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(54) Title: VENTILATION DUCTS AND CONNECTORS THEREFOR

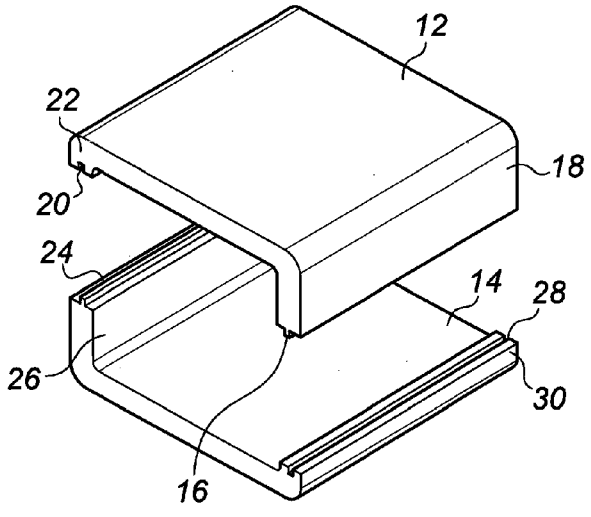

Fig. 2

(57) Abstract: The invention relates to a ventilation duct wall assemblies (10), their method of manufacture; and the means by which they are connected together within a ventilation system. The method of manufacture comprises the steps of: (i) providing a three- dimensional block of elastomeric material having two opposing end walls, each end wall having a height and width dimension, and the block having an overall length dimension; and (ii) using a cutting tool to form a plurality of predetermined lengthwise cuts along the full length of the block of elastomeric material between opposing end walls. The cross- sectional contours of the predetermined lengthwise cuts as viewed along the lengthwise axis of the block of material delineate the L-shaped cross-sectional peripheries of identical duct wall sub-assemblies (12, 14) which can be assembled to form a completed ventilation assembly section. Ventilation duct connectors (40) may be used to connect ventilation assembly sections and any associated gas impermeable liners (64, 66).

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VENTILATION DUCTS AND CONNECTORS THEREFOR

The present invention relates to a ventilation ducts and connectors for connecting together individual lengths of ventilation ducts. In particular, though not exclusively, the invention relates to ventilation ducts for channelling warmed or cooled air between zones of a building employing a Heating Ventilation and Air Conditioning (HVAC) system.

Rigid ducting systems have been in existence for many years; however, more recently flexible ducting formed of a compressible material such as expanded polystyrene foam have entered the market. Flexible ducting systems allow installers to easily cut ducting lengths to size in order to navigate them around corners and over obstacles etc. However, the process of manufacturing flexible ducting can be costly due to amount of waste material created during the forming process. Furthermore, once installed, flexible ducting can be difficult to connect and hence air leakage and associated efficiency problems can arise.

According to a first aspect of the present invention there is provided a method of manufacturing ventilation duct wall sub-assemblies comprising:

(i) providing a three-dimensional block of elastomeric material having two opposing end walls, each end wall having a height and width dimension, and the block having an overall length dimension; and

(ii) using a cutting tool to form a plurality of predetermined lengthwise cuts along the full length of the block of elastomeric material between opposing end walls;

wherein the cross-sectional contours of the predetermined lengthwise cuts as viewed along the lengthwise axis delineate the cross-sectional periphery of a complete duct wall sub-assembly.

Optionally, the step of forming a plurality of predetermined lengthwise cuts simultaneously delineates a plurality of completed duct wall sub-assemblies.

Optionally, the step of forming a plurality of predetermined lengthwise cuts involves arranging the cross-sectional peripheries of a completed duct wall sub-assemblies in a juxtaposed manner.

Optionally, the step of forming a plurality of predetermined lengthwise cuts involves delineating peripheries of completed duct wall sub-assemblies which are substantially L-shaped in cross-section.

It will be appreciated that, taken to the extreme, a single cut simultaneously delineates wall surfaces of two different duct sub-assemblies. Where this is undesirable, a small gap – for example, of less than 10 mm - can be maintained between adjacent duct sub-assembly walls. An L-shaped cross-section facilitates nesting together of a plurality of duct sub-assemblies. Other than the small amount of wastage between adjacent straight walls, the only other wastage occurs proximate curved surfaces where the two straight arms of the L-shaped duct wall sub-assembly meet.

Optionally, the step of forming a plurality of predetermined lengthwise cuts is performed by a hot-wire cutting method.

Optionally, the step of forming a plurality of predetermined lengthwise cuts is followed by the step of retaining the individual duct wall sub-assemblies in-situ within the block of elastomeric material for storage and/or transportation purposes.

It will be appreciated that retaining the individual duct wall sub-assemblies in-situ affords a number of advantages. Firstly, the absence of any significant gaps between individual duct wall sub-assemblies are maintained in a closely packed manner. Not only does this minimise wastage of elastomer material during production, but it also minimises the number of duct wall sub-assemblies per unit volume. Consequently, storage and transportation costs can be reduced. Indeed, the surrounding excess elastomer material provides a degree of protection to the encased duct wall sub-assemblies from impact damage during storage and transportation. The three-dimensional elastomeric block can

also be transported by a fork-lift truck without the need for being stacked on a heavy wooden pallet.

Optionally, the step of forming a plurality of predetermined lengthwise cuts is followed by the step of releasing the individual duct wall sub-assemblies from within the block of elastomeric material.

It will be appreciated that the individual duct wall sub-assemblies remain nested together within the block of elastomeric material by virtue of the frictional forces between adjacent cut surfaces. However, the frictional forces are such that they can be readily overcome by the application of a manual force (or with the assistance of a tool) along the direction of the lengthwise axis. Therefore, individual duct wall sub-assemblies can conveniently be released from the block of elastomeric material as and when they are required.

According to a second aspect of the present invention there is provided a ventilation duct assembly manufactured from duct wall sub-assemblies in accordance with the first aspect.

Optionally, the ventilation duct assembly comprises:

a first wall component having a substantially L-shaped cross section; and

a second wall component having a substantially L-shaped cross section;

wherein the respective first and second wall components are identical and mateable with one another to form an enclosed ducting cavity for channelling gases.

It will be appreciated that the duct wall sub-assemblies define individual wall components and that two identical wall components can be arranged to form a complete ventilation duct. This type of modular arrangement whereby a complete section of ventilation duct can be formed from two identical wall components simplifies and speeds up the installation process for ventilation ducts.

Optionally, mating of the first and second wall components is effected via at least one set of convexities and/or concavities on one lengthwise end thereof inter-fitting with a

complementary set of convexities and/or concavities on the opposite lengthwise end thereof.

Optionally, the convexities and/or concavities are adapted to provide a snap-fit engagement with one another.

It will be appreciated that once the lengthwise ends of each wall component are mated together the internal ducting cavity can effectively be sealed from the external environment. Such a seal may be ensured or enhanced by application of a fluid seal or adhesive along the lengthwise mating edges of each wall component.

Optionally, the internal walls of the respective duct wall sub-assemblies are provided with a surface profile adapted to absorb sound.

It will be appreciated that this arrangement helps to minimise the transfer of any noise associated with the passage of air over the interior walls of the ducting cavity. A suitable roughened surface profile may be selectively created at the manufacturing stage during the step of forming lengthwise cuts along the block of elastomeric material. Selection of a foam having suitable closed cell properties may also assist with noise ablation.

Optionally, the duct wall sub-assemblies are formed from a foamed elastomer.

Suitable foamed elastomers include expanded polystyrene.

Optionally, the ducting cavity within ventilation duct assembly is provided with a gas impermeable liner.

Optionally, individual L-shaped wall components may be colour-coded, or provided with other surface indicia, to indicate particular technical characteristics and/or intended orientation in use.

According to a third aspect of the present invention there is provided a ventilation duct connector for connecting lengths of ventilation duct assemblies in accordance with the second aspect.

Optionally, the ventilation duct connector comprises two aligned primary annular recesses separated from one another by an annular partition wall.

Optionally, the primary annular recesses are defined by coaxially arranged pairs of internal and external flanges each extending perpendicularly from the annular partition wall in opposite directions.

