provided in the filter medium 11. In this case, the rib 31 is inserted into the ribbon-shaped lack portion 14 free of the hot melt resin 15 provided on the filter medium 11, and the lath nets 30, 30 are fitted into and fixed in a cutout 25 provided in inner surfaces 21, 22, 23 and 24 of the filter frame 20.

The air filter according to the present embodiment is formed of the plurality of independent blocks, as described above. Thus, when a defect with regard to the performance of the air filter has been produced, only the block having such

defect can be removed, and a new block can be bonded to the remaining block utilizing the ribbon-shaped lack portion 14 free of the ribbon-shaped hot melt resin 15, thereby recovering the performance of the air filter. In addition, the strength of the filter pack is maintained by the rib 31 inserted in the ribbon-shaped lack portion 14.

Figs. 8 and 9 show a yet further embodiment of the present invention.

Each of two filter media 11, 11 made of a glass fiber and constituting a filter pack is folded in a zigzag fashion with fold-crests fixed using a ribbon-shaped hot melt resin 15 to provide a fixed folding distance, excluding a ribbon-shaped lack portion 14. The filter media 11 are bonded to each other at the ribbon-shaped lack portion 14 free of the hot melt resin 15 provided in each of the filter media 11 with a binding material 40 such as a urethane-silicone adhesive and the like, thereby forming a filter pack 10.

Even in this case, the lath net 30 is constructed so that it is fitted into and fixed in a cutout 25 provided in inner wall surfaces 21, 22, 23 and 24 of the filter frame 20. In addition, ends 11a and 11b of the filter medium 11 are fixed to the inner wall surfaces 21 and 22 of the filter frame 20, using an adhesive 12, and ends 11c and 11d of the filter medium 11 are fixed in a sealed manner to the inner wall surfaces 23

and 24 of the filter frame 20, using a sealant 13.

This embodiment has a feature that a single unit is constructed by forming the filter medium 11 constituting the filter pack 10 into blocks, and bonding the blocks to one another with the binding material 40 by utilizing the ribbon-shaped lack portion 14 of the filter medium 11 free of the hot melt resin 15. Therefore, even when the remaining portion of the filter medium 11 is too short to constitute one unit, if the length of the remaining portion is equal to or smaller than the length of one block, the remaining portion of the filter medium 11 can be used effectively for constituting a block. Thus, it is possible to effectively use a material and to reduce the industrial waste.

WHAT IS CLAIMED IS

1. An air filter comprising a filter pack, and a net-shaped member disposed at least at a location downstream of said filter pack, said net-shaped member having at least one rib which is provided thereon, so that it is accommodated in a filter frame.
2. An air filter according to claim 1, wherein said filter pack is comprised of a filter medium which is folded in a zigzag fashion and which has pleats, and said rib of the net-shaped member is provided in parallel to the pleats.
3. An air filter according to claim 1, wherein said filter pack is comprised of a filter medium which is folded in a zigzag fashion and which has pleats, said filter pack being divided into a plurality of portions in a direction perpendicular to the pleats, and said rib of the net-shaped member is provided in perpendicular to the pleats.
4. An air filter according to any of claims 1 to 3, wherein said rib of the net-shaped member is provided to face outwards.
5. An air filter according to any of claims 1 to 3, wherein said rib of the net-shaped member is provided to face inwards.
6. An air filter according to claim 2, wherein said rib of the net-shaped member is provided in parallel to the pleats, so that it is sunk into between fold-crests of the pleats of the filter medium.
7. An air filter according to claim 3, wherein said rib of the

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net-shaped member is provided perpendicular to the plates, so that it is sunk into between the portions of the filter medium which is divided into a plurality of portions.

8. An air filter according to any of claims 1 to 7, wherein a portion of contact of the filter medium with the rib of the net-shaped member is a non-permeable portion.

9. An air filter according to claim 1, wherein said filter pack is constituted of a filter medium which is folded in a zigzag fashion, with folded portions being fixed with a ribbon-shaped resin, a lack portion free of the ribbon-shaped resin being provided in an extent corresponding to at least one fold-crest to constitute independent blocks, and said rib of the net-shaped member being sunk into the lack portion.

10. An air filter according to claim 9, wherein said independent blocks are bonded at the lack portion to constitute the filter pack.