Optionally, one or more of the internal and/or external flanges may be provided with a non-smooth surface profile for promoting secure engagement of a ventilation duct assembly end within the primary annular recess.

It will be appreciated that the primary annular recesses and flange pairs are each adapted to accommodate, and at least partially surround and support, the corresponding internal and external end surfaces of ventilation duct assemblies in alignment with one another. The spacing of the pairs of flanges is substantially matched to the width of the wall components of the ventilation ducts. This ensures a friction fit of the latter within the former which may be enhanced by the formation of grooves or toothed projections on the flange surfaces. The annular partition wall provides two abutment surfaces against which the free ends of ventilation duct assembly sections may be abutted.

Optionally, two aligned secondary annular recesses are also separated from one another by the annular partition and defined in part by the internal flanges of the primary annular recesses.

Optionally, the inner extent of each secondary annular recess is defined by coaxially arranged pairs of innermost flanges each extending perpendicularly from the annular partition wall in opposite directions.

It will be appreciated that the secondary annular recesses are each adapted to accommodate, and at least partially surround and support, the ends of gas a relatively rigid gas impermeable liner for lining the ducting cavity. The spacing between the innermost and internal pairs of flanges is substantially matched to the width of the wall of the liner. This ensures a friction fit of the latter within the former. The annular partition wall provides two abutment surfaces against which the free ends of connected liner sections may be abutted.

Optionally, the ventilation duct connector is provided with at least one attachment flanges for attaching it to a wall, ceiling or other fixing point.

Optionally, the ventilation duct connector is formed from an optically transparent or translucent material.

It will be appreciated that by providing an optically transparent or translucent ventilation duct connector a user, tester or installer can visually verify that the ventilation wall sections and liners have been fully inserted within their recesses. Furthermore, it can also be verified that any appropriate sealants have been applied to inhibit or prevent gas leakage from the connector. Use of a sealant having an obvious colour contrast relative to the ventilation duct assembly walls is therefore preferable. Post-installation checking of this type is not possible, or is very difficult or inconvenient, in existing ventilation duct systems.

Further features and advantages of the various aspects of the present invention will become apparent from the claims and the following description.

Embodiments of the present invention will now be described by way of example only, with reference to the following diagrams, in which:-

Fig. 1 is a perspective illustration of assembled ventilation ducting assembly according to a first aspect of the present invention;

Fig. 2 is a perspective illustration of the ventilation ducting assembly shown in Fig. 1 prior to assembly;

Figs. 3a to 3c are end views of the ventilation ducting assembly of Fig. 1, each showing a different complementary mating connections between ventilation duct sub-assemblies;

Fig. 4 is an end view illustration of a single L-shaped ventilation duct wall sub-assemblies cut from a block of material;

Fig. 5 illustrates a block of elastomeric material having several of the L-shaped ventilation duct wall sub-assemblies of Fig. 4 pre-cut therein and held in-situ;

Fig. 6 is a perspective illustration of a ventilation duct connector in accordance with the second aspect of the invention;

Fig. 7 is a perspective illustration of the ventilation duct connector shown in Fig. 6, where a first ventilation duct assembly and a first section of rigid gas impermeable liner are connected thereto;

Fig. 8 is perspective illustration of a partial cutaway section of the apparatus of Fig. 7;

Fig. 9 is a transverse cross section of the apparatus of Fig. 7;

Fig. 10 is perspective illustration of the apparatus of Fig. 8 where a second ventilation duct assembly has been joined with the first ventilation duct assembly;

Fig. 11is a transverse cross sectional view of the apparatus of Fig. 10;

Fig. 12 is perspective illustration of a deviated corner ventilation duct assembly section having a ventilation duct connector attached at either end thereof;

Figs 13a and 13b are cross-sectional illustrations through a rigid duct and duct connector both with and without guide vane corner connectors according to a further aspect of the present invention;

Fig. 14 is a top view of the rigid duct and duct connectors of Fig. 13a; and

Figs. 15 to 17 are illustrations of alternative rigid duct and duct connector arrangements according to the present invention.

With reference to Figs. 1 to 3c there is shown a short length of a ventilation duct 10 consisting of an assembly of two duct wall components 12, 14. The respective duct wall components 12, 14 are each identical and L-shaped in cross-section through a plane

extending perpendicular to a central axis extending longitudinally through a ducting channel 34.

As best shown in Figs. 2 and 3a, the upper and lower duct wall components 12, 14 are provided with a convexity or protrusion 16, 24 extending lengthwise along the end surfaces of their shorter arms 18, 26. A complementary concavity or recess 20, 28 extends lengthwise along an end surface of its longer arm 20, 30.

The upper and lower duct wall components 12, 14 are mateable with one another as shown in Figs. 1 and 3a. Adhesive may be applied between the joints 32 in order to bond the respective duct wall components 12, 14 together. The respective duct wall components 12, 14 form an annulus which defines a central ducting channel 34. Figs. 3b and 3c show alternative joint configurations whereby the complementary surface profiles are shaped so as to allow a convenient snap-fit connection between the upper and lower duct wall components 12, 14 which may not require the application of an adhesive within the joint.

The particular duct wall components 12, 14 shown in the drawings are substantially L-shaped. However, it will be appreciated that the relative lengths of each of the connected arms may be varied to provide annular shapes for the central ducting channel 34 to meet particular requirements. Indeed, each duct wall components 12, 14 may instead be U-shaped in cross-section. The U-shaped cross-section may be symmetrical or asymmetrical. The internal and external corners where the arms meet may be rounded to increase their strength.

It should be noted that although relatively short sections of ventilation duct 10 are illustrated in Figs. 1 and 2, these may typically be supplied in longer sections which can easily be cut to the required size by an installer.

The ventilation duct sections 10 are preferably formed from a suitable elastomeric material. A particularly suitable elastomeric material is an expanded foam polystyrene. As shown in Fig. 5, individual duct wall components 12, 14 are cut from a block of

expanded polystyrene 36. Visible in the end face of the polystyrene block 36 is the cross-sectional contour lines associated with ten individual duct wall components 12, 14 arranged side-by-side with little or no mutual spacing. The number of duct wall components 12, 14 obtained per unit volume is thereby maximised and hence the amount of material wastage is minimised. Transportation and storage costs are also minimised. It will be appreciated that the L-shaped cross-sectional shape is particularly amenable to maximising yield and minimising waste because its 90 degree internal angle allows the duct wall components 12, 14 to be nested or stacked closely together within the polystyrene block 36 prior to be being released therefrom. In Fig. 5, the uppermost duct wall component is shown in a partially released position whereby it has been partially pushed in the longitudinal direction, i.e. into the plane of the end face.

A cutting tool – such a hot-wire cutter – may be arranged with a suitable cutting template for cutting lengthwise through the polystyrene block 36 to simultaneously form a plurality of individual duct wall components 12, 14. The cutting process may be adapted so as to provide abrade some or all surfaces of each duct wall components 12, 14. A roughened surface profile can help to absorb noise produced by airflow through the ventilation duct sections 10.

A ventilation duct connector 40 will now be described with reference to Figs. 6 to 12. The connector 40 comprises two aligned primary annular recesses 48 separated from one another by an annular partition wall 44. Each is defined by coaxially arranged pairs of radially spaced internal and external flanges 46, 42 each extending perpendicularly from the annular partition wall 44 in opposite directions. The annulus formed by the internal and external flanges 46, 42 has a cross-sectional profile matching that of the ventilation duct assemblies 10 shown in Figs. 1 to 3. The internal and external flanges 46, 42 are each provided with a non-smooth surface profile on their inward and outward facing surfaces respectively. The surface profile is in the form of circumferentially arranged projections or ridges 51, 53 for promoting secure engagement of the ends of ventilation duct assemblies within the primary annular recess 48 as best shown in Figs. 8 to 11. The annulus defines an internal ducting cavity 50 for channelling gases.

The ventilation duct connector 40 comprises two further aligned secondary annular recesses also separated from one another by the annular partition wall 44. The outer extent of each secondary annular recess is defined by the internal flanges 46 of the primary annular recesses 48. The inner extent of each secondary annular recess is defined by coaxially arranged pairs of innermost flanges 52 each extending perpendicularly from the innermost peripheral edge of the annular partition wall 44 in opposite directions. The annulus formed by the respective internal and innermost flanges 46, 52 has a cross-sectional profile matching that of a relatively rigid (e.g. PVC) gas impermeable liner 64 such that the latter can be in interference fit within the former.

The ventilation duct connector 40 is provided with two attachment flanges 54 extending from the external flange 42 for attaching the connector 40 in use to a wall, ceiling or other suitable fixing point.

An installation method for joining together ventilation duct sections 60, 62 according to the present invention will now be described with reference to Figs. 7 to 11. The distal end of a first section 60 is fully inserted into one of the primary annular recesses 48 of the ventilation duct connector 40 such that its distal end abuts against the annular partition wall 44 as shown in Fig. 8. In doing so, the projections or ridges 51, 53 within the annulus become exert localised pressure on, or become partially embedded within, the inner and outer surfaces of the first section 60 proximate its distal end. This ensures a secure attachment between the first ventilation duct section 60 and the ventilation duct connector 40.

Optionally, a distal end of a first gas impermeable liner 64 is simultaneously attached to the ventilation duct connector 40 within one of the secondary annular recesses as shown in Fig. 9.

The above steps are then repeated on the other side of the ventilation duct connector 40 in order to connect the second ventilation duct section 62 (and optionally a second gas impermeable liner 66) thereto as shown in Figs. 10 and 11. It will be appreciated that

multiple sections of ventilation ducts (and associated liners) may be connected together by a series of ventilation duct connectors 40.

It will be appreciated that other ventilation duct connector shapes and configurations may be provided, for example, to split a single ventilation duct into two separate ventilation ducts.

In order to prevent gas leakages where the first and second ventilation duct sections 60, 62 (and if present the liner 64, 66) interconnect with the ventilation duct connectors 40 it is necessary to apply an adhesive and/or sealant within the primary and/or secondary annular recesses. It is therefore advantageous if the ventilation duct connectors 40 are formed from an optically transparent or translucent material which permits the presence or absence of such an adhesive or sealant to be observed after assembly. Selection of an adhesive or sealant with an obvious colour contrast

The ventilation duct assembly and ventilation duct connectors of the present invention therefore provide a lightweight, sizeable product which is quick and easy to manufacture, transport, store, assemble, install and maintain.

An alternative aspect of the present invention will now be described with reference to Figs. 12 to 18.

To enable a ventilation system to be routed around obstacles the ventilation duct connectors 40 may angularly displaced relative to one another as shown in Fig. 12. A pair of guide vanes 80 is shown (see also Fig. 16) extending vertically between the upper and lower innermost flanges 52 and these provide both structural rigidity to the ventilation duct connectors 40 and help to direct gas flow through the corner region.

As illustrated in Figs. 13a and 14, alternative ventilation duct connectors 70A, 70B are provided for the purpose of connecting together lengths of relatively rigid ducting 72 which may be formed from PVC material. It will be noted that these ventilation duct connectors 70A, 70B are a simplification of the more complex ventilation duct connectors

40 described above insofar as they do not include primary annular recesses 48 for connecting together sections 60, 62 of elastomeric ventilation duct assemblies. The ducting 72 is connected via its ventilation duct connectors 70A and 70B to a corner member 74 (partially shown). The ventilation duct connectors 70A and 70B may be connected together at a mutual lateral edge in either a fixed or hinged manner. It will be appreciated that a hinged connection provides greater flexibility in terms of varying the respective angular displacement of adjoining ducting sections 72. The respective duct connectors 70A, 70B each include a pair of guide vanes 80 which provide both structural rigidity and help to direct gas flow through the ducting 72.

Fig. 13b is an illustration of an adaptation of the ventilation duct connector 70A of Fig. 13a. In this embodiment, the respective pairs of guide vanes 80 within each ventilation duct connector 70A, 70B are connected together by flexible arcuate PVC strips 80a, i.e. each guide vane 80 is contiguous throughout the 90 degree bend to thereby more efficiently redirect gas flow between adjacent ducting sections 72. The flexible arcuate PVC strips are provided with hooked ends for selective attachment to the guide vanes 80.

It will be appreciated that the flexible arcuate PVC strips may be provided with barbs or spiked along their longitudinal edges for embedding them into an elastomeric material of a corner member 74 such as that shown in Fig. 12.

Fig. 15 illustrates the structure of the connections between ducting sections 72, their respective ventilation duct connectors 70A, 70B, and the corner member 74. Ventilation duct connector 70A is provided with two aligned annular recesses 90 separated from one another by an annular partition wall 92. Each is defined by coaxially arranged pairs of radially spaced internal and external flanges 52, 76, 78 each extending perpendicularly from the annular partition wall 44 in opposite directions. The annulus formed by the internal and external flanges 52, 76, 78 has a stepped configuration in which an innermost portion proximate the annular partition wall 44 has a reduced cross-sectional profile matching that of the ends of the ducting sections 72. The cross-sectional profile increases in a stepwise fashion at a point spaced from the annular partition wall 44 matching that of

the ends of the corner member 74. Therefore, the annulus accommodates two different cross-sectional thicknesses.

With reference to Figs. 17A to 17C the ventilation duct connectors 40 may be provided with a stepped arrangement 82 which allows ventilation duct sections 60, 62 of different widths and/or heights to be connected together.

It is contemplated by the inventor that various substitutions, alterations, and modifications may be made to the invention without departing from the scope of the invention as defined by the accompanying claims.

CLAIMS

1. A method of manufacturing ventilation duct wall sub-assemblies comprising:
   (i) providing a three-dimensional block of elastomeric material having two opposing end walls, each end wall having a height and width dimension, and the block having an overall length dimension; and
   (ii) using a cutting tool to form a plurality of predetermined lengthwise cuts along the full length of the block of elastomeric material between opposing end walls;

wherein the cross-sectional contours of the predetermined lengthwise cuts as viewed along the lengthwise axis delineate the cross-sectional periphery of a completed duct wall sub-assembly.

2. A method according to claim 1, wherein the step of forming a plurality of predetermined lengthwise cuts simultaneously delineates a plurality of completed duct wall sub-assemblies.

3. A method according to claim 1 or 2, wherein the step of forming a plurality of predetermined lengthwise cuts involves arranging the cross-sectional peripheries of completed duct wall sub-assemblies in a juxtaposed manner.

4. A method according to any of claims 1 to 3, wherein the step of forming a plurality of predetermined lengthwise cuts involves delineating peripheries of completed duct wall sub-assemblies which are substantially L-shaped in cross-section.

5. A method according to any of claims 1 to 4, wherein the step of forming a plurality of predetermined lengthwise cuts is performed by a hot-wire cutting method.

6. A method according to any of claims 1 to 5, wherein the step of forming a plurality of predetermined lengthwise cuts is followed by the step of retaining the individual duct wall sub-assemblies in-situ within the block of elastomeric material for storage and/or transportation purposes.

7. A method according to any of claims 1 to 6, wherein the step of forming a plurality of predetermined lengthwise cuts is followed by the step of releasing the individual duct wall sub-assemblies from within the block of elastomeric material.

8. A ventilation duct assembly manufactured from duct wall sub-assemblies in accordance with any of claims 1 to 7.

9. A ventilation duct assembly according to claim 8, further comprising:

a first wall component having a substantially L-shaped cross section; and

a second wall component having a substantially L-shaped cross section;

wherein the respective first and second wall components are identical and mateable with one another to form an enclosed ducting cavity for channelling gases.

10. A ventilation duct assembly according to claim 9, wherein mating of the first and second wall components is effected via at least one set of convexities and/or concavities on one lengthwise end thereof inter-fitting with a complementary set of convexities and/or concavities on the opposite lengthwise end thereof.

11. A ventilation duct assembly according to claim 10, wherein the convexities and/or concavities are adapted to provide a snap-fit engagement with one another.

12. A ventilation duct assembly according to any of claims 8 to 11, wherein internal walls of the respective L-shaped wall components are provided with a surface profile adapted to absorb sound.

13. A ventilation duct assembly according to any of claims 8 to 12, wherein the duct wall sub-assemblies are formed from a foamed elastomer.

14. A ventilation duct assembly according to any of claims 8 to 13, wherein the ducting cavity within ventilation duct assembly is provided with a gas impermeable liner.

15. A ventilation duct assembly according to any of claims 8 to 14, wherein individual duct wall sub-assemblies may be colour-coded, or provided with other surface indicia, to indicate particular technical characteristics and/or intended orientation in use.

16. A ventilation duct connector for connecting lengths of ventilation duct assemblies in accordance with any of claims 8 to 15.

17. A ventilation duct connector according to claim 16, further comprising two aligned primary annular recesses separated from one another by an annular partition wall.

18. A ventilation duct connector according to claim 17, wherein the primary annular recesses are defined by coaxially arranged pairs of internal and external flanges each extending perpendicularly from the annular partition wall in opposite directions.

19. A ventilation duct connector according to claim 18, wherein one or more of the internal and/or external flanges may be provided with a non-smooth surface profile for promoting secure engagement of a ventilation duct assembly end within the primary annular recess.

20. A ventilation duct connector according to claim 18 or 19, wherein two aligned secondary annular recesses are also separated from one another by the annular partition and defined in part by the internal flanges of the primary annular recesses.

21. A ventilation duct connector according to claim 20, wherein the inner extent of each secondary annular recess is defined by coaxially arranged pairs of innermost flanges each extending perpendicularly from the annular partition wall in opposite directions.

22. A ventilation duct connector according to any of claims 16 to 21, wherein the ventilation duct connector is provided with at least one attachment flanges for attaching it to a wall, ceiling or other fixing point.

23. A ventilation duct connector according to any of claims 16 to 22, wherein the ventilation duct connector is formed from an optically transparent or translucent material.

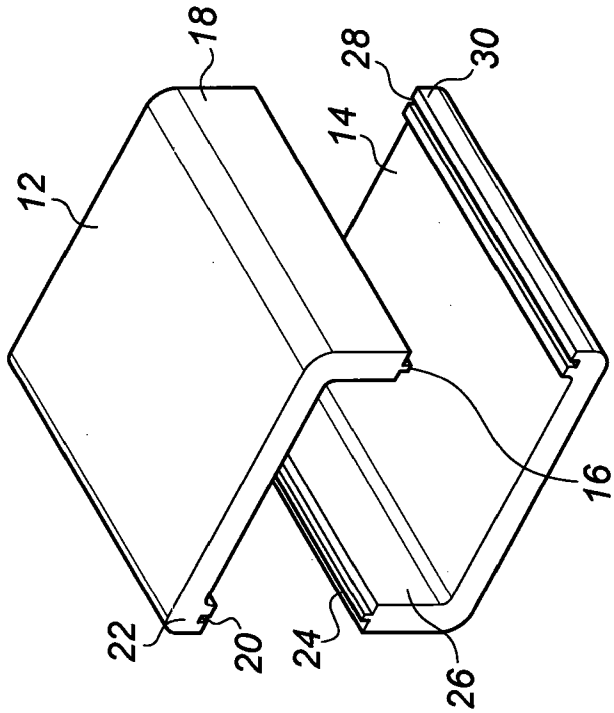

Fig. 2

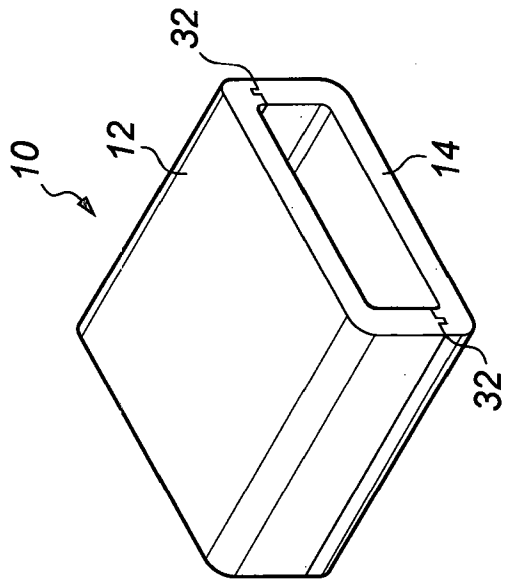

Fig. 1

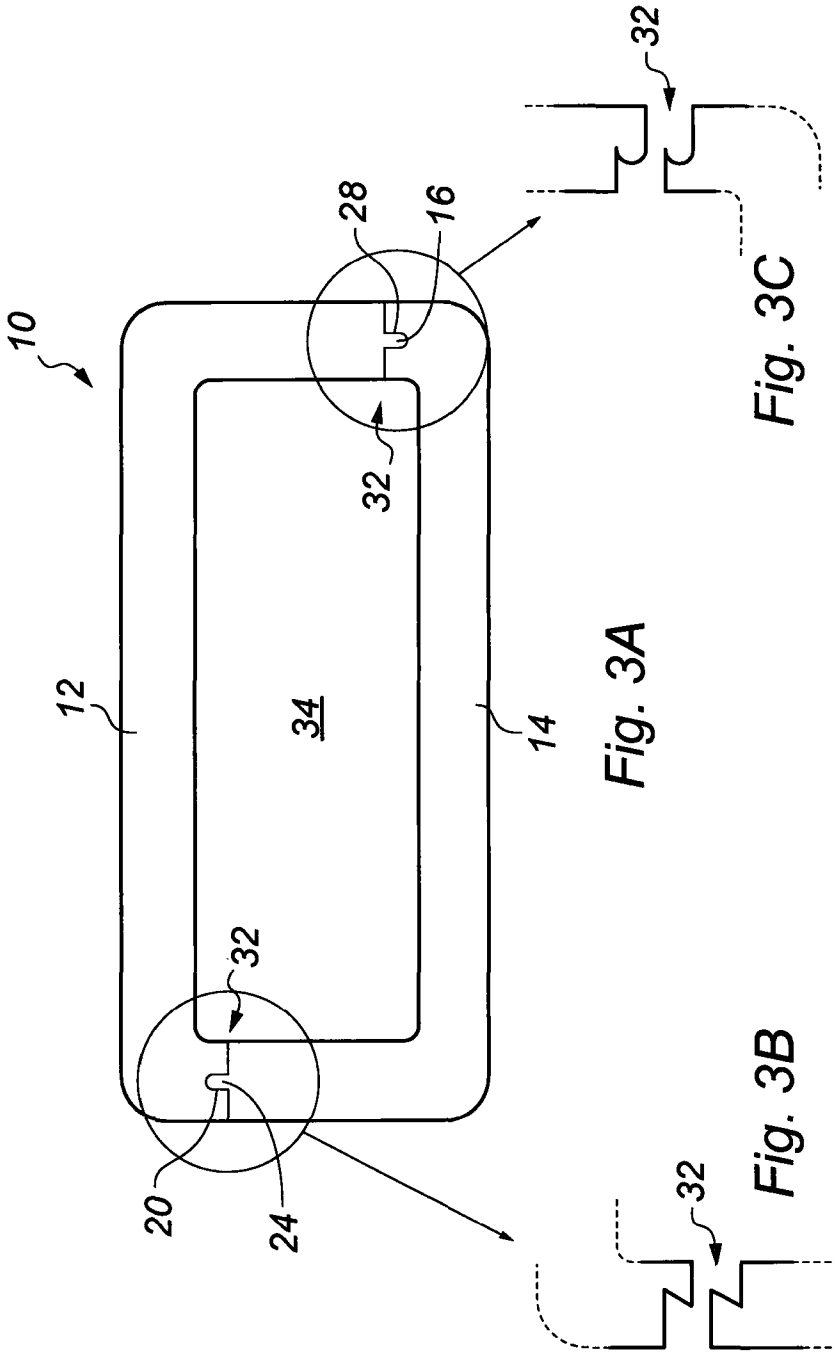

Fig. 3A

Fig. 3B

Fig. 3C

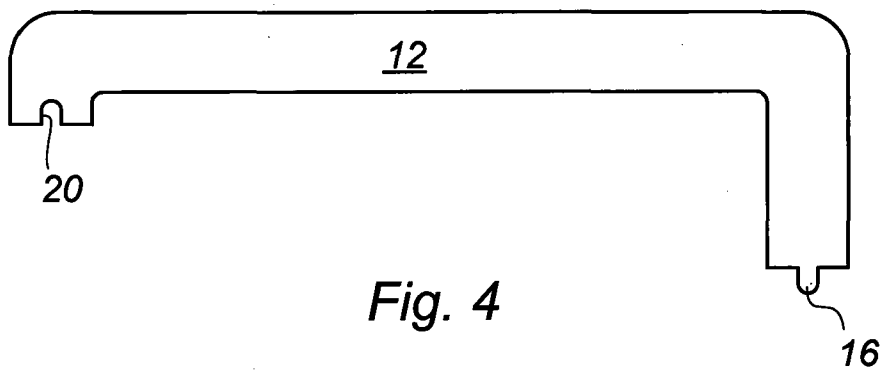

Fig. 4

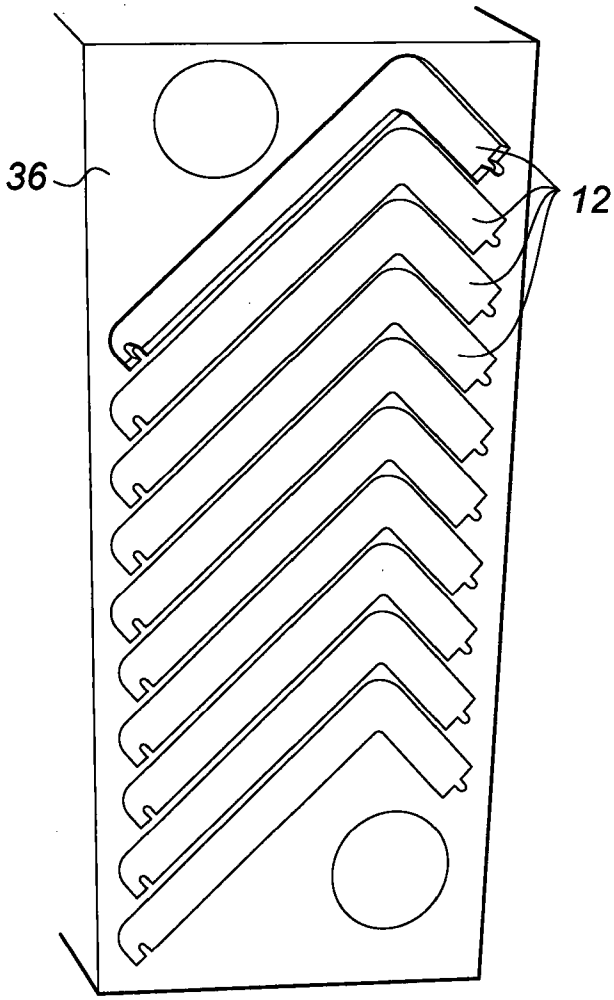

Fig. 5

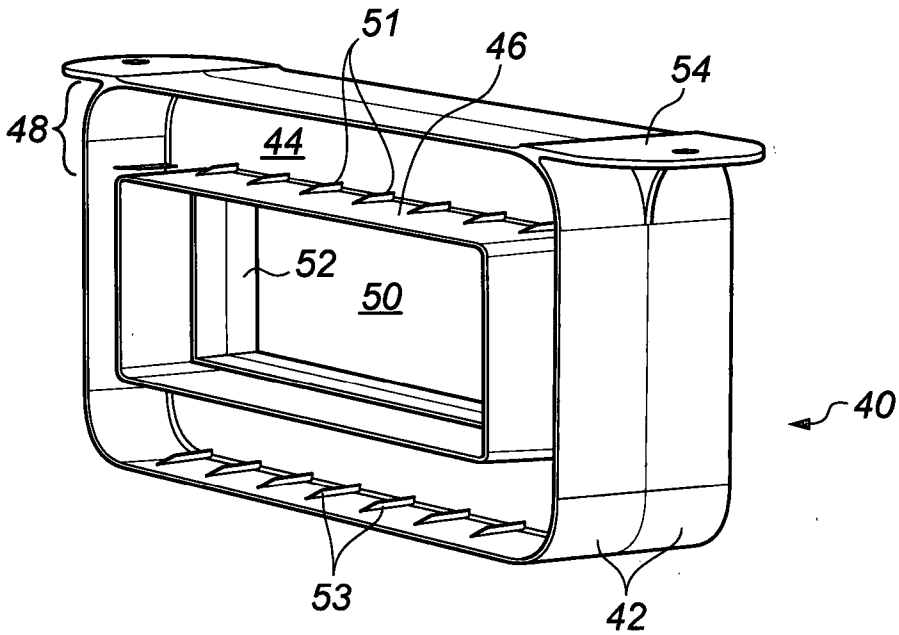

Fig. 6

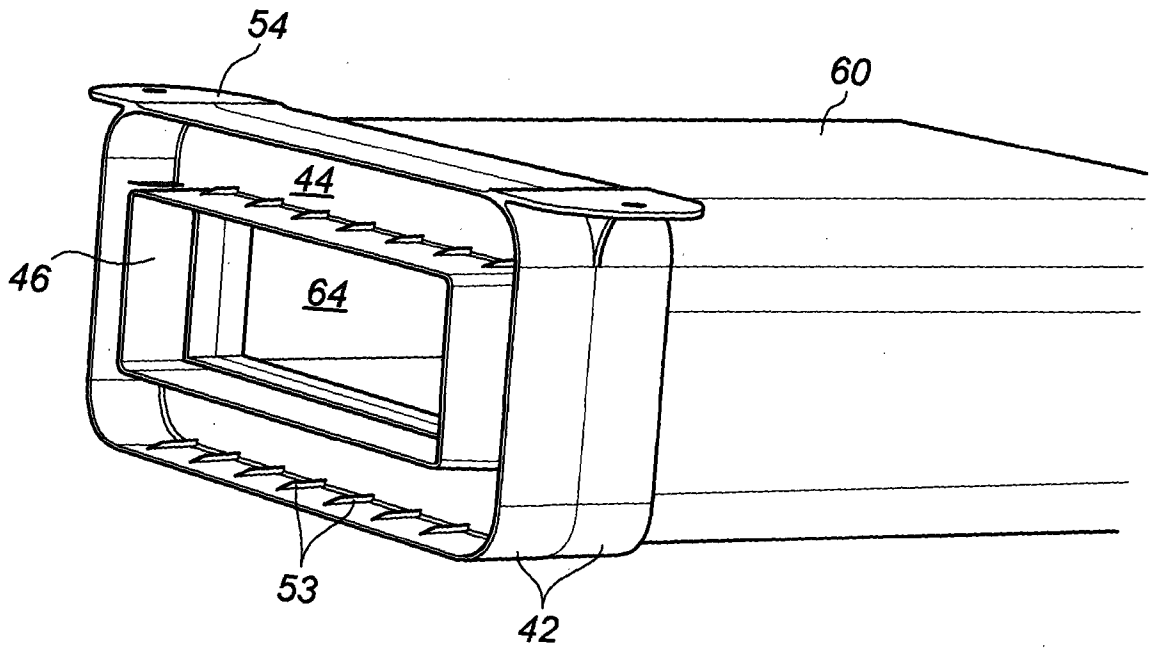

Fig. 7

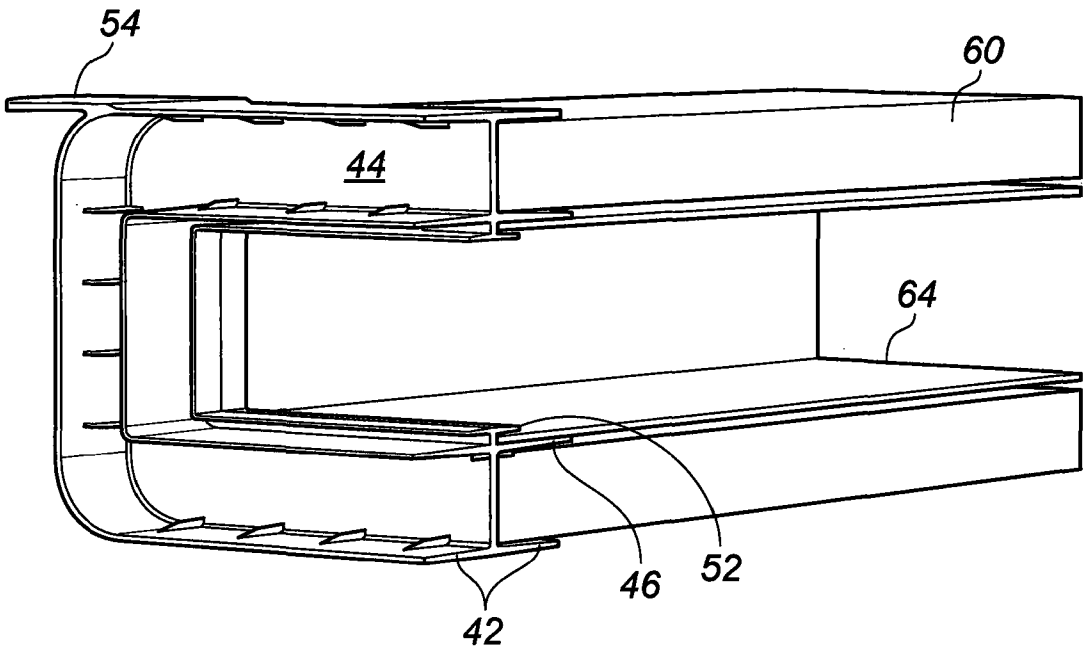

Fig. 8

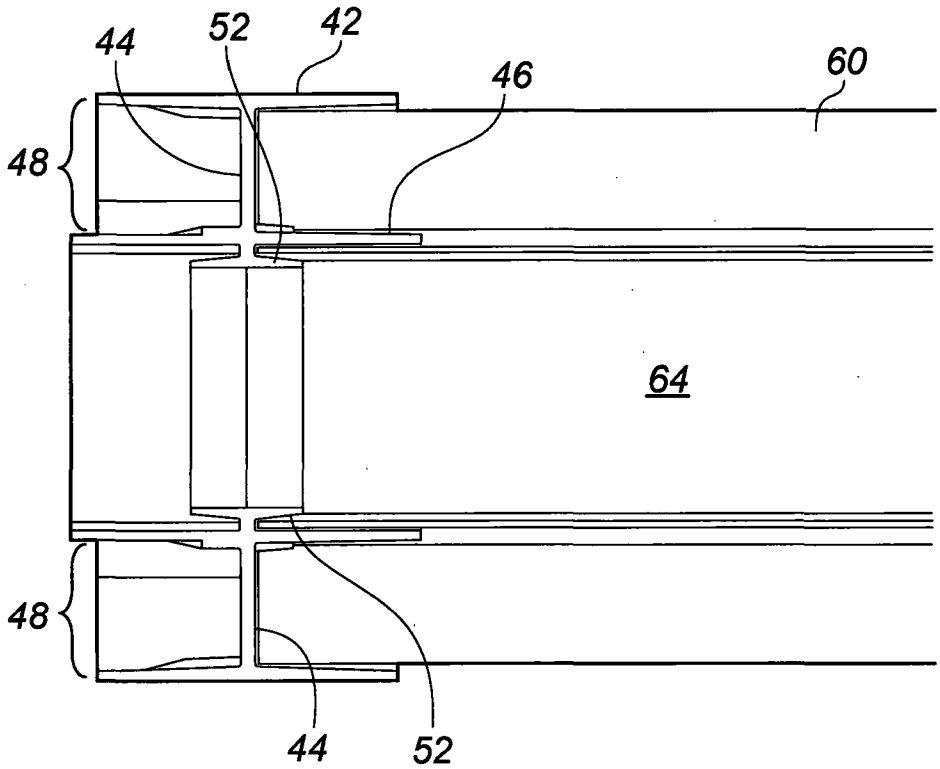

Fig. 9

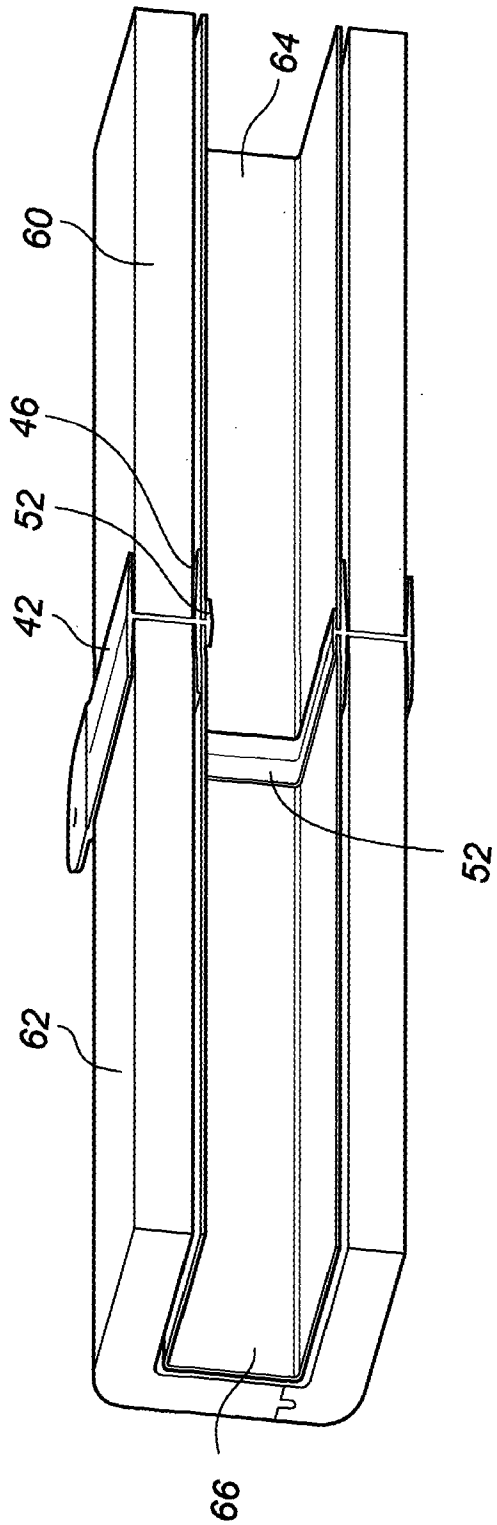

Fig. 10

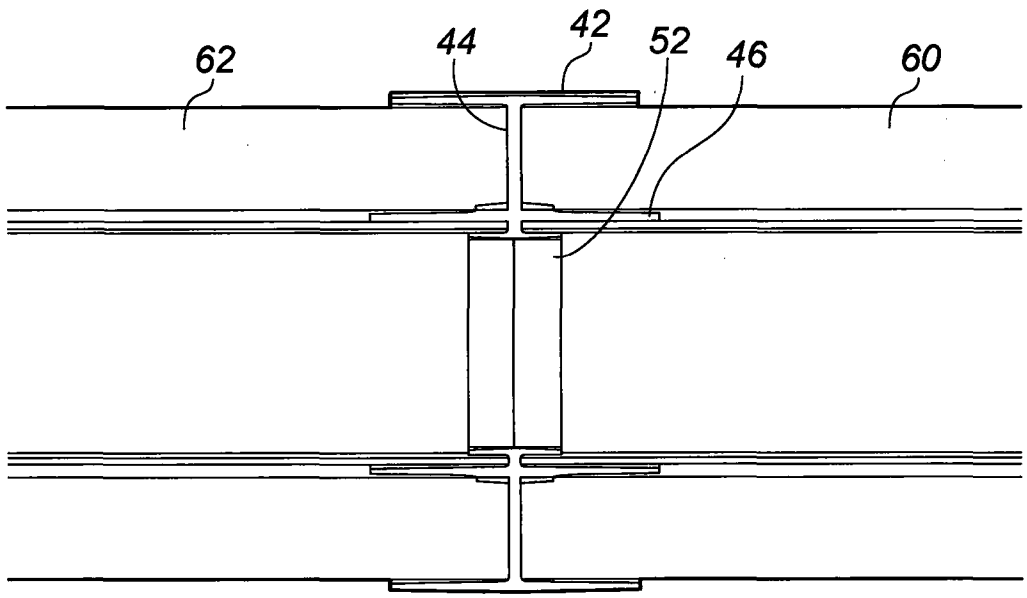

Fig. 11

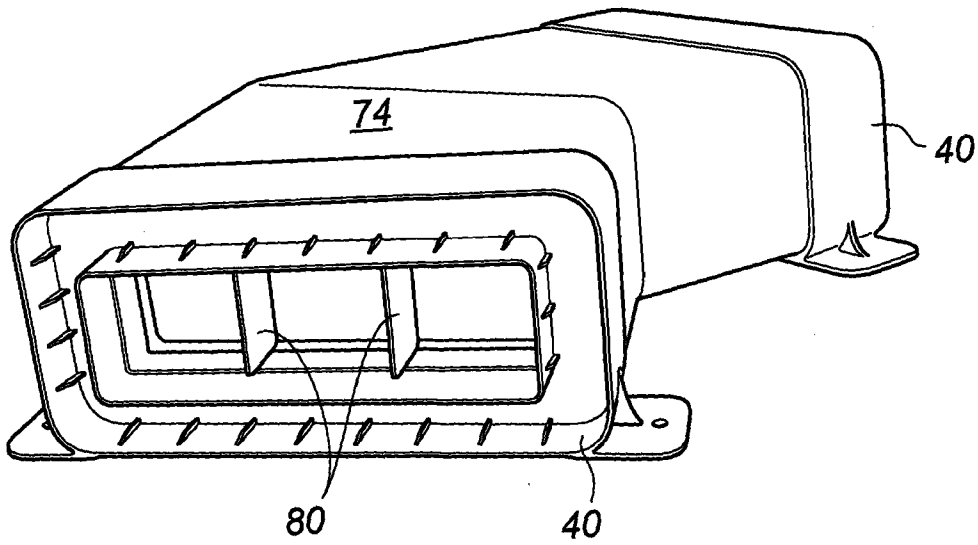

Fig. 12

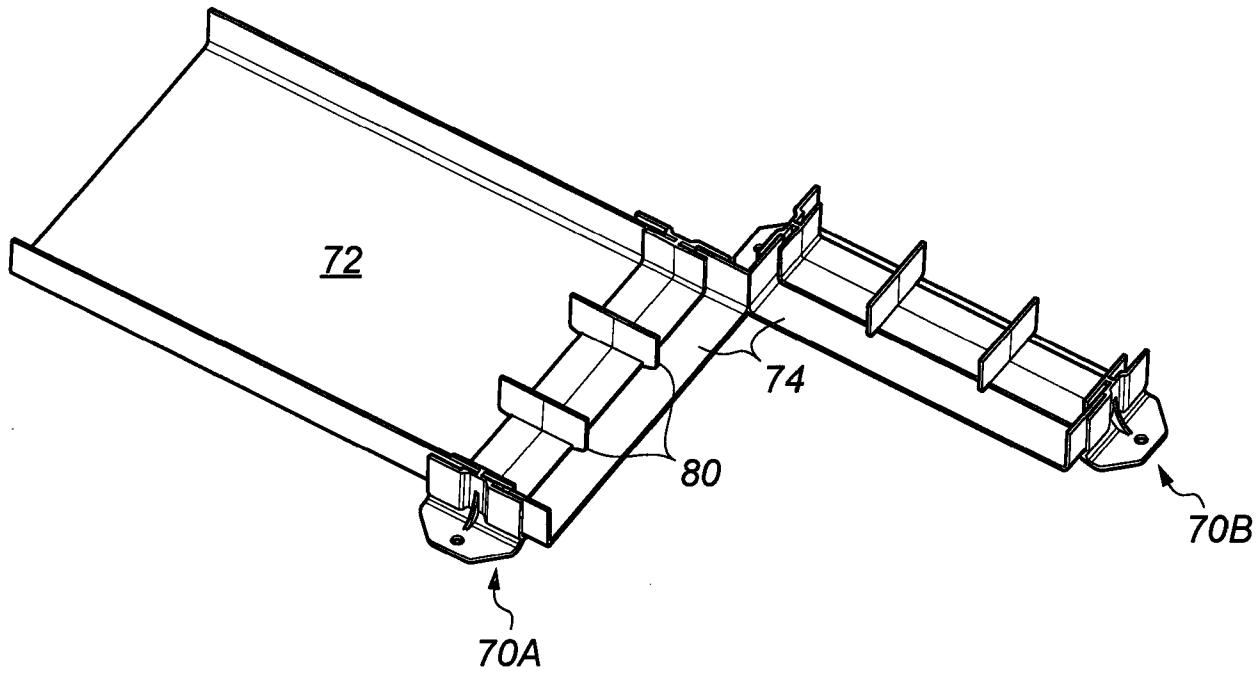

Fig. 13A

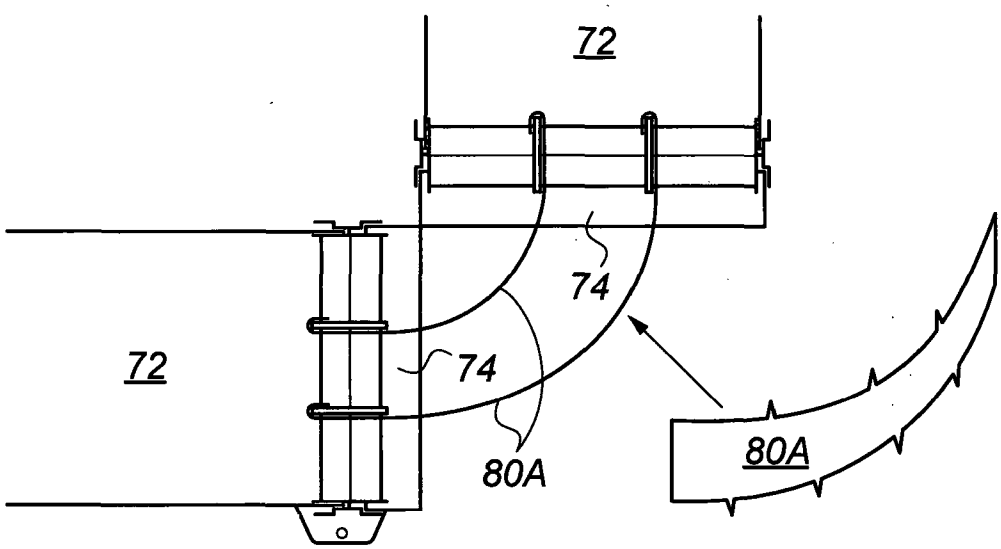

Fig. 13B

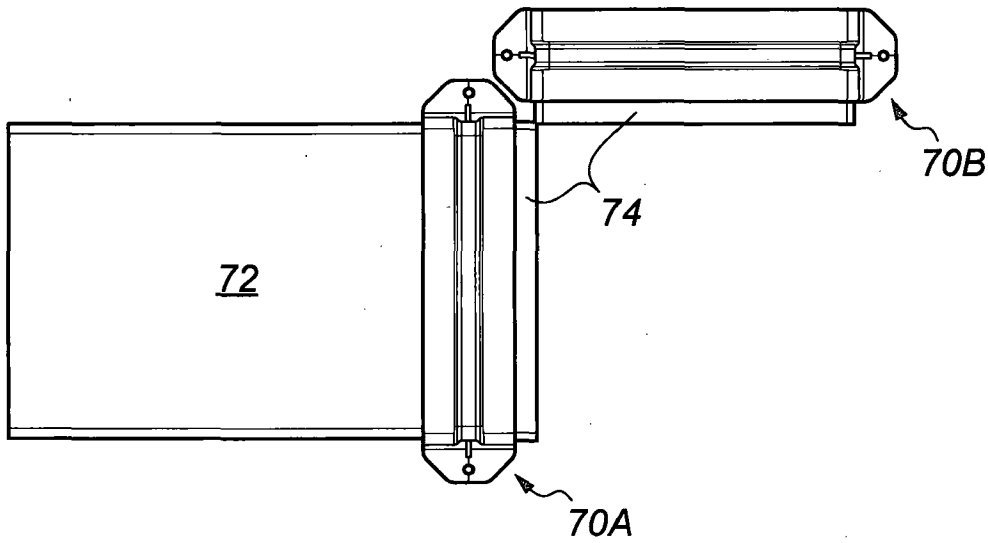

Fig. 14

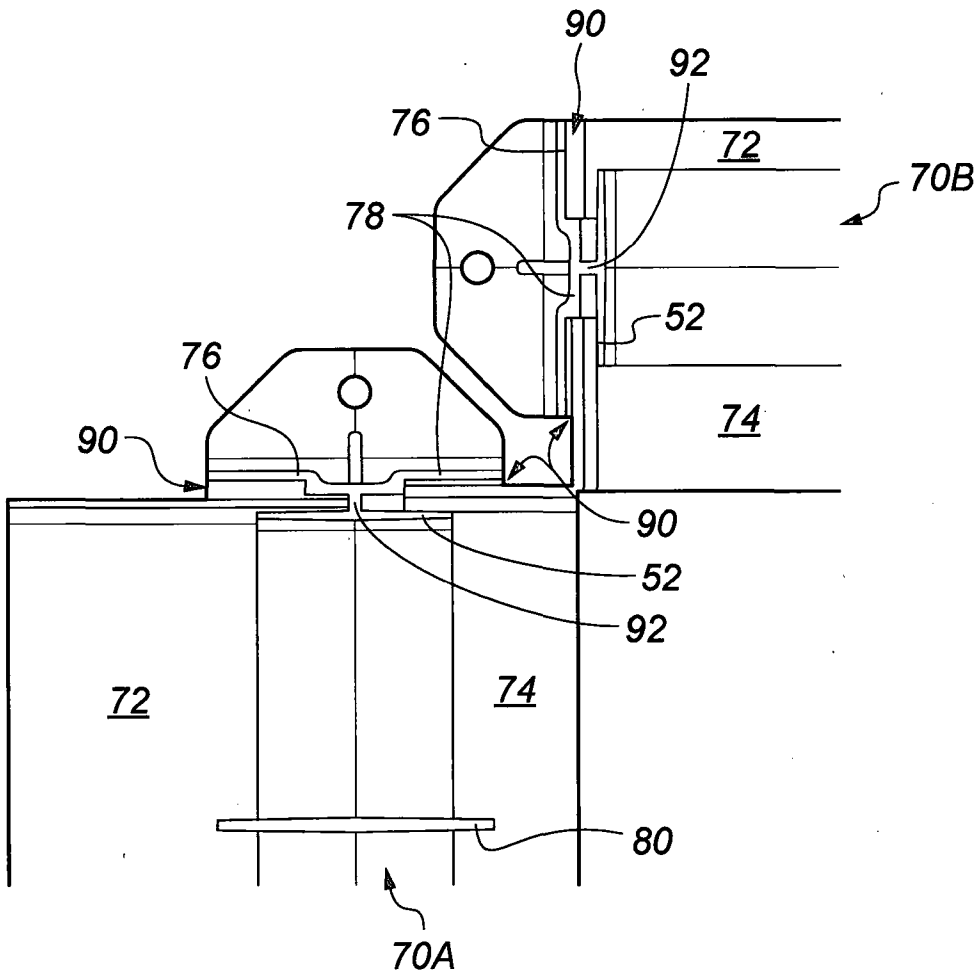

Fig. 15

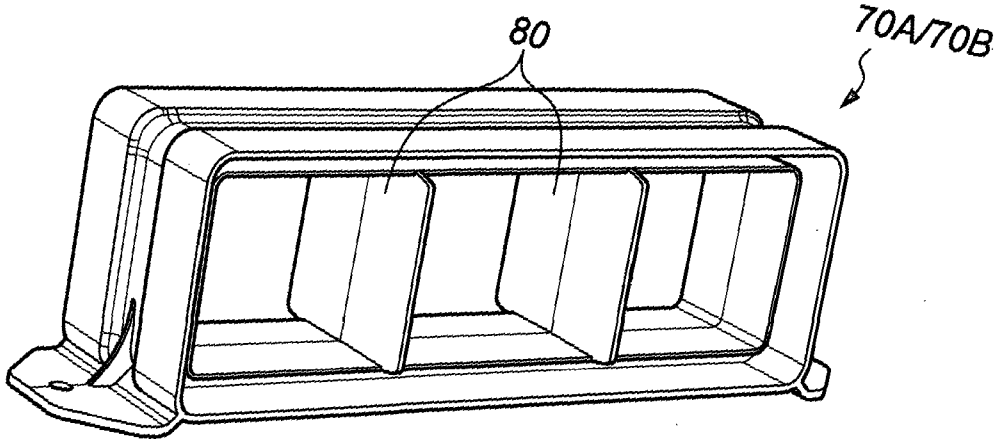

Fig. 16

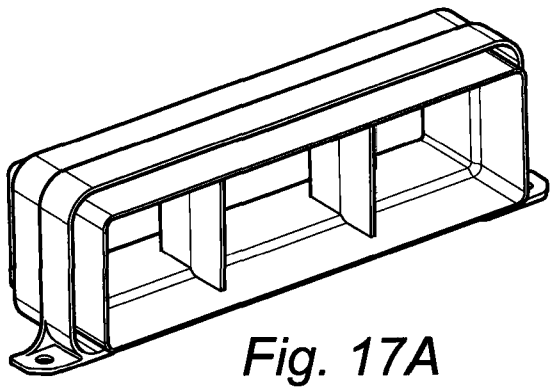

Fig. 17A

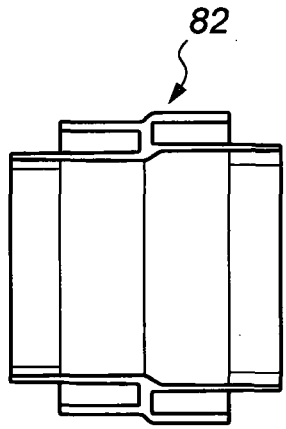

Fig. 17B

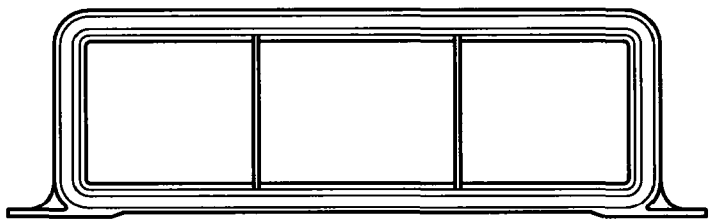

Fig. 17C

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/052711

A. CLASSIFICATION OF SUBJECT MATTER
INV. F24F13/02 B26D3/00 B26F1/38 B26F3/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 745 621 A (ANDREWS T ET AL) 17 July 1973 (1973-07-17)	1-13,15
A	abstract; claim 4; figures 4-6	14,20,21
X	US 2 183 174 A (WILEY SMITH ROBERT) 12 December 1939 (1939-12-12)	16-19, 22,23
A	claim 1; figures 7,6	8-15
A	EP 2 568 208 A1 (POLYPIPE LTD [GB]) 13 March 2013 (2013-03-13) abstract; figure 6	8-15
A	GB 2 261 624 A (BRITISH GAS PLC [GB]) 26 May 1993 (1993-05-26) abstract; figures 3-5	1-7
A	FR 2 780 481 A1 (SODISTRA [FR]) 31 December 1999 (1999-12-31) abstract; figure 2	8-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 November 2016	17/11/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Degen, Marcello

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2016/052711

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